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14. ABSTRACT

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, such as accommodation models, are needed by the ground vehicle community to address this issue (Zielinski, Huston II, Kozycki, Kouba, & Wodzinski, 2015). The third in a series of accommodation models being created is the Fixed Eye Point (FEP) accommodation model. Verification is intended to build confidence in the FEP CAD model for use in ground vehicle design. The model described in this verification report is the Ground Vehicle Systems Center (GVSC) Fixed Eye Point (FEP) CAD model. This model is applicable to ground vehicle driver workstations where the users tend toward a common eye point for performing tasks. This encompasses several scenarios, including the use of indirect vision systems (i.e., vision blocks or displays). The model is also applicable to non-driver workstations equipped with adjustable seats that require the crew to interact with controls and displays using hands and a common eye point. The boundaries defined provide required space claim for the equipped users' helmet, eyes, elbows, knees, and boots. 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).

15. SUBJECT TERMS

Fixed Eye Point, occupant workspace, equipment, verification, Computer-Aided Design (CAD), accommodation model, ground vehicle design, interior workspace, occupant, target design population, posture prediction, Human Accommodation Reference Point (HARP).

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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 Eye Point (FEP): Driver CAD model, referenced throughout the rest of the report as the FEP CAD model. This model is applicable to ground vehicle driver workstations where the users tend toward a common eye point for performing tasks. This encompasses several scenarios, including the use of indirect vision systems (i.e., vision blocks or displays). The model is also applicable to non-driver workstations equipped with adjustable seats that require the crew to interact with controls and displays using hands and a common eye point. The GVSC FEP CAD 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, and boots. 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). The Fixed Eye Point (FEP): Driver model is a statistical model created utilizing data collected from Soldiers at Fort Hood, Texas, and is documented in the report Development of Driver Posture Prediction and Accommodation Models for Military Vehicles: Fixed-Eye-Point, Out-of-Hatch, and Highly Reclined Driver Configurations (Reed et al 2020) 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 FEP 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 FEP: Driver CAD 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 *FEP_Accommodation_Models.28* (2021-01-06) spreadsheet; and boundary manikin hip and eye locations were compared to the outputs of the *Fixed Eye Point Posture Prediction.6* (2020-09-05) 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.

No issues were discovered during the verification of the model. The final outcome from the review was team consensus that the FEP CAD 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 (DOD, 2020). 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 third such CAD model to be developed is the Fixed Eye Point (FEP): Driver CAD accommodation model, referenced throughout the rest of the report as the FEP CAD model, Figure 1.

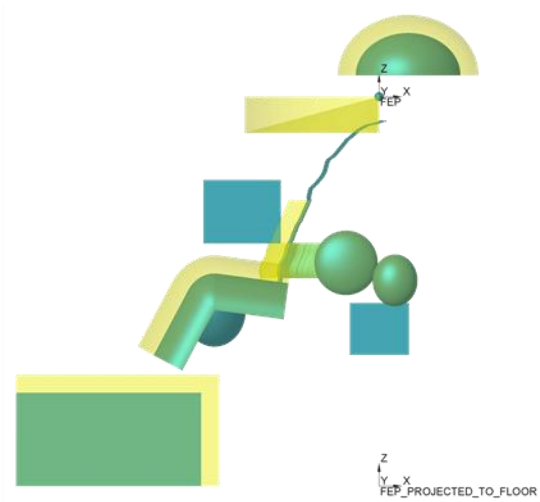

Figure 1: Fixed Eye Point (FEP): Driver CAD Accommodation Model

2.1 INTENDED USE

The FEP CAD model described in this verification plan is applicable to ground vehicles driver workstations where the users tend toward a common eye point for performing tasks. This encompasses several scenarios, including the use of indirect vision systems (i.e., vision blocks or displays). The associated tools are also applicable to non-driver workstations equipped with adjustable seats that require the crew to interact with controls and displays using hands and a common eye point.

The FEP CAD model provides composite boundaries representing the user population, including the effects of body size, protective equipment, and other gear. The boundaries defined include the required space needed for the equipped users' helmet, torso, elbows, knees, and boots. Minimum viewing distance to screens and 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).

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 FEP CAD model is a statistical model created utilizing data collected from Soldiers at Fort Hood, Texas, and is documented in the report *Development of Driver Posture Prediction and Accommodation Models for Military Vehicles: Fixed-Eye-Point, Out-of-Hatch, and Highly Reclined Driver Configurations* (Reed et al 2020) 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 and 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) (Gordon et al 2014), 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 Driver Posture Prediction and Accommodation Models for Military Vehicles: Fixed-Eye-Point, Out-of-Hatch, and Highly Reclined Driver Configurations*. 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 only vehicle input to the model is the eye point height which is the height of the eye above the heel rest surface, typically the floor. 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 FEP CAD 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, 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 FEP CAD 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 FEP CAD 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 eye point is the origin for the FEP CAD model, Figure 2. All outputs are determined with respect to the eye.

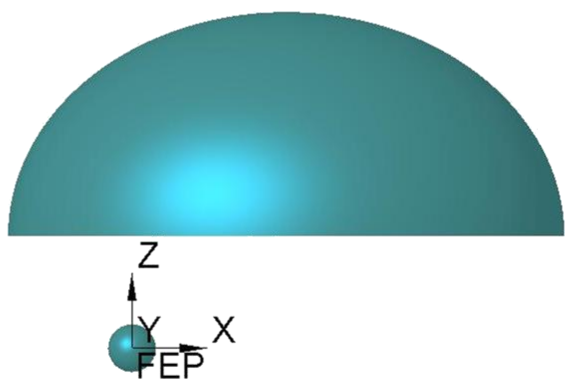

Figure 2: FEP CAD Model Origin

2.3.2 MODEL INPUTS

The FEP accommodation model requires six inputs, listed in Table 1:

Table 1: Fixed Eye Point 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 (2020), 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
Eye Point	The height of the eye above the heel rest surface (typically, the floor).

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
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

The primary model outputs include the seat adjustment range needed to reach vehicle controls 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.

Table 2: FEP CAD Model Accommodation Boundary Outputs and Definitions

Steering Mechanism (e.g. steering yoke) Travel Range	The steering mechanism travel range depicts the amount of adjustment (fore/aft and up/down) needed to accommodate the desired percentage of the user population.
Seat Track Travel Window (Seat Adjustment)	The seat track travel window depicts the range of seat track adjustment (fore/aft and up/down) needed to accommodate the desired percentage of the user population. Seat position is defined as the seat design HARP location after adjustment from the user. (Reed, 2020).
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, 2020).
Torso Boundary ENC and Torso Boundary PPE	The torso boundary depicts the distribution of user torsos, including the effects of ensemble (Reed, 2020).
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.
Elbow Boundary, Driving	This elbow boundary depicts the distribution of occupant elbow locations when hands are on the steering mechanism (i.e., in a driving posture) (Reed, 2020).
Elbow Boundary, Resting	This elbow boundary depicts the distribution of occupant elbow locations when not driving (i.e., in a relaxed posture) (Reed, 2020).
Boot Boundary	The boot contour is based on placing an estimated 95th percentile male boot at the front end of the calculated pedal location travel. The contour takes into account the seat height via the leg angle, so the boot is assumed to be on a pedal or foot rest holding it perpendicular to the leg.
Pedal Location Travel	The pedal location travel depicts the fore-aft range of preferred pedal positions relative to the fore-aft fixed eye location (Reed, 2020).

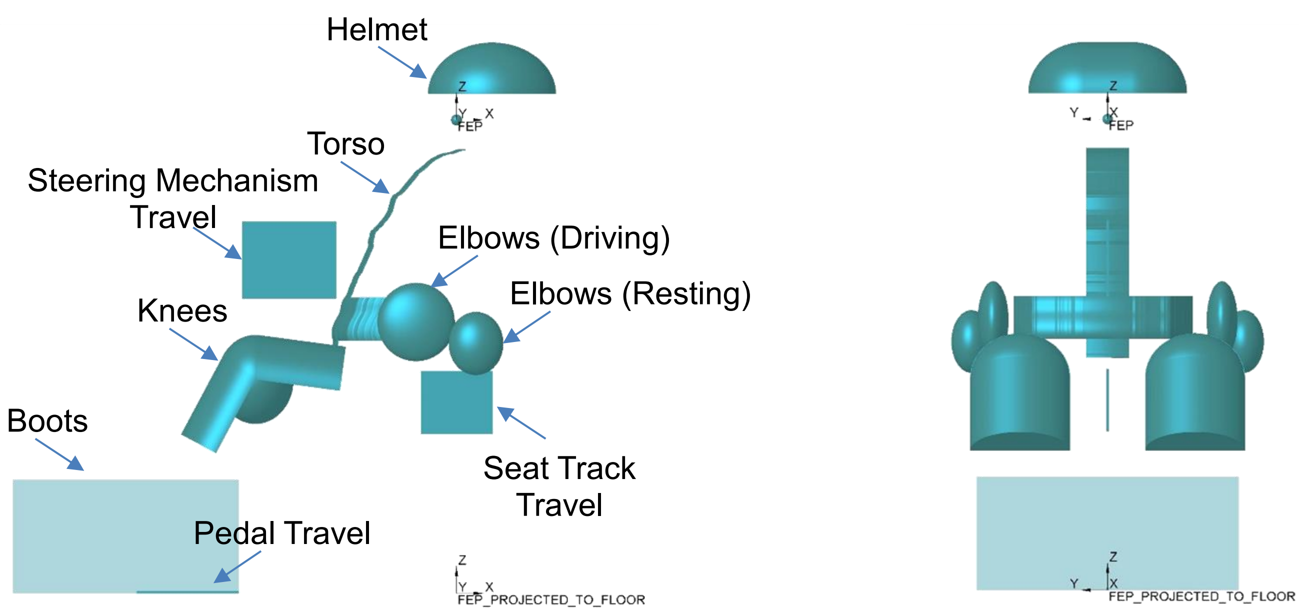

Figure 3: FEP CAD Model Example Output

2.3.4 MODEL OUTPUTS – OCCUPANT CLEARANCES BASED ON MIL-STD-1472

Clearance zones and a minimum distance for display placement are included in the model to serve as a visual check for vehicle designers to utilize when creating the occupant workspace. Clearances generally 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: FEP 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 driving 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.
Minimum Distance for Display Placement	The minimum recommended distance between the eye point and displays is 15 inches. The center of the display should be located on the horizontal line of sight or down by a maximum of 15 degrees.

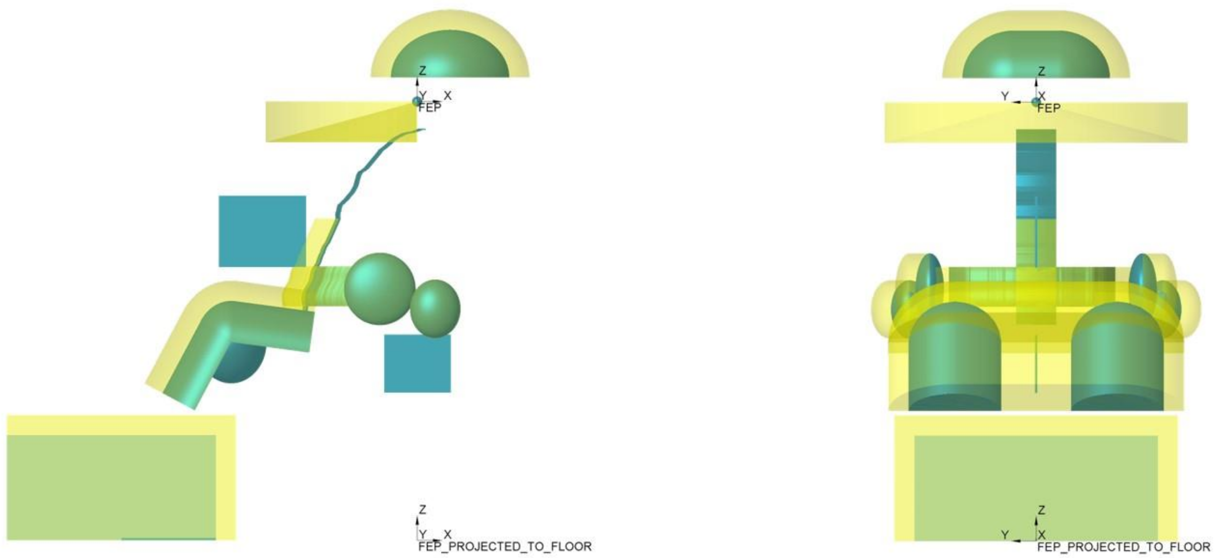

Figure 4: FEP CAD Accommodation Model Clearance Zone Outputs

2.3.5 MODEL OUTPUTS - MANIKIN PLACEMENT

Using the same data underlying the creation of the accommodation boundaries, CAD 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 4 and shown in Figure 5.

Table 4: Posture Prediction Model Output and Definitions based on Seated Soldier Study

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 (Reed, 2020).

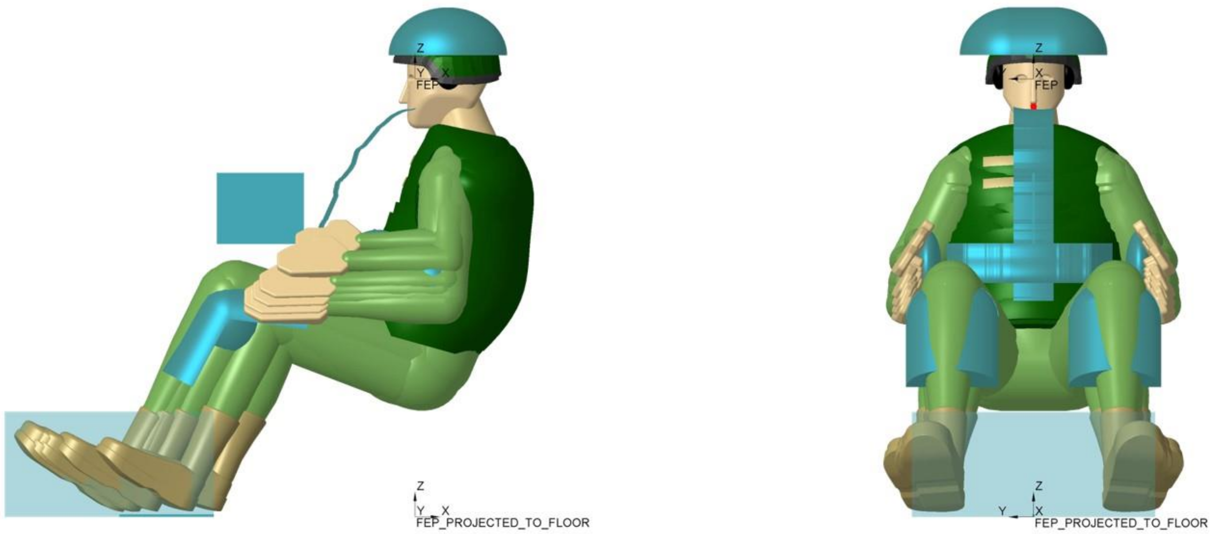

Figure 5: Manikin Placement Using Posture Prediction Model

2.4 VERIFICATION SCOPE

This report documents the verification of the FEP CAD 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 FEP CAD model.

Verification of the model was completed on 28 June 2021 by the Verification Agents listed in Table 8, Section 7. DEVCOM GVSC led the verification effort and requested review, feedback, and concurrence from the key participants listed in Table 8, Section 7.

The goal of verification was to evaluate the PTC Creo® 3D CAD version of the FEP CAD 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 *FEP_Accommodation_Model.28 2021-01-06*

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 *Fixed Eye Point Posture Prediction.6, 2020-09-05*

3. REQUIREMENTS AND ACCEPTABILITY CRITERIA

The FEP CAD model shall meet the requirements shown in Table 5 below:

Table 5: 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 eye point	4.1 Eye point 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 track travel window (seat adjustment)	7.1 Model outputs a fore/aft and vertical seat track travel window for a given population and gender mix and matches the UMTRI spreadsheet	7.1 Representative (Pass) / Non-Representative (Fail)
8	Model predicts the steering mechanism (e.g steering yoke) travel range	8.1 Model outputs a fore/aft and vertical steering mechanism travel window for a given population and gender mix and matches the UMTRI spreadsheet	8.1 Representative (Pass) / Non-Representative (Fail)
9	Model predicts the helmet contour boundary (helmet locations) with respect to the eye	9.1 Model outputs a helmet contour 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 knee contour with leg and thigh segment angles based on location of resting occupants' knees in vehicle	10.1 Model outputs a knee ellipsoid 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 predicts resting and driving elbow contours of the occupant in the vehicle	11.1 Model outputs elbow contours for the given population and gender mix that adjusts with different inputs	11.1 Representative (Pass)/ Non-Representative (Fail)
		11.2 CAD model matches the UMTRI spreadsheet	11.2 Representative (Pass)/ Non-Representative (Fail)
12	Model predicts boot contours based on location of resting occupants' boots in vehicle on a pedal	12.1 Model outputs boot contours for the given population and gender mix that adjusts with different inputs	12.1 Representative (Pass)/ Non-Representative (Fail)
		12.2 CAD model matches the UMTRI spreadsheet	12.2 Representative (Pass)/ Non-Representative (Fail)
13	Model provides a clearance zone for the head (helmet) to roof line based on MIL-STD- 1472 requirements	13.1 Model outputs a 2 inch clearance zone from the top of the helmet contour that adjusts with different inputs	13.1 Representative (Pass) / Non-Representative (Fail)
14	Model provides a clearance zone for the knee, leg and thigh based on HFE recommendations	14.1 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	14.1 Representative (Pass) / Non-Representative (Fail)
15	Model provides a lateral clearance zone for the elbow contours based on HFE recommendations	15.1 Model outputs a 2 inch clearance zone laterally for the resting elbow contours that adjusts with different inputs	15.1 Representative (Pass)/ Non-Representative (Fail)
16	Model provides a clearance zone for the boot based on HFE recommendations	16.1 Model outputs a 2 inch clearance zone from the top of the boot contour that adjusts with different inputs	16.1 Representative (Pass)/ Non-Representative (Fail)

Along with using the FEP CAD 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 6 below:

Table 6: 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 eye	1.1 Model outputs the location of the hip with respect to the eye 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 fore/aft location of the heel with respect to the eye	2.1 Model outputs the fore/aft location of the heel with respect to the eye that matches the UMTRI spreadsheet	2.1 Representative (Pass) / Non-Representative (Fail)
		2.2 The manikin heel aligns with the heel 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 FEP CAD model will provide government and industry partners with the following M&S capabilities:

- Relevant population size/shape boundaries for user posture 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 FEP CAD model has limitations based on the ground vehicle requirements for the occupant workspace, as follows:

- Predicts fixed eye point user conditions (e.g. driver or workstation with screens and hand controls) 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 if the clothing and equipment kits drastically change.
- 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 FEP CAD model is based on the following assumptions:

- The fixtures created and used by UMTRI to collect the occupant data are representative of a fixed eye point type environment for a driver or workstation with screens and hand controls.
- 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-duration driving.

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 Data 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 2020). The UMTRI documents capturing this work are listed below:

- *Development of Driver Posture Prediction and Accommodation Models for Military Vehicles: Fixed-Eye-Point, Out-of-Hatch, and Highly Reclined Driver Configuration: Final Report UMTRI-2020-5*
- *FEP_Accommodation_Models.28, 2021-01-06*, UMTRI Excel spreadsheet
- *Fixed Eye Point Posture Prediction.6, 2020-09-05*, UMTRI Excel spreadsheet

The information provided by UMTRI was utilized to create the FEP CAD 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 7, to compare outputs from the FEP CAD model to the UMTRI FEP Accommodation Model (2021) spreadsheet and Seated Fixed Eye Point Posture Prediction (2020) spreadsheets. The highlighted values in the table indicate which inputs were changed from the baseline test (Test #1).

Table 7: FEP CAD Accommodation Model Test Matrix

Test #	Target Accommodation	Fraction Male	Ensemble	Eye Point Height (in.)	HARP Measurement Tool	Hydration Pack Relief Availability	Remarks
1	90%	90%	PPE	43.3 (1100 mm)	SAE J826	No	Baseline test
2	90%	90%	PPE	39.4 (1000 mm)	SAE J826	No	Bottom of eye point range
3	90%	90%	PPE	47.2 (1200 mm)	SAE J826	No	Top of eye point range
4	90%	90%	PPE	43.3	ISO 5353	No	Alternate HARP measurement tool
5	90%	90%	ACU	43.3	SAE J826	No	Alternate ensembles
6	90%	90%	ENC	43.3	SAE J826	No	
7	90%	90%	ENC	43.3	SAE J826	Yes	Presence of hydration pack relief
8	90%	90%	PPE	43.3	SAE J826	Yes	
9	95%	90%	PPE	43.3	SAE J826	No	Increase accommodation level
10	90%	50%	PPE	43.3	SAE J826	No	Reduce males in population

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

- Geometry for composite body boundaries (except knees) is constant for a given Target Accommodation and Fraction Male, but position varies with Eye Point Height
- Knee Contour geometry and position are unique for each test to reflect changing shin and thigh angles
- Changing the HARP measurement tool shifts Seating Accommodation in the X-direction, but does not affect the position of composite body boundaries or the physical geometry of the seat
- Position for composite body boundaries shifts in the X-direction with the chosen Ensemble
- 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

Team consensus from the verification package review is that the FEP CAD model passed verification with no outstanding issues requiring corrective action. There are no recommendations from the team for the model.

7. KEY PARTICIPANTS

Table 8 identifies the participants involved in the verification effort, including their roles and responsibilities.

Table 8: 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.	Gale M. Litrichin, GVSC GVSP Eric S. Paternoster, GVSC CSI 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 Richard W. Kozycki, DAC David A. Hullinger, DAC Brian D. Corner, PhD, MERS - GCES Matthew P. Reed, Ph.D, UMTRI

8. ACTUAL VERIFICATION RESOURCES EXPENDED

8.1 VERIFICATION RESOURCES EXPENDED

Table 9 identifies the resources used to create the CCDC GVSP FEP CAD model and complete associated activities, including verification.

Table 9: Verification Resources

Document/Deliverable	Required Resources	POC
Development of Driver Posture Prediction and Accommodation Models for Military Vehicles: Fixed-Eye-Point, Out-of-Hatch, and Highly Reclined Driver Configuration: Final Report	M&S Developer and SME support	UMTRI

FEP Accommodation Models Excel Spreadsheet	M&S Developer and SME support	UMTRI
Fixed Eye Point Posture Prediction Excel Spreadsheet	M&S Developer and SME support	UMTRI
Accommodation Model Funding Approval for FY19	M&S Proponent	GVSC ACT
Fixed Eye Point Verification Plan	Verification Agent, M&S Developer and SME support	GVSC ACT
Accommodation Model Funding Approval FY20	M&S Proponent	GVSC ACT
Fixed Eye Point Accommodation Model Build	M&S Developer and SME support	GVSC ACT
Fixed Eye Point Accommodation Model Verification packet completed	M&S Developer and Verification Agent	GVSC ACT, UMTRI
Fixed Eye Point CAD Model Release into PDMLink	M&S Developer	GVSC ACT
Fixed Eye Point Verification Report Revision 1.0	Verification Agent, Validation Agent, M&S Developer and SME support	GVSC ACT
OPSEC of Fixed Eye Point Verification Report and CAD Model	M&S Proponent	GVSC ACT
Release of Fixed Eye Point Verification Report and CAD Model to the GVSC public website.	M&S Proponent	GVSC ACT

8.2 ACTUAL VERIFICATION MILESTONES AND TIMELINE

Table 10 identifies the major milestone achievements in the creation the FEP CAD model and completion of associated activities, including verification.

Table 10: Verification Milestone Timeline

Document/Deliverable	Delivery Date
Draft FEP Accommodation Model Spreadsheet	November 2016
Draft Posture Prediction Spreadsheet	November 2016
FEP CAD template development started	November 2017
FEP data applied to Armored Reconnaissance Vehicle (ARV)	February 2018
FEP data applied to Optionally Manned Tank (OMT)	June 2020
Fixed Eye Point Posture Prediction.6 Excel spreadsheet	September 2020
Development of Driver Posture Prediction and Accommodation Models for Military Vehicles: Fixed-Eye-Point, Out-of-Hatch, and Highly Reclined Driver Configuration	October 2020
FEP CAD Model Verification Plan	December 2020
FEP_Accommodation_Model.28 Excel spreadsheet	January 2021
FEP CAD model complete	January 2021
FEP CAD Model Verification Testing Complete	April 2021

FEP CAD Model Verification by supporting Resources	June 2021
Fixed Eye Point: Driver CAD Final Model Release into PDMLink	June 2021
Verification Report (Final)	July 2021

9. VERIFICATION LESSONS LEARNED

Verification of the FEP CAD model marks the third 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 **Error! Reference source not found.**) 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.

10. APPENDICES

10.1 APPENDIX A – M&S DESCRIPTION

10.1.1 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 Driver Posture Prediction and Accommodation Models for Military Vehicles: Fixed-Eye-Point, Out-of-Hatch, and Highly Reclined Driver Configuration* (2020).

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 (DOD, 2020). This analysis is available for the Fixed Eye Point (FEP) 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 Driver Posture Prediction and Accommodation Models for Military Vehicles: Fixed-Eye-Point, Out-of-Hatch, and Highly Reclined Driver Configuration* (Reed et al, 2020) was completed to capture Soldier preferred posture and position data on driver workstations with three configurations: a fixed eye point, an out-of-hatch posture with a high seat height, and highly reclined postures. Fixed Eye Point (FEP) designs are increasingly relevant for scenarios in which drivers are fully under armor, driving using optical systems (e.g., periscopes) or camera-based systems with screen displays.

The UMTRI study (2020) gathered data on Soldiers at Fort Hood, Texas, September through November 2014. Soldiers wore three levels of clothing and equipment including: 1) the advanced combat uniform (ACU), consisting of the Soldier's own jacket, trousers, shirt, and combat boots; 2) 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 3) 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, 2013).

The mockup used in the study simulates a (FEP): Driver workstation. The test seat was set to two different combinations of vertical and horizontal seat travel and seat back angle. Floor height was also adjustable and the Soldiers wore either PPE or ENC for the study.

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. 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 Driver Posture Prediction and Accommodation Models for Military Vehicles: Fixed-Eye-Point, Out-of-Hatch, and Highly Reclined Driver Configuration (2020).*

The CAD version of the FEP 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, along with minimum screen distance, 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 FEP 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 = ± 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.

10.1.2 M&S USE HISTORY

The data for the FEP CAD model was pulled ahead to apply to Combat Vehicle Prototyping (CVP), Armored Reconnaissance Vehicle (ARV), and Optionally Manned Tank (OMT) concepts. Each instance required manually running the spreadsheets from UMTRI and then transcribing the results to CAD. This early work provided valuable feedback to the CAD M&S Developer regarding the limits of the model and additional features that should be considered. For example, after inserting the CAD output into vehicle environments, it became apparent that contours representing population elbows and boots would benefit ground vehicle designers. The development of the final model, which has not yet been applied to a program, was an iterative process between the CAD M&S Developer and UMTRI to add and refine features.

10.1.3 CONFIGURATION MANAGEMENT

The GVSC ACT will manage any changes to the FEP CAD accommodation model and upload the latest version.

The FEP 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:
12647170 GVSC FIXED EYE POINT DRIVER

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

DEVCOM GVSC Advanced Concepts Team
6501 E. 11 Mile Road
Bldg. 200, FCDD-GVR-MSS
MS 207
Warren, MI 48397-5000

Gale L. Zielinski (Project Lead)
Office: (586) 282-5287

Frank J. Huston II (Model Developer)
Office: (586) 282-5657

E-mail: gale.zielinski2.civ@mail.mil E-mail: frank.j.huston.civ@mail.mil

10.2 APPENDIX B – REQUIREMENTS AND ACCEPTABILITY CRITERIA RESULTS

The requirements and acceptability criteria results for accommodation and posture prediction are shown below in Table 11 and Table 12, respectively. Metrics are noted as pass or fail. None of the metrics produced a failing result, so no corrective action plans are required.

Table 11: 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 eye point	4.1 Eye point 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 track travel window (seat adjustment)	7.1 Model outputs a fore/aft and vertical seat track travel window for a given population and gender mix and matches the UMTRI spreadsheet	7.1 Representative (Pass) / Non-Representative (Fail)
8	Model predicts the steering mechanism (e.g steering yoke) travel range	8.1 Model outputs a fore/aft and vertical steering mechanism travel window for a given population and gender mix and matches the UMTRI spreadsheet	8.1 Representative (Pass) / Non-Representative (Fail)
9	Model predicts the helmet contour boundary (helmet locations) with respect to the eye	9.1 Model outputs a helmet contour 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 knee contour with leg and thigh segment angles based on location of resting occupants' knees in vehicle	10.1 Model outputs a knee ellipsoid 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 predicts resting and driving elbow contours of the occupant in the vehicle	11.1 Model outputs elbow contours for the given population and gender mix that adjusts with different inputs	11.1 Representative (Pass)/ Non-Representative (Fail)
		11.2 CAD model matches the UMTRI spreadsheet	11.2 Representative (Pass)/ Non-Representative (Fail)
12	Model predicts boot contours based on location of resting occupants' boots in vehicle on a pedal	12.1 Model outputs boot contours for the given population and gender mix that adjusts with different inputs	12.1 Representative (Pass)/ Non-Representative (Fail)
		12.2 CAD model matches the UMTRI spreadsheet	12.2 Representative (Pass)/ Non-Representative (Fail)
13	Model provides a clearance zone for the head (helmet) to roof line based on a back calculation from MIL-STD-1472G requirements	13.1 Model outputs a 2 inch clearance zone from the top of the helmet contour that adjusts with different inputs	13.1 Representative (Pass) / Non-Representative (Fail)
14	Model provides a clearance zone for the knee, leg and thigh based on HFE recommendations	14.1 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	14.1 Representative (Pass) / Non-Representative (Fail)
15	Model provides a lateral clearance zone for the elbow contours based on HFE recommendations	15.1 Model outputs a 2 inch clearance zone laterally for the resting elbow contours that adjusts with different inputs	15.1 Representative (Pass)/ Non-Representative (Fail)
16	Model provides a clearance zone for the boot based on HFE recommendations	16.1 Model outputs a 2 inch clearance zone from the top of the boot contour that adjusts with different inputs	16.1 Representative (Pass)/ Non-Representative (Fail)

Table 12: Posture Prediction Model Results

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

10.2.1 TEST #1 – NUMERICAL RESULTS

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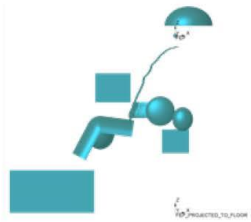
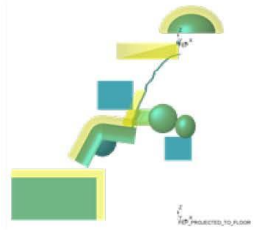
TEST #1: BASELINE TEST

Test #	Target Accommodation	Fraction Male	Ensemble	Eye Point Height (in.)	HARP Measurement Tool	Hydration Pack Relief Availability	Remarks
1	90%	90%	PPE	43.3 (1100 mm)	SAE J826	No	Baseline test

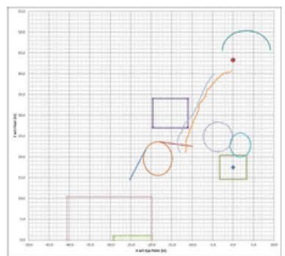


Basic Accommodation



Clearance (2.0 inches)

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:
0.005 inches
0.009 degrees

Manikin Placement:
0.000 inches

Values in agreement

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TEST #1: RESULTS, ACCOMMODATION

Eye Point

	UMTRI Value		GVSC Value		Difference	
EYE_POINT_X	0.000	in	0.000	in	0.000	in
EYE_POINT_Z	43.307	in	43.307	in	0.000	in

Seating Accommodation

	UMTRI Value		GVSC Value		Difference	
SEATING_ACC_CTR_OF_TRAVEL_X	0.033	in	0.033	in	0.000	in
SEATING_ACC_CTR_OF_TRAVEL_Z	17.465	in	17.463	in	0.002	in
SEATING_ACC_FORE_AFT_TRAVEL	6.575	in	6.576	in	0.002	in
SEATING_ACC_VERTICAL_TRAVEL	5.746	in	5.744	in	0.002	in

Seat Back Angle

	UMTRI Value		TARDEC Value		Difference	
SEAT_BACK_ANGLE_MEAN	20.433	deg	20.433	deg	0.000	deg
SEAT_BACK_ANGLE_RANGE	12.486	deg	12.495	deg	0.009	deg

Steering Position

	UMTRI Value		GVSC Value		Difference	
STEERING_POS_CTR_OF_TRAVEL_X	-15.305	in	-15.305	in	0.000	in
STEERING_POS_CTR_OF_TRAVEL_Z	30.500	in	30.500	in	0.000	in
STEERING_POS_FORE_AFT_TRAVEL	8.617	in	8.619	in	0.002	in
STEERING_POS_VERTICAL_TRAVEL	7.030	in	7.031	in	0.001	in

Pedal Position

	UMTRI Value		GVSC Value		Difference	
PEDAL_POS_CTR_OF_TRAVEL_X	-24.556	in	-24.557	in	0.001	in
PEDAL_POS_FORE_AFT_TRAVEL	9.331	in	9.335	in	0.005	in

Torso Boundary

	UMTRI Value		GVSC Value		Difference	
TORSO_WEIGHTED_REF_PT_PPE_X	-6.210	in	-6.212	in	0.002	in
TORSO_WEIGHTED_REF_PT_PPE_Z	34.666	in	34.666	in	0.000	in
TORSO_ROTATION_WRT_HARP	-1.347	deg	-1.347	deg	0.000	deg

Helmet Boundary

	UMTRI Value		GVSC Value		Difference	
HELMET_CONTOUR_CENTROID_X	3.246	in	3.246	in	0.000	in
HELMET_CONTOUR_CENTROID_Y (+/-)	2.185	in	2.185	in	0.000	in
HELMET_CONTOUR_CENTROID_Z	45.669	in	45.669	in	0.000	in
HELMET_CONTOUR_X_AXIS_LENGTH	11.703	in	11.704	in	0.001	in
HELMET_CONTOUR_Y_AXIS_LENGTH	10.228	in	10.228	in	0.000	in
HELMET_CONTOUR_Z_AXIS_LENGTH	9.427	in	9.429	in	0.001	in

Knee Boundary

	UMTRI Value		GVSC Value		Difference	
KNEE_CONTOUR_WEIGHTED_CENT_X	-18.395	in	-18.395	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Y (+/	8.033	in	8.033	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Z	19.570	in	19.570	in	0.000	in
KNEE_CONTOUR_X_AXIS_LENGTH	6.996	in	6.999	in	0.002	in
KNEE_CONTOUR_Y_AXIS_LENGTH	9.175	in	9.178	in	0.003	in
KNEE_CONTOUR_Z_AXIS_LENGTH	8.132	in	8.136	in	0.004	in
KNEE_SHIN_ANGLE	28.104	deg	28.104	deg	0.000	deg
KNEE_THIGH_ANGLE	7.627	deg	7.631	deg	0.004	deg

Elbow Boundary Driver

	UMTRI Value		GVSC Value		Difference	
ELBOW_CON_DYN_WEIGHTED_CENT_X	-3.697	in	-3.697	in	0.000	in
ELBOW_CON_DYN_WEIGHTED_CENT_Y	10.522	in	10.522	in	0.000	in
ELBOW_CON_DYN_WEIGHTED_CENT_Z	24.818	in	24.818	in	0.000	in
ELBOW_CON_DYN_X_AXIS_LENGTH	7.076	in	7.081	in	0.005	in
ELBOW_CON_DYN_Y_AXIS_LENGTH	2.835	in	2.836	in	0.002	in
ELBOW_CON_DYN_Z_AXIS_LENGTH	7.153	in	7.156	in	0.004	in

Elbow Boundary Non-Driver

	UMTRI Value		GVSC Value		Difference	
ELBOW_CON_REST_WEIGHTED_CENT_X	1.783	in	1.783	in	0.000	in
ELBOW_CON_REST_WEIGHTED_CENT_Y	12.526	in	12.526	in	0.000	in
ELBOW_REST_DYN_WEIGHTED_CENT_Z	22.856	in	22.856	in	0.000	in
ELBOW_CON_REST_X_AXIS_LENGTH	4.996	in	5.000	in	0.004	in
ELBOW_CON_REST_Y_AXIS_LENGTH	3.683	in	3.684	in	0.001	in
ELBOW_REST_DYN_Z_AXIS_LENGTH	5.779	in	5.782	in	0.003	in

Boot Boundary

	UMTRI Value		GVSC Value		Difference	
BOOT_CONTOUR_X_FRONT	-40.553	in	-40.556	in	0.003	in
BOOT_CONTOUR_X_REAR	-19.891	in	-19.889	in	0.002	in
BOOT_CONTOUR_Y_LATERAL	12.033	in	12.033	in	0.000	in
BOOT_CONTOUR_Z_TOP	10.392	in	10.393	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
0.009 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	0.474	in	0.474	in	0.000	in
POSTURE_DHM1_HIP_Z	20.287	in	20.287	in	0.000	in
POSTURE_DHM1_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM1_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM1_AHP_X	-19.443	in	-19.443	in	0.000	in
POSTURE_DHM1_AHP_Z	0.000	in	0.000	in	0.000	in

Small Overall Male

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM2_HIP_X	0.169	in	0.169	in	0.000	in
POSTURE_DHM2_HIP_Z	18.683	in	18.683	in	0.000	in
POSTURE_DHM2_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM2_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM2_AHP_X	-22.339	in	-22.339	in	0.000	in
POSTURE_DHM2_AHP_Z	0.000	in	0.000	in	0.000	in

Average Size Male

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM3_HIP_X	-0.683	in	-0.683	in	0.000	in
POSTURE_DHM3_HIP_Z	16.715	in	16.715	in	0.000	in
POSTURE_DHM3_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM3_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM3_AHP_X	-25.793	in	-25.793	in	0.000	in
POSTURE_DHM3_AHP_Z	0.000	in	0.000	in	0.000	in

Widest Shoulders Male

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM4_HIP_X	-1.314	in	-1.314	in	0.000	in
POSTURE_DHM4_HIP_Z	15.634	in	15.634	in	0.000	in
POSTURE_DHM4_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM4_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM4_AHP_X	-27.599	in	-27.599	in	0.000	in
POSTURE_DHM4_AHP_Z	0.000	in	0.000	in	0.000	in

Longest Torso Male

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM5_HIP_X	-2.569	in	-2.569	in	0.000	in
POSTURE_DHM5_HIP_Z	15.103	in	15.103	in	0.000	in
POSTURE_DHM5_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM5_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM5_AHP_X	-27.852	in	-27.852	in	0.000	in
POSTURE_DHM5_AHP_Z	0.000	in	0.000	in	0.000	in

Longest Legs Male

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM6_HIP_X	0.220	in	0.221	in	0.000	in
POSTURE_DHM6_HIP_Z	15.876	in	15.876	in	0.000	in
POSTURE_DHM6_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM6_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM6_AHP_X	-28.028	in	-28.028	in	0.000	in
POSTURE_DHM6_AHP_Z	0.000	in	0.000	in	0.000	in

Large Overall Male

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM7_HIP_X	-1.217	in	-1.217	in	0.000	in
POSTURE_DHM7_HIP_Z	14.756	in	14.756	in	0.000	in
POSTURE_DHM7_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM7_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM7_AHP_X	-29.194	in	-29.194	in	0.000	in
POSTURE_DHM7_AHP_Z	0.000	in	0.000	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

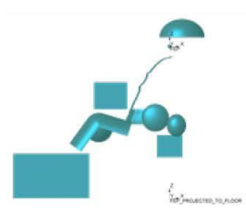
Values in agreement

10.2.2 TEST #2 – NUMERICAL RESULTS

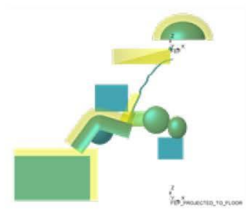
CUI

TEST #2: VARY EYE POINT HEIGHT (MIN)

Test #	Target Accommodation	Fraction Male	Ensemble	Eye Point Height (in.)	HARP Measurement Tool	Hydration Pack Relief Availability	Remarks
2	90%	90%	PPE	39.4 (1000 mm)	SAE J826	No	Bottom of eye point range

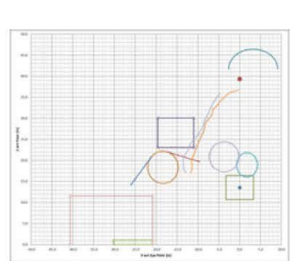


Basic Accommodation



Clearance (2.0 inches)

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:
0.005 inches
0.009 degrees

Manikin Placement:
0.000 inches

Values in agreement

DISTRIBUTION C. See first page. //CUI

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CUI

TEST #2: RESULTS, ACCOMMODATION

Eye Point

	UMTRI Value		GVSC Value		Difference	
EYE_POINT_X	0.000	in	0.000	in	0.000	in
EYE_POINT_Z	39.370	in	39.370	in	0.000	in

Seating Accommodation

	UMTRI Value		GVSC Value		Difference	
SEATING_ACC_CTR_OF_TRAVEL_X	0.033	in	0.033	in	0.000	in
SEATING_ACC_CTR_OF_TRAVEL_Z	13.528	in	13.526	in	0.002	in
SEATING_ACC_FORE_AFT_TRAVEL	6.575	in	6.576	in	0.002	in
SEATING_ACC_VERTICAL_TRAVEL	5.746	in	5.744	in	0.002	in

Seat Back Angle

	UMTRI Value		TARDEC Value		Difference	
SEAT_BACK_ANGLE_MEAN	20.433	deg	20.433	deg	0.000	deg
SEAT_BACK_ANGLE_RANGE	12.486	deg	12.495	deg	0.009	deg

Steering Position

	UMTRI Value		GVSC Value		Difference	
STEERING_POS_CTR_OF_TRAVEL_X	-15.305	in	-15.305	in	0.000	in
STEERING_POS_CTR_OF_TRAVEL_Z	26.563	in	26.563	in	0.000	in
STEERING_POS_FORE_AFT_TRAVEL	8.617	in	8.619	in	0.002	in
STEERING_POS_VERTICAL_TRAVEL	7.030	in	7.031	in	0.001	in

Pedal Position

	UMTRI Value		GVSC Value		Difference	
PEDAL_POS_CTR_OF_TRAVEL_X	-25.576	in	-25.576	in	0.000	in
PEDAL_POS_FORE_AFT_TRAVEL	9.331	in	9.335	in	0.005	in

Torso Boundary

	UMTRI Value		GVSC Value		Difference	
TORSO_WEIGHTED_REF_PT_PPE_X	-6.210	in	-6.212	in	0.002	in
TORSO_WEIGHTED_REF_PT_PPE_Z	30.729	in	30.729	in	0.000	in
TORSO_ROTATION_WRT_HARP	-1.347	deg	-1.347	deg	0.000	deg

Helmet Boundary

	UMTRI Value		GVSC Value		Difference	
HELMET_CONTOUR_CENTROID_X	3.246	in	3.246	in	0.000	in
HELMET_CONTOUR_CENTROID_Y (+/-)	2.185	in	2.185	in	0.000	in
HELMET_CONTOUR_CENTROID_Z	41.732	in	41.732	in	0.000	in
HELMET_CONTOUR_X_AXIS_LENGTH	11.703	in	11.704	in	0.001	in
HELMET_CONTOUR_Y_AXIS_LENGTH	10.228	in	10.228	in	0.000	in
HELMET_CONTOUR_Z_AXIS_LENGTH	9.427	in	9.429	in	0.001	in

Knee Boundary

	UMTRI Value		GVSC Value		Difference	
KNEE_CONTOUR_WEIGHTED_CENT_X	-18.395	in	-18.395	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Y (+/	8.033	in	8.033	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Z	18.348	in	18.348	in	0.000	in
KNEE_CONTOUR_X_AXIS_LENGTH	7.306	in	7.308	in	0.002	in
KNEE_CONTOUR_Y_AXIS_LENGTH	9.175	in	9.178	in	0.003	in
KNEE_CONTOUR_Z_AXIS_LENGTH	7.640	in	7.644	in	0.004	in
KNEE_SHIN_ANGLE	36.204	deg	36.204	deg	0.000	deg
KNEE_THIGH_ANGLE	16.727	deg	16.731	deg	0.004	deg

Elbow Boundary Driver

	UMTRI Value		GVSC Value		Difference	
ELBOW_CON_DYN_WEIGHTED_CENT_X	-3.697	in	-3.697	in	0.000	in
ELBOW_CON_DYN_WEIGHTED_CENT_Y	10.522	in	10.522	in	0.000	in
ELBOW_CON_DYN_WEIGHTED_CENT_Z	20.881	in	20.881	in	0.000	in
ELBOW_CON_DYN_X_AXIS_LENGTH	7.076	in	7.081	in	0.005	in
ELBOW_CON_DYN_Y_AXIS_LENGTH	2.835	in	2.836	in	0.002	in
ELBOW_CON_DYN_Z_AXIS_LENGTH	7.153	in	7.156	in	0.004	in

Elbow Boundary Non-Driver

	UMTRI Value		GVSC Value		Difference	
ELBOW_CON_REST_WEIGHTED_CENT_X	1.783	in	1.783	in	0.000	in
ELBOW_CON_REST_WEIGHTED_CENT_Y	12.526	in	12.526	in	0.000	in
ELBOW_REST_DYN_WEIGHTED_CENT_Z	18.919	in	18.919	in	0.000	in
ELBOW_CON_REST_X_AXIS_LENGTH	4.996	in	5.000	in	0.004	in
ELBOW_CON_REST_Y_AXIS_LENGTH	3.683	in	3.684	in	0.001	in
ELBOW_REST_DYN_Z_AXIS_LENGTH	5.779	in	5.782	in	0.003	in

Boot Boundary

	UMTRI Value		GVSC Value		Difference	
BOOT_CONTOUR_X_FRONT	-40.607	in	-40.610	in	0.003	in
BOOT_CONTOUR_X_REAR	-20.911	in	-20.909	in	0.002	in
BOOT_CONTOUR_Y_LATERAL	12.033	in	12.033	in	0.000	in
BOOT_CONTOUR_Z_TOP	11.559	in	11.559	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
0.009 degrees

Values in agreement

DISTRIBUTION C. See first page. //CUI

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TEST #2: RESULTS, MANIKIN POSITIONING

Small Overall Female						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM1_HIP_X	0.474	in	0.474	in	0.000	in
POSTURE_DHM1_HIP_Z	16.350	in	16.350	in	0.000	in
POSTURE_DHM1_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM1_EYE_Z	39.370	in	39.370	in	0.000	in
POSTURE_DHM1_AHP_X	-20.463	in	-20.463	in	0.000	in
POSTURE_DHM1_AHP_Z	0.000	in	0.000	in	0.000	in

Small Overall Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM2_HIP_X	0.169	in	0.169	in	0.000	in
POSTURE_DHM2_HIP_Z	14.746	in	14.746	in	0.000	in
POSTURE_DHM2_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM2_EYE_Z	39.370	in	39.370	in	0.000	in
POSTURE_DHM2_AHP_X	-23.358	in	-23.358	in	0.000	in
POSTURE_DHM2_AHP_Z	0.000	in	0.000	in	0.000	in

Average Size Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM3_HIP_X	-0.683	in	-0.683	in	0.000	in
POSTURE_DHM3_HIP_Z	12.778	in	12.778	in	0.000	in
POSTURE_DHM3_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM3_EYE_Z	39.370	in	39.370	in	0.000	in
POSTURE_DHM3_AHP_X	-26.813	in	-26.813	in	0.000	in
POSTURE_DHM3_AHP_Z	0.000	in	0.000	in	0.000	in

Widest Shoulders Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM4_HIP_X	-1.314	in	-1.314	in	0.000	in
POSTURE_DHM4_HIP_Z	11.697	in	11.697	in	0.000	in
POSTURE_DHM4_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM4_EYE_Z	39.370	in	39.370	in	0.000	in
POSTURE_DHM4_AHP_X	-28.619	in	-28.619	in	0.000	in
POSTURE_DHM4_AHP_Z	0.000	in	0.000	in	0.000	in

Longest Torso Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM5_HIP_X	-2.569	in	-2.569	in	0.000	in
POSTURE_DHM5_HIP_Z	11.166	in	11.166	in	0.000	in
POSTURE_DHM5_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM5_EYE_Z	39.370	in	39.370	in	0.000	in
POSTURE_DHM5_AHP_X	-28.871	in	-28.871	in	0.000	in
POSTURE_DHM5_AHP_Z	0.000	in	0.000	in	0.000	in

Longest Legs Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM6_HIP_X	0.220	in	0.221	in	0.000	in
POSTURE_DHM6_HIP_Z	11.939	in	11.939	in	0.000	in
POSTURE_DHM6_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM6_EYE_Z	39.370	in	39.370	in	0.000	in
POSTURE_DHM6_AHP_X	-29.048	in	-29.048	in	0.000	in
POSTURE_DHM6_AHP_Z	0.000	in	0.000	in	0.000	in

Large Overall Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM7_HIP_X	-1.217	in	-1.217	in	0.000	in
POSTURE_DHM7_HIP_Z	10.819	in	10.819	in	0.000	in
POSTURE_DHM7_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM7_EYE_Z	39.370	in	39.370	in	0.000	in
POSTURE_DHM7_AHP_X	-30.213	in	-30.213	in	0.000	in
POSTURE_DHM7_AHP_Z	0.000	in	0.000	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

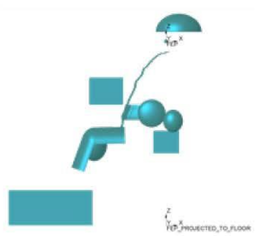
Values in agreement

10.2.3 TEST #3 – NUMERICAL RESULTS

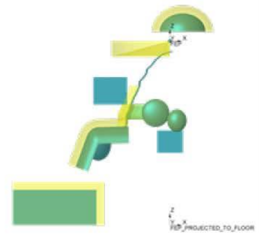
CUI

TEST #3: VARY EYE POINT HEIGHT (MAX)

Test #	Target Accommodation	Fraction Male	Ensemble	Eye Point Height (in.)	HARP Measurement Tool	Hydration Pack Relief Availability	Remarks
3	90%	90%	PPE	47.2 (1200 mm)	SAE J826	No	Top of eye point range

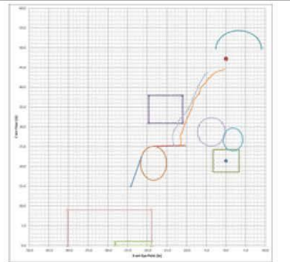


Basic Accommodation



Clearance (2.0 inches)

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:
0.005 inches
0.009 degrees

Manikin Placement:
0.000 inches

Values in agreement

DISTRIBUTION C. See first page. //CUI

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CUI

TEST #3: RESULTS, ACCOMMODATION

Eye Point	UMTRI Value	GVSC Value	Difference
EYE_POINT_X	0.000 in	0.000 in	0.000 in
EYE_POINT_Z	47.244 in	47.244 in	0.000 in

Seating Accommodation	UMTRI Value	GVSC Value	Difference
SEATING_ACC_CTR_OF_TRAVEL_X	0.033 in	0.033 in	0.000 in
SEATING_ACC_CTR_OF_TRAVEL_Z	21.402 in	21.400 in	0.002 in
SEATING_ACC_FORE_AFT_TRAVEL	6.575 in	6.576 in	0.002 in
SEATING_ACC_VERTICAL_TRAVEL	5.745 in	5.744 in	0.001 in

Seat Back Angle	UMTRI Value	TARDEC Value	Difference
SEAT_BACK_ANGLE_MEAN	20.433 deg	20.433 deg	0.000 deg
SEAT_BACK_ANGLE_RANGE	12.486 deg	12.495 deg	0.009 deg

Steering Position	UMTRI Value	GVSC Value	Difference
STEERING_POS_CTR_OF_TRAVEL_X	-15.305 in	-15.305 in	0.000 in
STEERING_POS_CTR_OF_TRAVEL_Z	34.437 in	34.437 in	0.000 in
STEERING_POS_FORE_AFT_TRAVEL	8.617 in	8.619 in	0.002 in
STEERING_POS_VERTICAL_TRAVEL	7.031 in	7.031 in	0.001 in

Pedal Position	UMTRI Value	GVSC Value	Difference
PEDAL_POS_CTR_OF_TRAVEL_X	-23.537 in	-23.537 in	0.001 in
PEDAL_POS_FORE_AFT_TRAVEL	9.331 in	9.335 in	0.004 in

Torso Boundary	UMTRI Value	GVSC Value	Difference
TORSO_WEIGHTED_REF_PT_PPE_X	-6.210 in	-6.212 in	0.002 in
TORSO_WEIGHTED_REF_PT_PPE_Z	38.603 in	38.603 in	0.000 in
TORSO_ROTATION_WRT_HARP	-1.347 deg	-1.347 deg	0.000 deg

Helmet Boundary	UMTRI Value	GVSC Value	Difference
HELMET_CONTOUR_CENTROID_X	3.246 in	3.246 in	0.000 in
HELMET_CONTOUR_CENTROID_Y (+/-)	2.185 in	2.185 in	0.000 in
HELMET_CONTOUR_CENTROID_Z	49.606 in	49.606 in	0.000 in
HELMET_CONTOUR_X_AXIS_LENGTH	11.703 in	11.704 in	0.001 in
HELMET_CONTOUR_Y_AXIS_LENGTH	10.228 in	10.228 in	0.000 in
HELMET_CONTOUR_Z_AXIS_LENGTH	9.427 in	9.429 in	0.001 in

Knee Boundary	UMTRI Value	GVSC Value	Difference
KNEE_CONTOUR_WEIGHTED_CENT_X	-18.395 in	-18.395 in	0.000 in
KNEE_CONTOUR_WEIGHTED_CENT_Y (+/	8.033 in	8.033 in	0.000 in
KNEE_CONTOUR_WEIGHTED_CENT_Z	20.817 in	20.817 in	0.000 in
KNEE_CONTOUR_X_AXIS_LENGTH	6.621 in	6.623 in	0.002 in
KNEE_CONTOUR_Y_AXIS_LENGTH	9.175 in	9.178 in	0.003 in
KNEE_CONTOUR_Z_AXIS_LENGTH	8.576 in	8.580 in	0.004 in
KNEE_SHIN_ANGLE	20.004 deg	20.004 deg	0.000 deg
KNEE_THIGH_ANGLE	-1.473 deg	-1.469 deg	0.004 deg

Elbow Boundary Driver	UMTRI Value	GVSC Value	Difference
ELBOW_CON_DYN_WEIGHTED_CENT_X	-3.697 in	-3.697 in	0.000 in
ELBOW_CON_DYN_WEIGHTED_CENT_Y	10.522 in	10.522 in	0.000 in
ELBOW_CON_DYN_WEIGHTED_CENT_Z	28.755 in	28.755 in	0.000 in
ELBOW_CON_DYN_X_AXIS_LENGTH	7.076 in	7.081 in	0.005 in
ELBOW_CON_DYN_Y_AXIS_LENGTH	2.835 in	2.836 in	0.002 in
ELBOW_CON_DYN_Z_AXIS_LENGTH	7.153 in	7.156 in	0.004 in

Elbow Boundary Non-Driver	UMTRI Value	GVSC Value	Difference
ELBOW_CON_REST_WEIGHTED_CENT_X	1.783 in	1.783 in	0.000 in
ELBOW_CON_REST_WEIGHTED_CENT_Y	12.526 in	12.526 in	0.000 in
ELBOW_REST_DYN_WEIGHTED_CENT_Z	26.793 in	26.793 in	0.000 in
ELBOW_CON_REST_X_AXIS_LENGTH	4.996 in	5.000 in	0.004 in
ELBOW_CON_REST_Y_AXIS_LENGTH	3.683 in	3.684 in	0.001 in
ELBOW_REST_DYN_Z_AXIS_LENGTH	5.779 in	5.782 in	0.003 in

Boot Boundary	UMTRI Value	GVSC Value	Difference
BOOT_CONTOUR_X_FRONT	-40.273 in	-40.276 in	0.003 in
BOOT_CONTOUR_X_REAR	-18.871 in	-18.869 in	0.002 in
BOOT_CONTOUR_Y_LATERAL	12.033 in	12.033 in	0.000 in
BOOT_CONTOUR_Z_TOP	9.019 in	9.019 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
0.009 degrees

Values in agreement

DISTRIBUTION C. See first page. //CUI

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TEST #3: RESULTS, MANIKIN POSITIONING

Small Overall Female

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM1_HIP_X	0.474	in	0.474	in	0.000	in
POSTURE_DHM1_HIP_Z	24.224	in	24.224	in	0.000	in
POSTURE_DHM1_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM1_EYE_Z	47.244	in	47.244	in	0.000	in
POSTURE_DHM1_AHP_X	-18.423	in	-18.423	in	0.000	in
POSTURE_DHM1_AHP_Z	0.000	in	0.000	in	0.000	in

Small Overall Male

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM2_HIP_X	0.169	in	0.169	in	0.000	in
POSTURE_DHM2_HIP_Z	22.620	in	22.620	in	0.000	in
POSTURE_DHM2_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM2_EYE_Z	47.244	in	47.244	in	0.000	in
POSTURE_DHM2_AHP_X	-21.319	in	-21.319	in	0.000	in
POSTURE_DHM2_AHP_Z	0.000	in	0.000	in	0.000	in

Average Size Male

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM3_HIP_X	-0.683	in	-0.683	in	0.000	in
POSTURE_DHM3_HIP_Z	20.652	in	20.652	in	0.000	in
POSTURE_DHM3_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM3_EYE_Z	47.244	in	47.244	in	0.000	in
POSTURE_DHM3_AHP_X	-24.773	in	-24.773	in	0.000	in
POSTURE_DHM3_AHP_Z	0.000	in	0.000	in	0.000	in

Widest Shoulders Male

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM4_HIP_X	-1.314	in	-1.314	in	0.000	in
POSTURE_DHM4_HIP_Z	19.571	in	19.571	in	0.000	in
POSTURE_DHM4_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM4_EYE_Z	47.244	in	47.244	in	0.000	in
POSTURE_DHM4_AHP_X	-26.580	in	-26.580	in	0.000	in
POSTURE_DHM4_AHP_Z	0.000	in	0.000	in	0.000	in

Longest Torso Male

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM5_HIP_X	-2.569	in	-2.569	in	0.000	in
POSTURE_DHM5_HIP_Z	19.040	in	19.040	in	0.000	in
POSTURE_DHM5_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM5_EYE_Z	47.244	in	47.244	in	0.000	in
POSTURE_DHM5_AHP_X	-26.832	in	-26.832	in	0.000	in
POSTURE_DHM5_AHP_Z	0.000	in	0.000	in	0.000	in

Longest Legs Male

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM6_HIP_X	0.220	in	0.221	in	0.000	in
POSTURE_DHM6_HIP_Z	19.813	in	19.813	in	0.000	in
POSTURE_DHM6_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM6_EYE_Z	47.244	in	47.244	in	0.000	in
POSTURE_DHM6_AHP_X	-27.009	in	-27.009	in	0.000	in
POSTURE_DHM6_AHP_Z	0.000	in	0.000	in	0.000	in

Large Overall Male

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM7_HIP_X	-1.217	in	-1.217	in	0.000	in
POSTURE_DHM7_HIP_Z	18.693	in	18.693	in	0.000	in
POSTURE_DHM7_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM7_EYE_Z	47.244	in	47.244	in	0.000	in
POSTURE_DHM7_AHP_X	-28.174	in	-28.174	in	0.000	in
POSTURE_DHM7_AHP_Z	0.000	in	0.000	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

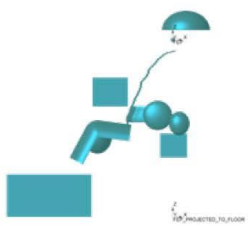
Values in agreement

10.2.4 TEST #4 – NUMERICAL RESULTS

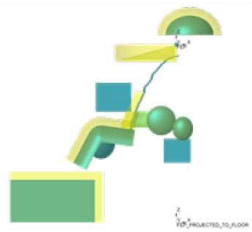
CUI

TEST #4: VARY HARP MEASUREMENT TOOL

Test #	Target Accommodation	Fraction Male	Ensemble	Eye Point Height (in.)	HARP Measurement Tool	Hydration Pack Relief Availability	Remarks
4	90%	90%	PPE	43.3	ISO 5353	No	Alternate HARP measurement tool

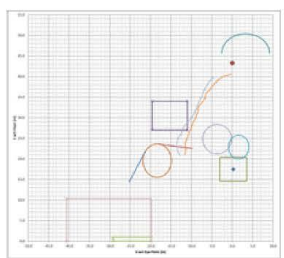


Basic Accommodation



Clearance (2.0 inches)

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:
0.005 inches
0.009 degrees

Manikin Placement:
0.000 inches

Values in agreement

DISTRIBUTION C. See first page. //CUI

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TEST #4: RESULTS, ACCOMMODATION

Eye Point

	UMTRI Value		GVSC Value		Difference	
EYE_POINT_X	0.000	in	0.000	in	0.000	in
EYE_POINT_Z	43.307	in	43.307	in	0.000	in

Seating Accommodation

	UMTRI Value		GVSC Value		Difference	
SEATING_ACC_CTR_OF_TRAVEL_X	0.230	in	0.230	in	0.000	in
SEATING_ACC_CTR_OF_TRAVEL_Z	17.465	in	17.463	in	0.002	in
SEATING_ACC_FORE_AFT_TRAVEL	6.575	in	6.576	in	0.002	in
SEATING_ACC_VERTICAL_TRAVEL	5.746	in	5.744	in	0.002	in

Seat Back Angle

	UMTRI Value		TARDEC Value		Difference	
SEAT_BACK_ANGLE_MEAN	20.433	deg	20.433	deg	0.000	deg
SEAT_BACK_ANGLE_RANGE	12.486	deg	12.495	deg	0.009	deg

Steering Position

	UMTRI Value		GVSC Value		Difference	
STEERING_POS_CTR_OF_TRAVEL_X	-15.305	in	-15.305	in	0.000	in
STEERING_POS_CTR_OF_TRAVEL_Z	30.500	in	30.500	in	0.000	in
STEERING_POS_FORE_AFT_TRAVEL	8.617	in	8.619	in	0.002	in
STEERING_POS_VERTICAL_TRAVEL	7.030	in	7.031	in	0.001	in

Pedal Position

	UMTRI Value		GVSC Value		Difference	
PEDAL_POS_CTR_OF_TRAVEL_X	-24.556	in	-24.557	in	0.001	in
PEDAL_POS_FORE_AFT_TRAVEL	9.331	in	9.335	in	0.005	in

Torso Boundary

	UMTRI Value		GVSC Value		Difference	
TORSO_WEIGHTED_REF_PT_PPE_X	-6.210	in	-6.212	in	0.002	in
TORSO_WEIGHTED_REF_PT_PPE_Z	34.666	in	34.666	in	0.000	in
TORSO_ROTATION_WRT_HARP	-1.347	deg	-1.347	deg	0.000	deg

Helmet Boundary

	UMTRI Value		GVSC Value		Difference	
HELMET_CONTOUR_CENTROID_X	3.246	in	3.246	in	0.000	in
HELMET_CONTOUR_CENTROID_Y (+/-)	2.185	in	2.185	in	0.000	in
HELMET_CONTOUR_CENTROID_Z	45.669	in	45.669	in	0.000	in
HELMET_CONTOUR_X_AXIS_LENGTH	11.703	in	11.704	in	0.001	in
HELMET_CONTOUR_Y_AXIS_LENGTH	10.228	in	10.228	in	0.000	in
HELMET_CONTOUR_Z_AXIS_LENGTH	9.427	in	9.429	in	0.001	in

Knee Boundary

	UMTRI Value		GVSC Value		Difference	
KNEE_CONTOUR_WEIGHTED_CENT_X	-18.395	in	-18.395	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Y (+/	8.033	in	8.033	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Z	19.570	in	19.570	in	0.000	in
KNEE_CONTOUR_X_AXIS_LENGTH	6.996	in	6.999	in	0.002	in
KNEE_CONTOUR_Y_AXIS_LENGTH	9.175	in	9.178	in	0.003	in
KNEE_CONTOUR_Z_AXIS_LENGTH	8.132	in	8.136	in	0.004	in
KNEE_SHIN_ANGLE	28.104	deg	28.104	deg	0.000	deg
KNEE_THIGH_ANGLE	7.627	deg	7.631	deg	0.004	deg

Elbow Boundary Driver

	UMTRI Value		GVSC Value		Difference	
ELBOW_CON_DYN_WEIGHTED_CENT_X	-3.697	in	-3.697	in	0.000	in
ELBOW_CON_DYN_WEIGHTED_CENT_Y	10.522	in	10.522	in	0.000	in
ELBOW_CON_DYN_WEIGHTED_CENT_Z	24.818	in	24.818	in	0.000	in
ELBOW_CON_DYN_X_AXIS_LENGTH	7.076	in	7.081	in	0.005	in
ELBOW_CON_DYN_Y_AXIS_LENGTH	2.835	in	2.836	in	0.002	in
ELBOW_CON_DYN_Z_AXIS_LENGTH	7.153	in	7.156	in	0.004	in

Elbow Boundary Non-Driver

	UMTRI Value		GVSC Value		Difference	
ELBOW_CON_REST_WEIGHTED_CENT_X	1.586	in	1.586195	in	0.000	in
ELBOW_CON_REST_WEIGHTED_CENT_Y	12.526	in	12.526338	in	0.000	in
ELBOW_REST_DYN_WEIGHTED_CENT_Z	22.856	in	22.856213	in	0.000	in
ELBOW_CON_REST_X_AXIS_LENGTH	4.996	in	5.000083	in	0.004	in
ELBOW_CON_REST_Y_AXIS_LENGTH	3.683	in	3.684049	in	0.001	in
ELBOW_REST_DYN_Z_AXIS_LENGTH	5.779	in	5.781634	in	0.003	in

Boot Boundary

	UMTRI Value		GVSC Value		Difference	
BOOT_CONTOUR_X_FRONT	-40.553	in	-40.556	in	0.003	in
BOOT_CONTOUR_X_REAR	-19.891	in	-19.889	in	0.002	in
BOOT_CONTOUR_Y_LATERAL	12.033	in	12.033	in	0.000	in
BOOT_CONTOUR_Z_TOP	10.392	in	10.393	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
0.009 degrees

Values in agreement

DISTRIBUTION C. See first page. //CUI

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Test #4: Results, Manikin Positioning

Small Overall Female

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM1_HIP_X	0.474	in	0.474	in	0.000	in
POSTURE_DHM1_HIP_Z	20.287	in	20.287	in	0.000	in
POSTURE_DHM1_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM1_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM1_AHP_X	-19.443	in	-19.443	in	0.000	in
POSTURE_DHM1_AHP_Z	0.000	in	0.000	in	0.000	in

Small Overall Male

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM2_HIP_X	0.169	in	0.169	in	0.000	in
POSTURE_DHM2_HIP_Z	18.683	in	18.683	in	0.000	in
POSTURE_DHM2_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM2_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM2_AHP_X	-22.339	in	-22.339	in	0.000	in
POSTURE_DHM2_AHP_Z	0.000	in	0.000	in	0.000	in

Average Size Male

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM3_HIP_X	-0.683	in	-0.683	in	0.000	in
POSTURE_DHM3_HIP_Z	16.715	in	16.715	in	0.000	in
POSTURE_DHM3_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM3_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM3_AHP_X	-25.793	in	-25.793	in	0.000	in
POSTURE_DHM3_AHP_Z	0.000	in	0.000	in	0.000	in

Widest Shoulders Male

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM4_HIP_X	-1.314	in	-1.314	in	0.000	in
POSTURE_DHM4_HIP_Z	15.634	in	15.634	in	0.000	in
POSTURE_DHM4_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM4_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM4_AHP_X	-27.599	in	-27.599	in	0.000	in
POSTURE_DHM4_AHP_Z	0.000	in	0.000	in	0.000	in

Longest Torso Male

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM5_HIP_X	-2.569	in	-2.569	in	0.000	in
POSTURE_DHM5_HIP_Z	15.103	in	15.103	in	0.000	in
POSTURE_DHM5_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM5_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM5_AHP_X	-27.852	in	-27.852	in	0.000	in
POSTURE_DHM5_AHP_Z	0.000	in	0.000	in	0.000	in

Longest Legs Male

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM6_HIP_X	0.220	in	0.221	in	0.000	in
POSTURE_DHM6_HIP_Z	15.876	in	15.876	in	0.000	in
POSTURE_DHM6_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM6_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM6_AHP_X	-28.028	in	-28.028	in	0.000	in
POSTURE_DHM6_AHP_Z	0.000	in	0.000	in	0.000	in

Large Overall Male

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM7_HIP_X	-1.217	in	-1.217	in	0.000	in
POSTURE_DHM7_HIP_Z	14.756	in	14.756	in	0.000	in
POSTURE_DHM7_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM7_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM7_AHP_X	-29.194	in	-29.194	in	0.000	in
POSTURE_DHM7_AHP_Z	0.000	in	0.000	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

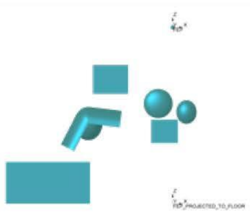
Values in agreement

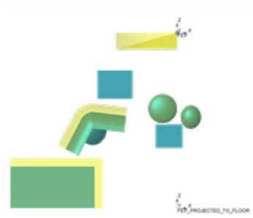
10.2.5 TEST #5 – NUMERICAL RESULTS

CUI

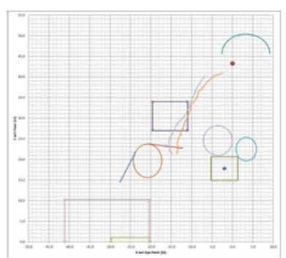
TEST #5: VARY ENSEMBLE

Test #	Target Accommodation	Fraction Male	Ensemble	Eye Point Height (in.)	HARP Measurement Tool	Hydration Pack Relief Availability	Remarks
5	90%	90%	ACU	43.3	SAE J826	No	Alternate ensembles


Basic Accommodation


Clearance (2.0 inches)


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:
0.005 inches
0.009 degrees

Manikin Placement:
0.000 inches

Values in agreement

DISTRIBUTION C. See first page. //CUI

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TEST #5: RESULTS, ACCOMMODATION

Eye Point	UMTRI Value	GVSC Value	Difference
EYE_POINT_X	0.000 in	0.000 in	0.000 in
EYE_POINT_Z	43.307 in	43.307 in	0.000 in

Seating Accommodation	UMTRI Value	GVSC Value	Difference
SEATING_ACC_CTR_OF_TRAVEL_X	-1.975 in	-1.975 in	0.000 in
SEATING_ACC_CTR_OF_TRAVEL_Z	17.780 in	17.778 in	0.002 in
SEATING_ACC_FORE_AFT_TRAVEL	6.575 in	6.576 in	0.002 in
SEATING_ACC_VERTICAL_TRAVEL	5.746 in	5.744 in	0.002 in

Seat Back Angle	UMTRI Value	TARDEC Value	Difference
SEAT_BACK_ANGLE_MEAN	19.433 deg	19.433 deg	0.000 deg
SEAT_BACK_ANGLE_RANGE	12.486 deg	12.495 deg	0.009 deg

Steering Position	UMTRI Value	GVSC Value	Difference
STEERING_POS_CTR_OF_TRAVEL_X	-15.305 in	-15.305 in	0.000 in
STEERING_POS_CTR_OF_TRAVEL_Z	30.500 in	30.500 in	0.000 in
STEERING_POS_FORE_AFT_TRAVEL	8.617 in	8.619 in	0.002 in
STEERING_POS_VERTICAL_TRAVEL	7.030 in	7.031 in	0.001 in

Pedal Position	UMTRI Value	GVSC Value	Difference
PEDAL_POS_CTR_OF_TRAVEL_X	-25.026 in	-25.026 in	0.001 in
PEDAL_POS_FORE_AFT_TRAVEL	9.331 in	9.335 in	0.004 in

Torso Boundary

The ACU ensemble does not include the calculation of a torso boundary.

Helmet Boundary

The ACU ensemble does not include a helmet.

Knee Boundary	UMTRI Value	GVSC Value	Difference
KNEE_CONTOUR_WEIGHTED_CENT_X	-20.796 in	-20.796 in	0.000 in
KNEE_CONTOUR_WEIGHTED_CENT_Y (+/	8.033 in	8.033 in	0.000 in
KNEE_CONTOUR_WEIGHTED_CENT_Z	19.669 in	19.669 in	0.000 in
KNEE_CONTOUR_X_AXIS_LENGTH	6.969 in	6.971 in	0.002 in
KNEE_CONTOUR_Y_AXIS_LENGTH	9.175 in	9.178 in	0.003 in
KNEE_CONTOUR_Z_AXIS_LENGTH	8.170 in	8.174 in	0.004 in
KNEE_SHIN_ANGLE	27.456 deg	27.456 deg	0.000 deg
KNEE_THIGH_ANGLE	6.899 deg	6.903 deg	0.004 deg

Elbow Boundary Driver	UMTRI Value	GVSC Value	Difference
ELBOW_CON_DYN_WEIGHTED_CENT_X	-3.579 in	-3.579 in	0.000 in
ELBOW_CON_DYN_WEIGHTED_CENT_Y	9.735 in	9.735 in	0.000 in
ELBOW_CON_DYN_WEIGHTED_CENT_Z	24.582 in	24.582 in	0.000 in
ELBOW_CON_DYN_X_AXIS_LENGTH	7.076 in	7.081 in	0.005 in
ELBOW_CON_DYN_Y_AXIS_LENGTH	2.835 in	2.836 in	0.002 in
ELBOW_CON_DYN_Z_AXIS_LENGTH	7.153 in	7.156 in	0.004 in

Elbow Boundary Non-Driver	UMTRI Value	GVSC Value	Difference
ELBOW_CON_REST_WEIGHTED_CENT_X	3.374 in	3.374 in	0.000 in
ELBOW_CON_REST_WEIGHTED_CENT_Y	11.792 in	11.792 in	0.000 in
ELBOW_REST_DYN_WEIGHTED_CENT_Z	22.503 in	22.503 in	0.000 in
ELBOW_CON_REST_X_AXIS_LENGTH	4.996 in	5.000 in	0.004 in
ELBOW_CON_REST_Y_AXIS_LENGTH	3.683 in	3.684 in	0.001 in
ELBOW_REST_DYN_Z_AXIS_LENGTH	5.779 in	5.782 in	0.003 in

Boot Boundary	UMTRI Value	GVSC Value	Difference
BOOT_CONTOUR_X_FRONT	-41.090 in	-41.094 in	0.003 in
BOOT_CONTOUR_X_REAR	-20.360 in	-20.359 in	0.002 in
BOOT_CONTOUR_Y_LATERAL	12.033 in	12.033 in	0.000 in
BOOT_CONTOUR_Z_TOP	10.290 in	10.290 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
0.009 degrees

Values in agreement

DISTRIBUTION C. See first page. //CUI

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Test #5: Results, Manikin Positioning

Small Overall Female						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM1_HIP_X	-1.140	in	-1.140	in	0.000	in
POSTURE_DHM1_HIP_Z	20.602	in	20.602	in	0.000	in
POSTURE_DHM1_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM1_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM1_AHP_X	-19.994	in	-19.994	in	0.000	in
POSTURE_DHM1_AHP_Z	0.000	in	0.000	in	0.000	in

Small Overall Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM2_HIP_X	-1.445	in	-1.445	in	0.000	in
POSTURE_DHM2_HIP_Z	18.998	in	18.998	in	0.000	in
POSTURE_DHM2_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM2_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM2_AHP_X	-22.890	in	-22.890	in	0.000	in
POSTURE_DHM2_AHP_Z	0.000	in	0.000	in	0.000	in

Average Size Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM3_HIP_X	-2.297	in	-2.297	in	0.000	in
POSTURE_DHM3_HIP_Z	17.030	in	17.030	in	0.000	in
POSTURE_DHM3_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM3_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM3_AHP_X	-26.344	in	-26.344	in	0.000	in
POSTURE_DHM3_AHP_Z	0.000	in	0.000	in	0.000	in

Widest Shoulders Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM4_HIP_X	-2.928	in	-2.928	in	0.000	in
POSTURE_DHM4_HIP_Z	15.949	in	15.949	in	0.000	in
POSTURE_DHM4_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM4_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM4_AHP_X	-28.151	in	-28.150	in	0.000	in
POSTURE_DHM4_AHP_Z	0.000	in	0.000	in	0.000	in

Longest Torso Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM5_HIP_X	-4.183	in	-4.183	in	0.000	in
POSTURE_DHM5_HIP_Z	15.418	in	15.418	in	0.000	in
POSTURE_DHM5_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM5_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM5_AHP_X	-28.403	in	-28.403	in	0.000	in
POSTURE_DHM5_AHP_Z	0.000	in	0.000	in	0.000	in

Longest Legs Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM6_HIP_X	-1.394	in	-1.394	in	0.000	in
POSTURE_DHM6_HIP_Z	16.191	in	16.191	in	0.000	in
POSTURE_DHM6_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM6_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM6_AHP_X	-28.579	in	-28.579	in	0.000	in
POSTURE_DHM6_AHP_Z	0.000	in	0.000	in	0.000	in

Large Overall Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM7_HIP_X	-2.831	in	-2.831	in	0.000	in
POSTURE_DHM7_HIP_Z	15.071	in	15.071	in	0.000	in
POSTURE_DHM7_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM7_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM7_AHP_X	-29.745	in	-29.745	in	0.000	in
POSTURE_DHM7_AHP_Z	0.000	in	0.000	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

Values in agreement

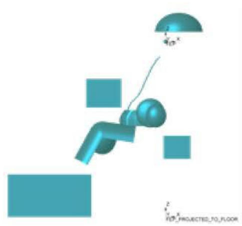
10.2.6 TEST #6 – NUMERICAL RESULTS

CUI

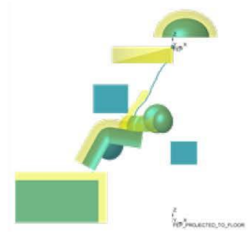
TEST #6: VARY ENSEMBLE

DEVCOM GROUND VEHICLE SYSTEMS CENTER

Test #	Target Accommodation	Fraction Male	Ensemble	Eye Point Height (in.)	HARP Measurement Tool	Hydration Pack Relief Availability	Remarks
6	90%	90%	ENC	43.3	SAE J826	No	Alternate ensembles

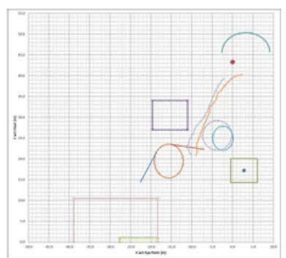


Basic Accommodation



Clearance (2.0 inches)

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:
0.005 inches
0.009 degrees

Manikin Placement:
0.000 inches

Values in agreement

DISTRIBUTION C. See first page. //CUI 33

CUI

TEST #6: RESULTS, ACCOMMODATION

DEVCOM GROUND VEHICLE SYSTEMS CENTER

Eye Point	UMTRI Value		GVSC Value		Difference	
EYE_POINT_X	0.000	in	0.000	in	0.000	in
EYE_POINT_Z	43.307	in	43.307	in	0.000	in

Seating Accommodation	UMTRI Value		GVSC Value		Difference	
SEATING_ACC_CTR_OF_TRAVEL_X	2.789	in	2.789	in	0.000	in
SEATING_ACC_CTR_OF_TRAVEL_Z	17.189	in	17.188	in	0.002	in
SEATING_ACC_FORE_AFT_TRAVEL	6.575	in	6.576	in	0.002	in
SEATING_ACC_VERTICAL_TRAVEL	5.745	in	5.744	in	0.001	in

Seat Back Angle	UMTRI Value		TARDEC Value		Difference	
SEAT_BACK_ANGLE_MEAN	22.333	deg	22.333	deg	0.000	deg
SEAT_BACK_ANGLE_RANGE	12.486	deg	12.495	deg	0.009	deg

Steering Position	UMTRI Value		GVSC Value		Difference	
STEERING_POS_CTR_OF_TRAVEL_X	-15.305	in	-15.305	in	0.000	in
STEERING_POS_CTR_OF_TRAVEL_Z	30.500	in	30.500	in	0.000	in
STEERING_POS_FORE_AFT_TRAVEL	8.617	in	8.619	in	0.002	in
STEERING_POS_VERTICAL_TRAVEL	7.030	in	7.031	in	0.001	in

Pedal Position	UMTRI Value		GVSC Value		Difference	
PEDAL_POS_CTR_OF_TRAVEL_X	-23.013	in	-23.014	in	0.001	in
PEDAL_POS_FORE_AFT_TRAVEL	9.331	in	9.335	in	0.004	in

Torso Boundary	UMTRI Value		GVSC Value		Difference	
TORSO_WEIGHTED_REF_PT_ENC_X	-10.229	in	-10.230	in	0.002	in
TORSO_WEIGHTED_REF_PT_ENC_Z	28.859	in	28.859	in	0.000	in
TORSO_ROTATION_WRT_HARP	-1.347	deg	-1.347	deg	0.000	deg

Helmet Boundary	UMTRI Value		GVSC Value		Difference	
HELMET_CONTOUR_CENTROID_X	3.246	in	3.246	in	0.000	in
HELMET_CONTOUR_CENTROID_Y (+/-)	2.185	in	2.185	in	0.000	in
HELMET_CONTOUR_CENTROID_Z	45.669	in	45.669	in	0.000	in
HELMET_CONTOUR_X_AXIS_LENGTH	11.703	in	11.704	in	0.001	in
HELMET_CONTOUR_Y_AXIS_LENGTH	10.228	in	10.228	in	0.000	in
HELMET_CONTOUR_Z_AXIS_LENGTH	9.427	in	9.429	in	0.001	in

Knee Boundary	UMTRI Value		GVSC Value		Difference	
KNEE_CONTOUR_WEIGHTED_CENT_X	-15.639	in	-15.639	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Y (+/	8.033	in	8.033	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Z	19.484	in	19.484	in	0.000	in
KNEE_CONTOUR_X_AXIS_LENGTH	7.020	in	7.023	in	0.002	in
KNEE_CONTOUR_Y_AXIS_LENGTH	9.175	in	9.178	in	0.003	in
KNEE_CONTOUR_Z_AXIS_LENGTH	8.099	in	8.103	in	0.004	in
KNEE_SHIN_ANGLE	28.671	deg	28.671	deg	0.000	deg
KNEE_THIGH_ANGLE	8.264	deg	8.268	deg	0.004	deg

Elbow Boundary Driver	UMTRI Value		GVSC Value		Difference	
ELBOW_CON_DYN_WEIGHTED_CENT_X	-3.776	in	-3.776	in	0.000	in
ELBOW_CON_DYN_WEIGHTED_CENT_Y	10.916	in	10.916	in	0.000	in
ELBOW_CON_DYN_WEIGHTED_CENT_Z	25.645	in	25.645	in	0.000	in
ELBOW_CON_DYN_X_AXIS_LENGTH	7.076	in	7.081	in	0.005	in
ELBOW_CON_DYN_Y_AXIS_LENGTH	2.835	in	2.836	in	0.002	in
ELBOW_CON_DYN_Z_AXIS_LENGTH	7.153	in	7.156	in	0.004	in

Elbow Boundary Non-Driver	UMTRI Value		GVSC Value		Difference	
ELBOW_CON_REST_WEIGHTED_CENT_X	-2.354	in	-2.354	in	0.000	in
ELBOW_CON_REST_WEIGHTED_CENT_Y	14.800	in	14.800	in	0.000	in
ELBOW_REST_DYN_WEIGHTED_CENT_Z	24.975	in	24.975	in	0.000	in
ELBOW_CON_REST_X_AXIS_LENGTH	4.996	in	5.000	in	0.004	in
ELBOW_CON_REST_Y_AXIS_LENGTH	3.683	in	3.684	in	0.001	in
ELBOW_REST_DYN_Z_AXIS_LENGTH	5.779	in	5.782	in	0.003	in

Boot Boundary	UMTRI Value		GVSC Value		Difference	
BOOT_CONTOUR_X_FRONT	-38.950	in	-38.953	in	0.003	in
BOOT_CONTOUR_X_REAR	-18.348	in	-18.346	in	0.002	in
BOOT_CONTOUR_Y_LATERAL	12.033	in	12.033	in	0.000	in
BOOT_CONTOUR_Z_TOP	10.481	in	10.481	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
0.009 degrees

Values in agreement

DISTRIBUTION C. See first page. //CUI 34

TEST #6: RESULTS, MANIKIN POSITIONING

Small Overall Female						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM1_HIP_X	3.230	in	3.230	in	0.000	in
POSTURE_DHM1_HIP_Z	20.011	in	20.011	in	0.000	in
POSTURE_DHM1_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM1_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM1_AHP_X	-17.829	in	-17.829	in	0.000	in
POSTURE_DHM1_AHP_Z	0.000	in	0.000	in	0.000	in

Small Overall Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM2_HIP_X	2.925	in	2.925	in	0.000	in
POSTURE_DHM2_HIP_Z	18.407	in	18.407	in	0.000	in
POSTURE_DHM2_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM2_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM2_AHP_X	-20.725	in	-20.725	in	0.000	in
POSTURE_DHM2_AHP_Z	0.000	in	0.000	in	0.000	in

Average Size Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM3_HIP_X	2.073	in	2.073	in	0.000	in
POSTURE_DHM3_HIP_Z	16.439	in	16.439	in	0.000	in
POSTURE_DHM3_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM3_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM3_AHP_X	-24.179	in	-24.179	in	0.000	in
POSTURE_DHM3_AHP_Z	0.000	in	0.000	in	0.000	in

Widest Shoulders Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM4_HIP_X	1.442	in	1.442	in	0.000	in
POSTURE_DHM4_HIP_Z	15.358	in	15.358	in	0.000	in
POSTURE_DHM4_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM4_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM4_AHP_X	-25.985	in	-25.985	in	0.000	in
POSTURE_DHM4_AHP_Z	0.000	in	0.000	in	0.000	in

Longest Torso Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM5_HIP_X	0.187	in	0.187	in	0.000	in
POSTURE_DHM5_HIP_Z	14.828	in	14.828	in	0.000	in
POSTURE_DHM5_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM5_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM5_AHP_X	-26.237	in	-26.237	in	0.000	in
POSTURE_DHM5_AHP_Z	0.000	in	0.000	in	0.000	in

Longest Legs Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM6_HIP_X	2.976	in	2.976	in	0.000	in
POSTURE_DHM6_HIP_Z	15.600	in	15.600	in	0.000	in
POSTURE_DHM6_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM6_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM6_AHP_X	-26.414	in	-26.414	in	0.000	in
POSTURE_DHM6_AHP_Z	0.000	in	0.000	in	0.000	in

Large Overall Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM7_HIP_X	1.539	in	1.539	in	0.000	in
POSTURE_DHM7_HIP_Z	14.480	in	14.480	in	0.000	in
POSTURE_DHM7_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM7_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM7_AHP_X	-27.580	in	-27.579	in	0.000	in
POSTURE_DHM7_AHP_Z	0.000	in	0.000	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

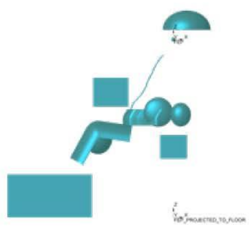
Values in agreement

10.2.7 TEST #7 – NUMERICAL RESULTS

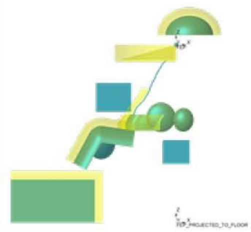
CUI

TEST #7: PROVIDE HYDRATION PACK RELIEF

Test #	Target Accommodation	Fraction Male	Ensemble	Eye Point Height (in.)	HARP Measurement Tool	Hydration Pack Relief Availability	Remarks
7	90%	90%	ENC	43.3	SAE J826	Yes	Presence of hydration pack relief

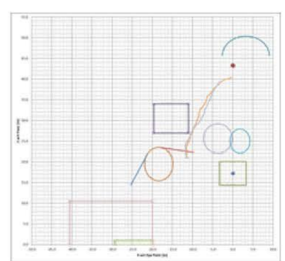


Basic Accommodation



Clearance (2.0 inches)

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:
0.005 inches
0.009 degrees

Manikin Placement:
0.000 inches

Values in agreement

DISTRIBUTION C. See first page. //CUI 37

CUI

TEST #7: RESULTS, ACCOMMODATION

Eye Point	UMTRI Value		GVSC Value		Difference	
EYE_POINT_X	0.000	in	0.000	in	0.000	in
EYE_POINT_Z	43.307	in	43.307	in	0.000	in

Seating Accommodation	UMTRI Value		GVSC Value		Difference	
SEATING_ACC_CTR_OF_TRAVEL_X	0.033	in	0.033	in	0.000	in
SEATING_ACC_CTR_OF_TRAVEL_Z	17.189	in	17.188	in	0.002	in
SEATING_ACC_FORE_AFT_TRAVEL	6.575	in	6.576	in	0.002	in
SEATING_ACC_VERTICAL_TRAVEL	5.745	in	5.744	in	0.001	in

Seat Back Angle	UMTRI Value		TARDEC Value		Difference	
SEAT_BACK_ANGLE_MEAN	20.433	deg	20.433	deg	0.000	deg
SEAT_BACK_ANGLE_RANGE	12.486	deg	12.495	deg	0.009	deg

Steering Position	UMTRI Value		GVSC Value		Difference	
STEERING_POS_CTR_OF_TRAVEL_X	-15.305	in	-15.305	in	0.000	in
STEERING_POS_CTR_OF_TRAVEL_Z	30.500	in	30.500	in	0.000	in
STEERING_POS_FORE_AFT_TRAVEL	8.617	in	8.619	in	0.002	in
STEERING_POS_VERTICAL_TRAVEL	7.030	in	7.031	in	0.001	in

Pedal Position	UMTRI Value		GVSC Value		Difference	
PEDAL_POS_CTR_OF_TRAVEL_X	-24.628	in	-24.628	in	0.001	in
PEDAL_POS_FORE_AFT_TRAVEL	9.331	in	9.335	in	0.004	in

Torso Boundary	UMTRI Value		GVSC Value		Difference	
TORSO_WEIGHTED_REF_PT_ENC_X	-11.256	in	-11.258	in	0.002	in
TORSO_WEIGHTED_REF_PT_ENC_Z	28.859	in	28.859	in	0.000	in
TORSO_ROTATION_WRT_HARP	-1.347	deg	-1.347	deg	0.000	deg

Helmet Boundary	UMTRI Value		GVSC Value		Difference	
HELMET_CONTOUR_CENTROID_X	3.246	in	3.246	in	0.000	in
HELMET_CONTOUR_CENTROID_Y (+/-)	2.185	in	2.185	in	0.000	in
HELMET_CONTOUR_CENTROID_Z	45.669	in	45.669	in	0.000	in
HELMET_CONTOUR_X_AXIS_LENGTH	11.703	in	11.704	in	0.001	in
HELMET_CONTOUR_Y_AXIS_LENGTH	10.228	in	10.228	in	0.000	in
HELMET_CONTOUR_Z_AXIS_LENGTH	9.427	in	9.429	in	0.001	in

Knee Boundary	UMTRI Value		GVSC Value		Difference	
KNEE_CONTOUR_WEIGHTED_CENT_X	-18.395	in	-18.395	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Y (+/	8.033	in	8.033	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Z	19.484	in	19.484	in	0.000	in
KNEE_CONTOUR_X_AXIS_LENGTH	7.020	in	7.023	in	0.002	in
KNEE_CONTOUR_Y_AXIS_LENGTH	9.175	in	9.178	in	0.003	in
KNEE_CONTOUR_Z_AXIS_LENGTH	8.099	in	8.103	in	0.004	in
KNEE_SHIN_ANGLE	28.671	deg	28.671	deg	0.000	deg
KNEE_THIGH_ANGLE	8.264	deg	8.268	deg	0.004	deg

Elbow Boundary Driver	UMTRI Value		GVSC Value		Difference	
ELBOW_CON_DYN_WEIGHTED_CENT_X	-3.697	in	-3.697	in	0.000	in
ELBOW_CON_DYN_WEIGHTED_CENT_Y	10.916	in	10.916	in	0.000	in
ELBOW_CON_DYN_WEIGHTED_CENT_Z	25.645	in	25.645	in	0.000	in
ELBOW_CON_DYN_X_AXIS_LENGTH	7.076	in	7.081	in	0.005	in
ELBOW_CON_DYN_Y_AXIS_LENGTH	2.835	in	2.836	in	0.002	in
ELBOW_CON_DYN_Z_AXIS_LENGTH	7.153	in	7.156	in	0.004	in

Elbow Boundary Non-Driver	UMTRI Value		GVSC Value		Difference	
ELBOW_CON_REST_WEIGHTED_CENT_X	1.783	in	1.783	in	0.000	in
ELBOW_CON_REST_WEIGHTED_CENT_Y	14.759	in	14.759	in	0.000	in
ELBOW_REST_DYN_WEIGHTED_CENT_Z	25.029	in	25.029	in	0.000	in
ELBOW_CON_REST_X_AXIS_LENGTH	4.996	in	5.000	in	0.004	in
ELBOW_CON_REST_Y_AXIS_LENGTH	3.683	in	3.684	in	0.001	in
ELBOW_REST_DYN_Z_AXIS_LENGTH	5.779	in	5.782	in	0.003	in

Boot Boundary	UMTRI Value		GVSC Value		Difference	
BOOT_CONTOUR_X_FRONT	-40.564	in	-40.567	in	0.003	in
BOOT_CONTOUR_X_REAR	-19.962	in	-19.960	in	0.002	in
BOOT_CONTOUR_Y_LATERAL	12.033	in	12.033	in	0.000	in
BOOT_CONTOUR_Z_TOP	10.481	in	10.481	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
0.009 degrees

Values in agreement

DISTRIBUTION C. See first page. //CUI 38

TEST #7: RESULTS, MANIKIN POSITIONING

Small Overall Female						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM1_HIP_X	0.474	in	0.474	in	0.000	in
POSTURE_DHM1_HIP_Z	20.287	in	20.287	in	0.000	in
POSTURE_DHM1_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM1_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM1_AHP_X	-19.443	in	-19.443	in	0.000	in
POSTURE_DHM1_AHP_Z	0.000	in	0.000	in	0.000	in

Small Overall Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM2_HIP_X	0.169	in	0.169	in	0.000	in
POSTURE_DHM2_HIP_Z	18.683	in	18.683	in	0.000	in
POSTURE_DHM2_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM2_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM2_AHP_X	-22.339	in	-22.339	in	0.000	in
POSTURE_DHM2_AHP_Z	0.000	in	0.000	in	0.000	in

Average Size Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM3_HIP_X	-0.683	in	-0.683	in	0.000	in
POSTURE_DHM3_HIP_Z	16.715	in	16.715	in	0.000	in
POSTURE_DHM3_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM3_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM3_AHP_X	-25.793	in	-25.793	in	0.000	in
POSTURE_DHM3_AHP_Z	0.000	in	0.000	in	0.000	in

Widest Shoulders Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM4_HIP_X	-1.314	in	-1.314	in	0.000	in
POSTURE_DHM4_HIP_Z	15.634	in	15.634	in	0.000	in
POSTURE_DHM4_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM4_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM4_AHP_X	-27.599	in	-27.599	in	0.000	in
POSTURE_DHM4_AHP_Z	0.000	in	0.000	in	0.000	in

Longest Torso Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM5_HIP_X	-2.569	in	-2.569	in	0.000	in
POSTURE_DHM5_HIP_Z	15.103	in	15.103	in	0.000	in
POSTURE_DHM5_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM5_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM5_AHP_X	-27.852	in	-27.852	in	0.000	in
POSTURE_DHM5_AHP_Z	0.000	in	0.000	in	0.000	in

Longest Legs Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM6_HIP_X	0.220	in	0.221	in	0.000	in
POSTURE_DHM6_HIP_Z	15.876	in	15.876	in	0.000	in
POSTURE_DHM6_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM6_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM6_AHP_X	-28.028	in	-28.028	in	0.000	in
POSTURE_DHM6_AHP_Z	0.000	in	0.000	in	0.000	in

Large Overall Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM7_HIP_X	-1.217	in	-1.217	in	0.000	in
POSTURE_DHM7_HIP_Z	14.756	in	14.756	in	0.000	in
POSTURE_DHM7_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM7_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM7_AHP_X	-29.194	in	-29.194	in	0.000	in
POSTURE_DHM7_AHP_Z	0.000	in	0.000	in	0.000	in

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

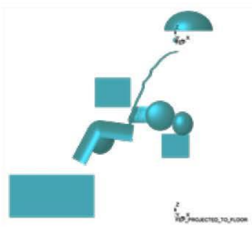
Largest Observed Differences:
0.004 inches

Values in agreement

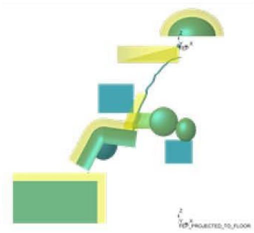
10.2.8 TEST #8 – NUMERICAL RESULTS

Test #8: Provide Hydration Pack Relief

Test #	Target Accommodation	Fraction Male	Ensemble	Eye Point Height (in.)	HARP Measurement Tool	Hydration Pack Relief Availability	Remarks
8	90%	90%	PPE	43.3	SAE J826	Yes	Presence of hydration pack relief

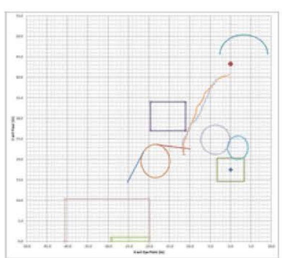


Basic Accommodation



Clearance (2.0 inches)

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:
0.005 inches
0.009 degrees

Manikin Placement:
0.000 inches

Values in agreement

Test #8: Results, Accommodation

Eye Point	UMTRI Value		GVSC Value		Difference	
EYE_POINT_X	0.000	in	0.000	in	0.000	in
EYE_POINT_Z	43.307	in	43.307	in	0.000	in

Seating Accommodation	UMTRI Value		GVSC Value		Difference	
SEATING_ACC_CTR_OF_TRAVEL_X	0.033	in	0.033	in	0.000	in
SEATING_ACC_CTR_OF_TRAVEL_Z	17.465	in	17.463	in	0.002	in
SEATING_ACC_FORE_AFT_TRAVEL	6.575	in	6.576	in	0.002	in
SEATING_ACC_VERTICAL_TRAVEL	5.746	in	5.744	in	0.002	in

Seat Back Angle	UMTRI Value		TARDEC Value		Difference	
SEAT_BACK_ANGLE_MEAN	20.433	deg	20.433	deg	0.000	deg
SEAT_BACK_ANGLE_RANGE	12.486	deg	12.495	deg	0.009	deg

Steering Position	UMTRI Value		GVSC Value		Difference	
STEERING_POS_CTR_OF_TRAVEL_X	-15.305	in	-15.305	in	0.000	in
STEERING_POS_CTR_OF_TRAVEL_Z	30.500	in	30.500	in	0.000	in
STEERING_POS_FORE_AFT_TRAVEL	8.617	in	8.619	in	0.002	in
STEERING_POS_VERTICAL_TRAVEL	7.030	in	7.031	in	0.001	in

Pedal Position	UMTRI Value		GVSC Value		Difference	
PEDAL_POS_CTR_OF_TRAVEL_X	-24.556	in	-24.557	in	0.001	in
PEDAL_POS_FORE_AFT_TRAVEL	9.331	in	9.335	in	0.005	in

Torso Boundary	UMTRI Value		GVSC Value		Difference	
TORSO_WEIGHTED_REF_PT_PPE_X	-6.210	in	-6.212	in	0.002	in
TORSO_WEIGHTED_REF_PT_PPE_Z	34.666	in	34.666	in	0.000	in
TORSO_ROTATION_WRT_HARP	-1.347	deg	-1.347	deg	0.000	deg

Helmet Boundary	UMTRI Value		GVSC Value		Difference	
HELMET_CONTOUR_CENTROID_X	3.246	in	3.246	in	0.000	in
HELMET_CONTOUR_CENTROID_Y (+/-)	2.185	in	2.185	in	0.000	in
HELMET_CONTOUR_CENTROID_Z	45.669	in	45.669	in	0.000	in
HELMET_CONTOUR_X_AXIS_LENGTH	11.703	in	11.704	in	0.001	in
HELMET_CONTOUR_Y_AXIS_LENGTH	10.228	in	10.228	in	0.000	in
HELMET_CONTOUR_Z_AXIS_LENGTH	9.427	in	9.429	in	0.001	in

Knee Boundary	UMTRI Value		GVSC Value		Difference	
KNEE_CONTOUR_WEIGHTED_CENT_X	-18.395	in	-18.395	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Y (+/	8.033	in	8.033	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Z	19.570	in	19.570	in	0.000	in
KNEE_CONTOUR_X_AXIS_LENGTH	6.996	in	6.999	in	0.002	in
KNEE_CONTOUR_Y_AXIS_LENGTH	9.175	in	9.178	in	0.003	in
KNEE_CONTOUR_Z_AXIS_LENGTH	8.132	in	8.136	in	0.004	in
KNEE_SHIN_ANGLE	28.104	deg	28.104	deg	0.000	deg
KNEE_THIGH_ANGLE	7.627	deg	7.631	deg	0.004	deg

Elbow Boundary Driver	UMTRI Value		GVSC Value		Difference	
ELBOW_CON_DYN_WEIGHTED_CENT_X	-3.697	in	-3.697	in	0.000	in
ELBOW_CON_DYN_WEIGHTED_CENT_Y	10.522	in	10.522	in	0.000	in
ELBOW_CON_DYN_WEIGHTED_CENT_Z	24.818	in	24.818	in	0.000	in
ELBOW_CON_DYN_X_AXIS_LENGTH	7.076	in	7.081	in	0.005	in
ELBOW_CON_DYN_Y_AXIS_LENGTH	2.835	in	2.836	in	0.002	in
ELBOW_CON_DYN_Z_AXIS_LENGTH	7.153	in	7.156	in	0.004	in

Elbow Boundary Non-Driver	UMTRI Value		GVSC Value		Difference	
ELBOW_CON_REST_WEIGHTED_CENT_X	1.783	in	1.783	in	0.000	in
ELBOW_CON_REST_WEIGHTED_CENT_Y	12.526	in	12.526	in	0.000	in
ELBOW_REST_DYN_WEIGHTED_CENT_Z	22.856	in	22.856	in	0.000	in
ELBOW_CON_REST_X_AXIS_LENGTH	4.996	in	5.000	in	0.004	in
ELBOW_CON_REST_Y_AXIS_LENGTH	3.683	in	3.684	in	0.001	in
ELBOW_REST_DYN_Z_AXIS_LENGTH	5.779	in	5.782	in	0.003	in

Boot Boundary	UMTRI Value		GVSC Value		Difference	
BOOT_CONTOUR_X_FRONT	-40.553	in	-40.556	in	0.003	in
BOOT_CONTOUR_X_REAR	-19.891	in	-19.889	in	0.002	in
BOOT_CONTOUR_Y_LATERAL	12.033	in	12.033	in	0.000	in
BOOT_CONTOUR_Z_TOP	10.392	in	10.393	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
0.009 degrees

Values in agreement

TEST #8: RESULTS, MANIKIN POSITIONING

Small Overall Female						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM1_HIP_X	0.474	in	0.474	in	0.000	in
POSTURE_DHM1_HIP_Z	20.287	in	20.287	in	0.000	in
POSTURE_DHM1_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM1_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM1_AHP_X	-19.443	in	-19.443	in	0.000	in
POSTURE_DHM1_AHP_Z	0.000	in	0.000	in	0.000	in

Small Overall Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM2_HIP_X	0.169	in	0.169	in	0.000	in
POSTURE_DHM2_HIP_Z	18.683	in	18.683	in	0.000	in
POSTURE_DHM2_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM2_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM2_AHP_X	-22.339	in	-22.339	in	0.000	in
POSTURE_DHM2_AHP_Z	0.000	in	0.000	in	0.000	in

Average Size Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM3_HIP_X	-0.683	in	-0.683	in	0.000	in
POSTURE_DHM3_HIP_Z	16.715	in	16.715	in	0.000	in
POSTURE_DHM3_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM3_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM3_AHP_X	-25.793	in	-25.793	in	0.000	in
POSTURE_DHM3_AHP_Z	0.000	in	0.000	in	0.000	in

Widest Shoulders Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM4_HIP_X	-1.314	in	-1.314	in	0.000	in
POSTURE_DHM4_HIP_Z	15.634	in	15.634	in	0.000	in
POSTURE_DHM4_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM4_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM4_AHP_X	-27.599	in	-27.599	in	0.000	in
POSTURE_DHM4_AHP_Z	0.000	in	0.000	in	0.000	in

Longest Torso Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM5_HIP_X	-2.569	in	-2.569	in	0.000	in
POSTURE_DHM5_HIP_Z	15.103	in	15.103	in	0.000	in
POSTURE_DHM5_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM5_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM5_AHP_X	-27.852	in	-27.852	in	0.000	in
POSTURE_DHM5_AHP_Z	0.000	in	0.000	in	0.000	in

Longest Legs Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM6_HIP_X	0.220	in	0.221	in	0.000	in
POSTURE_DHM6_HIP_Z	15.876	in	15.876	in	0.000	in
POSTURE_DHM6_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM6_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM6_AHP_X	-28.028	in	-28.028	in	0.000	in
POSTURE_DHM6_AHP_Z	0.000	in	0.000	in	0.000	in

Large Overall Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM7_HIP_X	-1.217	in	-1.217	in	0.000	in
POSTURE_DHM7_HIP_Z	14.756	in	14.756	in	0.000	in
POSTURE_DHM7_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM7_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM7_AHP_X	-29.194	in	-29.194	in	0.000	in
POSTURE_DHM7_AHP_Z	0.000	in	0.000	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

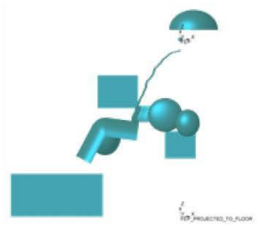
Values in agreement

10.2.9 TEST #9 – NUMERICAL RESULTS

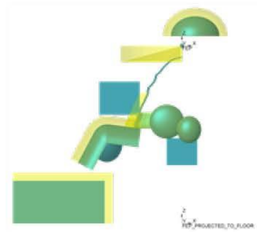
CUI

TEST #9: VARY TARGET ACCOMMODATION

Test #	Target Accommodation	Fraction Male	Ensemble	Eye Point Height (in.)	HARP Measurement Tool	Hydration Pack Relief Availability	Remarks
9	95%	90%	PPE	43.3	SAE J826	No	Increase accommodation level

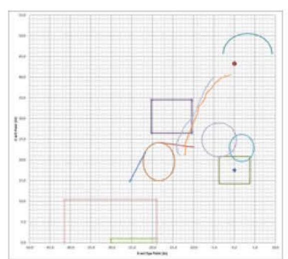


Basic Accommodation



Clearance (2.0 inches)

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:
0.010 inches
0.004 degrees

Manikin Placement:
0.000 inches

Values in agreement

DISTRIBUTION C. See first page. //CUI 45

CUI

TEST #9: RESULTS, ACCOMMODATION

Eye Point	UMTRI Value	GVSC Value	Difference
EYE_POINT_X	0.000 in	0.000 in	0.000 in
EYE_POINT_Z	43.307 in	43.307 in	0.000 in

Seating Accommodation	UMTRI Value	GVSC Value	Difference
SEATING_ACC_CTR_OF_TRAVEL_X	0.033 in	0.033 in	0.000 in
SEATING_ACC_CTR_OF_TRAVEL_Z	17.502 in	17.500 in	0.002 in
SEATING_ACC_FORE_AFT_TRAVEL	7.545 in	7.538 in	0.007 in
SEATING_ACC_VERTICAL_TRAVEL	6.612 in	6.604 in	0.008 in

Seat Back Angle	UMTRI Value	TARDEC Value	Difference
SEAT_BACK_ANGLE_MEAN	20.432 deg	20.432 deg	0.000 deg
SEAT_BACK_ANGLE_RANGE	14.878 deg	14.881 deg	0.003 deg

Steering Position	UMTRI Value	GVSC Value	Difference
STEERING_POS_CTR_OF_TRAVEL_X	-15.302 in	-15.303 in	0.000 in
STEERING_POS_CTR_OF_TRAVEL_Z	30.505 in	30.505 in	0.000 in
STEERING_POS_FORE_AFT_TRAVEL	9.890 in	9.880 in	0.010 in
STEERING_POS_VERTICAL_TRAVEL	8.069 in	8.061 in	0.008 in

Pedal Position	UMTRI Value	GVSC Value	Difference
PEDAL_POS_CTR_OF_TRAVEL_X	-24.525 in	-24.526 in	0.002 in
PEDAL_POS_FORE_AFT_TRAVEL	11.133 in	11.132 in	0.001 in

Torso Boundary	UMTRI Value	GVSC Value	Difference
TORSO_WEIGHTED_REF_PT_PPE_X	-6.714 in	-6.714 in	0.001 in
TORSO_WEIGHTED_REF_PT_PPE_Z	34.666 in	34.666 in	0.000 in
TORSO_ROTATION_WRT_HARP	-1.347 deg	-1.347 deg	0.000 deg

Helmet Boundary	UMTRI Value	GVSC Value	Difference
HELMET_CONTOUR_CENTROID_X	3.246 in	3.246 in	0.000 in
HELMET_CONTOUR_CENTROID_Y (+/-)	2.185 in	2.185 in	0.000 in
HELMET_CONTOUR_CENTROID_Z	45.669 in	45.669 in	0.000 in
HELMET_CONTOUR_X_AXIS_LENGTH	11.914 in	11.914 in	0.000 in
HELMET_CONTOUR_Y_AXIS_LENGTH	10.228 in	10.228 in	0.000 in
HELMET_CONTOUR_Z_AXIS_LENGTH	9.698 in	9.698 in	0.000 in

Knee Boundary	UMTRI Value	GVSC Value	Difference
KNEE_CONTOUR_WEIGHTED_CENT_X	-18.395 in	-18.395 in	0.000 in
KNEE_CONTOUR_WEIGHTED_CENT_Y (+/	8.033 in	8.033 in	0.000 in
KNEE_CONTOUR_WEIGHTED_CENT_Z	19.570 in	19.570 in	0.000 in
KNEE_CONTOUR_X_AXIS_LENGTH	7.675 in	7.677 in	0.001 in
KNEE_CONTOUR_Y_AXIS_LENGTH	10.093 in	10.094 in	0.001 in
KNEE_CONTOUR_Z_AXIS_LENGTH	9.223 in	9.224 in	0.001 in
KNEE_SHIN_ANGLE	28.104 deg	28.104 deg	0.000 deg
KNEE_THIGH_ANGLE	7.540 deg	7.544 deg	0.004 deg

Elbow Boundary Driver	UMTRI Value	GVSC Value	Difference
ELBOW_CON_DYN_WEIGHTED_CENT_X	-3.697 in	-3.697 in	0.000 in
ELBOW_CON_DYN_WEIGHTED_CENT_Y	10.522 in	10.522 in	0.000 in
ELBOW_CON_DYN_WEIGHTED_CENT_Z	24.818 in	24.818 in	0.000 in
ELBOW_CON_DYN_X_AXIS_LENGTH	8.431 in	8.434 in	0.002 in
ELBOW_CON_DYN_Y_AXIS_LENGTH	3.381 in	3.381 in	0.000 in
ELBOW_CON_DYN_Z_AXIS_LENGTH	8.243 in	8.245 in	0.002 in

Elbow Boundary Non-Driver	UMTRI Value	GVSC Value	Difference
ELBOW_CON_REST_WEIGHTED_CENT_X	1.783 in	1.783 in	0.000 in
ELBOW_CON_REST_WEIGHTED_CENT_Y	12.526 in	12.526 in	0.000 in
ELBOW_REST_DYN_WEIGHTED_CENT_Z	22.856 in	22.856 in	0.000 in
ELBOW_CON_REST_X_AXIS_LENGTH	5.953 in	5.955 in	0.002 in
ELBOW_CON_REST_Y_AXIS_LENGTH	4.409 in	4.407 in	0.001 in
ELBOW_REST_DYN_Z_AXIS_LENGTH	6.624 in	6.625 in	0.001 in

Boot Boundary	UMTRI Value	GVSC Value	Difference
BOOT_CONTOUR_X_FRONT	-41.422 in	-41.424 in	0.002 in
BOOT_CONTOUR_X_REAR	-18.958 in	-18.960 in	0.002 in
BOOT_CONTOUR_Y_LATERAL	12.033 in	12.033 in	0.000 in
BOOT_CONTOUR_Z_TOP	10.392 in	10.393 in	0.000 in

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

Largest Observed Differences:
0.010 inches
0.004 degrees

Values in agreement

DISTRIBUTION C. See first page. //CUI 46

TEST #9: RESULTS, MANIKIN POSITIONING

DEVCOM GROUND VEHICLE SYSTEMS CENTER

Small Overall Female	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM1_HIP_X	0.474	in	0.474	in	0.000	in
POSTURE_DHM1_HIP_Z	20.287	in	20.287	in	0.000	in
POSTURE_DHM1_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM1_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM1_AHP_X	-19.443	in	-19.443	in	0.000	in
POSTURE_DHM1_AHP_Z	0.000	in	0.000	in	0.000	in

Small Overall Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM2_HIP_X	0.169	in	0.169	in	0.000	in
POSTURE_DHM2_HIP_Z	18.683	in	18.683	in	0.000	in
POSTURE_DHM2_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM2_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM2_AHP_X	-22.339	in	-22.339	in	0.000	in
POSTURE_DHM2_AHP_Z	0.000	in	0.000	in	0.000	in

Average Size Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM3_HIP_X	-0.683	in	-0.683	in	0.000	in
POSTURE_DHM3_HIP_Z	16.715	in	16.715	in	0.000	in
POSTURE_DHM3_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM3_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM3_AHP_X	-25.793	in	-25.793	in	0.000	in
POSTURE_DHM3_AHP_Z	0.000	in	0.000	in	0.000	in

Widest Shoulders Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM4_HIP_X	-1.314	in	-1.314	in	0.000	in
POSTURE_DHM4_HIP_Z	15.634	in	15.634	in	0.000	in
POSTURE_DHM4_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM4_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM4_AHP_X	-27.599	in	-27.599	in	0.000	in
POSTURE_DHM4_AHP_Z	0.000	in	0.000	in	0.000	in

Longest Torso Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM5_HIP_X	-2.569	in	-2.569	in	0.000	in
POSTURE_DHM5_HIP_Z	15.103	in	15.103	in	0.000	in
POSTURE_DHM5_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM5_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM5_AHP_X	-27.852	in	-27.852	in	0.000	in
POSTURE_DHM5_AHP_Z	0.000	in	0.000	in	0.000	in

Longest Legs Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM6_HIP_X	0.220	in	0.221	in	0.000	in
POSTURE_DHM6_HIP_Z	15.876	in	15.876	in	0.000	in
POSTURE_DHM6_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM6_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM6_AHP_X	-28.028	in	-28.028	in	0.000	in
POSTURE_DHM6_AHP_Z	0.000	in	0.000	in	0.000	in

Large Overall Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM7_HIP_X	-1.217	in	-1.217	in	0.000	in
POSTURE_DHM7_HIP_Z	14.756	in	14.756	in	0.000	in
POSTURE_DHM7_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM7_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM7_AHP_X	-29.194	in	-29.194	in	0.000	in
POSTURE_DHM7_AHP_Z	0.000	in	0.000	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

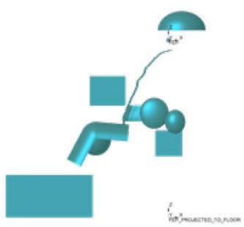
Values in agreement

10.2.10 TEST #10 – NUMERICAL RESULTS

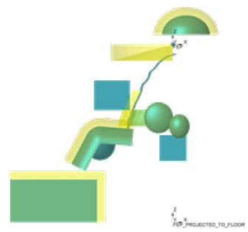
CUI

TEST #10: VARY GENDER MIX

Test #	Target Accommodation	Fraction Male	Ensemble	Eye Point Height (in.)	HARP Measurement Tool	Hydration Pack Relief Availability	Remarks
10	90%	50%	PPE	43.3	SAE J826	No	Reduce males in population

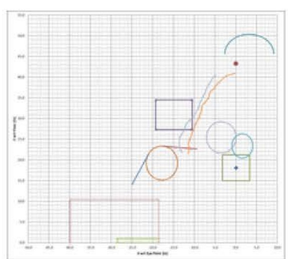


Basic Accommodation



Clearance (2.0 inches)

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:
0.005 inches
0.008 degrees

Manikin Placement:
0.000 inches

Values in agreement

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TEST #10: RESULTS, ACCOMMODATION

Eye Point	UMTRI Value		GVSC Value		Difference	
EYE_POINT_X	0.000	in	0.000	in	0.000	in
EYE_POINT_Z	43.307	in	43.307	in	0.000	in

Seating Accommodation	UMTRI Value		GVSC Value		Difference	
SEATING_ACC_CTR_OF_TRAVEL_X	0.078	in	0.077	in	0.000	in
SEATING_ACC_CTR_OF_TRAVEL_Z	18.093	in	18.093	in	0.000	in
SEATING_ACC_FORE_AFT_TRAVEL	6.576	in	6.578	in	0.002	in
SEATING_ACC_VERTICAL_TRAVEL	6.288	in	6.288	in	0.000	in

Seat Back Angle	UMTRI Value		TARDEC Value		Difference	
SEAT_BACK_ANGLE_MEAN	20.066	deg	20.066	deg	0.000	deg
SEAT_BACK_ANGLE_RANGE	12.552	deg	12.560	deg	0.008	deg

Steering Position	UMTRI Value		GVSC Value		Difference	
STEERING_POS_CTR_OF_TRAVEL_X	-14.887	in	-14.887	in	0.000	in
STEERING_POS_CTR_OF_TRAVEL_Z	30.914	in	30.914	in	0.000	in
STEERING_POS_FORE_AFT_TRAVEL	8.755	in	8.756	in	0.001	in
STEERING_POS_VERTICAL_TRAVEL	7.206	in	7.207	in	0.000	in

Pedal Position	UMTRI Value		GVSC Value		Difference	
PEDAL_POS_CTR_OF_TRAVEL_X	-23.526	in	-23.525	in	0.000	in
PEDAL_POS_FORE_AFT_TRAVEL	9.959	in	9.960	in	0.001	in

Torso Boundary	UMTRI Value		GVSC Value		Difference	
TORSO_WEIGHTED_REF_PT_PPE_X	-6.062	in	-6.064	in	0.002	in
TORSO_WEIGHTED_REF_PT_PPE_Z	34.984	in	34.984	in	0.000	in
TORSO_ROTATION_WRT_HARP	-1.460	deg	-1.460	deg	0.000	deg

Helmet Boundary	UMTRI Value		GVSC Value		Difference	
HELMET_CONTOUR_CENTROID_X	3.246	in	3.246	in	0.000	in
HELMET_CONTOUR_CENTROID_Y (+/-)	2.185	in	2.185	in	0.000	in
HELMET_CONTOUR_CENTROID_Z	45.669	in	45.669	in	0.000	in
HELMET_CONTOUR_X_AXIS_LENGTH	11.703	in	11.704	in	0.001	in
HELMET_CONTOUR_Y_AXIS_LENGTH	10.228	in	10.228	in	0.000	in
HELMET_CONTOUR_Z_AXIS_LENGTH	9.427	in	9.429	in	0.001	in

Knee Boundary	UMTRI Value		GVSC Value		Difference	
KNEE_CONTOUR_WEIGHTED_CENT_X	-17.800	in	-17.800	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Y (+/	7.537	in	7.537	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Z	19.230	in	19.230	in	0.000	in
KNEE_CONTOUR_X_AXIS_LENGTH	7.558	in	7.558	in	0.000	in
KNEE_CONTOUR_Y_AXIS_LENGTH	9.455	in	9.456	in	0.001	in
KNEE_CONTOUR_Z_AXIS_LENGTH	8.225	in	8.227	in	0.003	in
KNEE_SHIN_ANGLE	28.104	deg	28.104	deg	0.000	deg
KNEE_THIGH_ANGLE	4.817	deg	4.817	deg	0.000	deg

Elbow Boundary Driver	UMTRI Value		GVSC Value		Difference	
ELBOW_CON_DYN_WEIGHTED_CENT_X	-3.495	in	-3.495	in	0.000	in
ELBOW_CON_DYN_WEIGHTED_CENT_Y	10.293	in	10.293	in	0.000	in
ELBOW_CON_DYN_WEIGHTED_CENT_Z	25.452	in	25.452	in	0.000	in
ELBOW_CON_DYN_X_AXIS_LENGTH	7.088	in	7.093	in	0.005	in
ELBOW_CON_DYN_Y_AXIS_LENGTH	2.891	in	2.893	in	0.001	in
ELBOW_CON_DYN_Z_AXIS_LENGTH	7.555	in	7.556	in	0.001	in

Elbow Boundary Non-Driver	UMTRI Value		GVSC Value		Difference	
ELBOW_CON_REST_WEIGHTED_CENT_X	1.608	in	1.608	in	0.000	in
ELBOW_CON_REST_WEIGHTED_CENT_Y	12.072	in	12.072	in	0.000	in
ELBOW_REST_DYN_WEIGHTED_CENT_Z	23.377	in	23.377	in	0.000	in
ELBOW_CON_REST_X_AXIS_LENGTH	5.006	in	5.009	in	0.003	in
ELBOW_CON_REST_Y_AXIS_LENGTH	3.857	in	3.857	in	0.000	in
ELBOW_REST_DYN_Z_AXIS_LENGTH	5.843	in	5.845	in	0.002	in

Boot Boundary	UMTRI Value		GVSC Value		Difference	
BOOT_CONTOUR_X_FRONT	-39.837	in	-39.837	in	0.001	in
BOOT_CONTOUR_X_REAR	-18.546	in	-18.545	in	0.001	in
BOOT_CONTOUR_Y_LATERAL	11.537	in	11.537	in	0.000	in
BOOT_CONTOUR_Z_TOP	10.392	in	10.393	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
0.008 degrees

Values in agreement

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TEST #10: RESULTS, MANIKIN POSITIONING

Small Overall Female						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM1_HIP_X	0.474	in	0.474	in	0.000	in
POSTURE_DHM1_HIP_Z	20.287	in	20.287	in	0.000	in
POSTURE_DHM1_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM1_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM1_AHP_X	-19.443	in	-19.443	in	0.000	in
POSTURE_DHM1_AHP_Z	0.000	in	0.000	in	0.000	in

Small Overall Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM2_HIP_X	0.169	in	0.169	in	0.000	in
POSTURE_DHM2_HIP_Z	18.683	in	18.683	in	0.000	in
POSTURE_DHM2_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM2_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM2_AHP_X	-22.339	in	-22.339	in	0.000	in
POSTURE_DHM2_AHP_Z	0.000	in	0.000	in	0.000	in

Average Size Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM3_HIP_X	-0.683	in	-0.683	in	0.000	in
POSTURE_DHM3_HIP_Z	16.715	in	16.715	in	0.000	in
POSTURE_DHM3_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM3_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM3_AHP_X	-25.793	in	-25.793	in	0.000	in
POSTURE_DHM3_AHP_Z	0.000	in	0.000	in	0.000	in

Widest Shoulders Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM4_HIP_X	-1.314	in	-1.314	in	0.000	in
POSTURE_DHM4_HIP_Z	15.634	in	15.634	in	0.000	in
POSTURE_DHM4_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM4_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM4_AHP_X	-27.599	in	-27.599	in	0.000	in
POSTURE_DHM4_AHP_Z	0.000	in	0.000	in	0.000	in

Longest Torso Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM5_HIP_X	-2.569	in	-2.569	in	0.000	in
POSTURE_DHM5_HIP_Z	15.103	in	15.103	in	0.000	in
POSTURE_DHM5_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM5_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM5_AHP_X	-27.852	in	-27.852	in	0.000	in
POSTURE_DHM5_AHP_Z	0.000	in	0.000	in	0.000	in

Longest Legs Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM6_HIP_X	0.220	in	0.221	in	0.000	in
POSTURE_DHM6_HIP_Z	15.876	in	15.876	in	0.000	in
POSTURE_DHM6_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM6_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM6_AHP_X	-28.028	in	-28.028	in	0.000	in
POSTURE_DHM6_AHP_Z	0.000	in	0.000	in	0.000	in

Large Overall Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM7_HIP_X	-1.217	in	-1.217	in	0.000	in
POSTURE_DHM7_HIP_Z	14.756	in	14.756	in	0.000	in
POSTURE_DHM7_EYE_X	0.000	in	0.000	in	0.000	in
POSTURE_DHM7_EYE_Z	43.307	in	43.307	in	0.000	in
POSTURE_DHM7_AHP_X	-29.194	in	-29.194	in	0.000	in
POSTURE_DHM7_AHP_Z	0.000	in	0.000	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

Values in agreement

10.3 APPENDIX C – REFERENCES

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10.4 APPENDIX D – ACRONYMS

ACH	Advanced Combat Helmet
ACT	Advanced Concepts Team
ACU	Advanced Combat Uniform
ANSUR	Army Anthropometric Survey
ARV	Armored Reconnaissance Vehicle
CAD	Computer-Aided Design
CDF	Comulative Distribution Function
COTS	Commercial Off-The-Shelf
CSI	Center for System Integration
CVP	Combat Vehicle Prototyping
DAC	Data and Analysis Center
EMD	Engineering Manufacturing and Development
ENC	Encumbered
ESAPI	Enhanced Small Arms Protective Insert
ESBI	Enhanced Side Ballistic Inserts
FEP	Fixed Eye Point
GCES	Ground Combat Element Systems
GVSC	Ground Vehicle Systems Center
GVSP	Ground Vehicle Survivability and Protection
HARP	Human Accommodation Reference Point
HFE	Human Factors Engineering
HSI	Human Systems Integration
IOTV	Improved Outer Tactical Vest
MCoE	Maneuver Center of Excellence
MCSC	Marine Corps Systems Command
MERS	Marine Expeditionary Rifle Squad
MS	Milestone
M&S	Modeling and Simulation
OMT	Optionally Manned Tank
PPE	Personal Protective Equipment
SIP	Seat Index Point
SME	Subject Matter Experts
TAP	Tactical Assault Panel
UMTRI	University of Michigan Transportation Research Institute
USMC	U.S. Marine Corps

10.5 APPENDIX E – DISTRIBUTION LIST

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10.6 APPENDIX F – VERIFICATION PLAN

The *Fixed Eye Point (FEP) CAD Accommodation Model Verification Plan* (2020) 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. (2020). U.S. Army DEVCOM Ground Vehicle Systems Center (GVSC) Fixed Eye Point CAD Accommodation Model Verification Plan 16Dec2020v1. http://www.usarmygvsc.com/index.php/accommodation-models/. U.S. Army DEVCOM GVSC, Warren, MI.