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14. ABSTRACT

Military ground vehicles are currently designed using requirements from MIL-STD-1472G, 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- 1472G (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 PLAN 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) 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). Direct vision zones have been added based on MIL-STD-1472 and SAE Recommended Practice J1050. The FEP 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 compatible formats for assessment and perform detailed human figure modeling.

The FEP CAD accommodation model verification effort will produce a verification report that captures the results of the activities completed as described in this plan. Any areas that do not meet the defined verification acceptability requirements will be reviewed and an action item will be assigned to correct the issue. The verification report will be signed off by the model developers along with the respective Verification and Validation (V&V) SMEs.

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, 2012). 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) accommodation model, Figure 1.

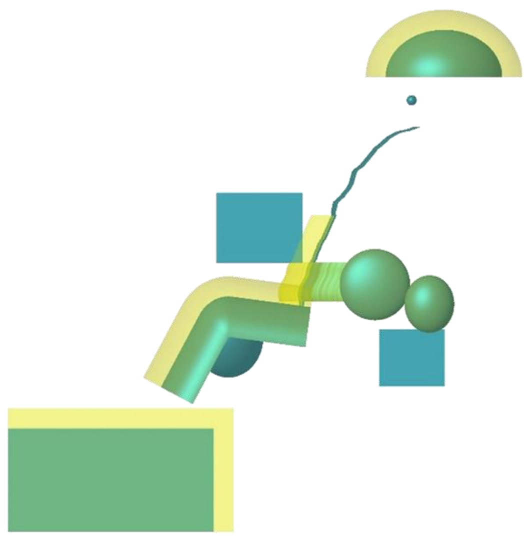

Figure 1: Fixed Eye Point (FEP) CAD Accommodation Model

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 is intended to provide the composite boundaries representing the body of the defined user population, including the effects of body size, 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).

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), 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 ANSUR 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.

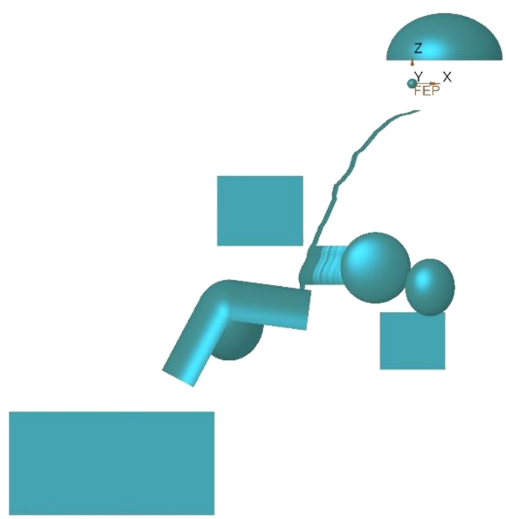

Figure 2: Eye Point Example for the FEP CAD Model

2.3.2 MODEL INPUTS

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

Table 1: Fixed Seat: Non-Driver Accommodation Model Inputs

Target Accommodation	The percentage of the target design population to be accommodated. The occupants not accommodated are evenly split between the smaller and larger extremes of the population. In MIL-STD-1472 (2012), the accommodation target has been set at 90%.
Fraction Male	The percentage of males in the defined target design population.

Ensemble	Clothing and equipment available for selection in the model: • [1]PPE = ACU + IOTV + ACH • [2]ENC = ACU + PPE + Rifleman
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 – SEAT TRAVEL AND 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, 2015).
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, 2015).
Torso Boundary ENC and Torso Boundary PPE	The torso boundary depicts the distribution of user torsos, including the effects of ensemble (Reed, 2015).
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).

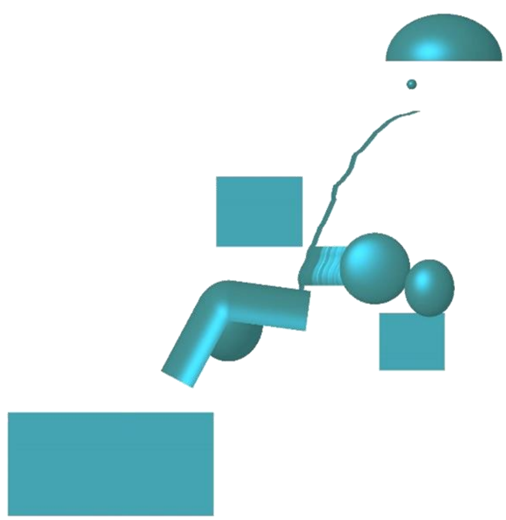

Figure 3: FEP CAD Model Example Output

2.3.4 MODEL OUTPUTS – BASED ON MIL-STD-1472

Additional outputs of the model include interpretation of MIL-STD 1472 for the vehicle designer to utilize when creating the occupant workspace. Clearances 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 Minimum Display Placement and Clearance Zone Outputs

2.3.5 MODEL OUTPUTS - MANIKIN PLACEMENT

Using the same data underlying the creation of the accommodation boundaries, boundary manikins representing the anthropometric extremes of vehicle workstation design are placed in their nominal positions. This is helpful in understanding how specific individuals in the population fit into the vehicle and aids visualization for those unfamiliar with the accommodation boundaries (Huston II et al 2016). Model outputs are described below in Table 4.

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, 2019).

2.4 VERIFICATION SCOPE

The scope of this effort is to verify the GVSC CAD accommodation model for a FEP position where the user interacts with controls and displays. 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. The verification is intended to build confidence in the FEP accommodation model for use in the ground vehicle design community.

Verification per the *Department of Defense Standard Practice Documentation of Verification, Validation, and Accreditation (VV&A) for Models and Simulation* (2008) is defined as follows:

Verification is the process of determining that a model, simulation, or federation of models and simulations implementations and their associated data accurately represents the developer's conceptual description and specifications.

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 elbow contours based on location of resting occupants' elbows in 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	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)

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 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 METHODOLOGY

5.1 PLANNED DATA VERIFICATION TASKS

No specific data verification tasks were completed 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*
- *Seated Soldier Elbow Clearance Zones, 2016-12-10*
- *FEP_Accommodation_Models.24, 2020-10-18,* UMTRI Excel spreadsheet
- *Fixed Eye Point Posture Prediction.6, 2020-9-5,* 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 PLANNED MODEL VERIFICATION

The CAD accommodation model developer (GVSC ACT), working with the V&V agent (GVSC and DAC), will compare the output received in CAD to the output shown in the UMTRI *FEP_Accommodation_Models.24 (2020)* Excel spreadsheet and verify that the two correlate. The model input values will be changed to ensure that the helmet boundary, helmet boundary clearance, abdominal boundary, leg, thigh, and knee boundary, elbow boundary, seat adjustment, and steering mechanism adjustment all adjust as expected.

5.2.1 PLANNED MODEL VERIFICATION TEST RUN

An audit of the FEP CAD model will be completed with the M&S proponent, V&V agent, and SMEs. GVSC ACT will adjust input values of the accommodation model and the team will verify that the outputs previously defined in Table 2 adjust as expected. The test matrix to be used for the verification of the model is shown in Table 7 below:

Table 7: FEP 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

5.3 PLANNED VERIFICATION REPORTING

The FEP CAD model verification effort will produce a verification report that captures the results of the activities completed per this verification plan. Any areas that do not meet the defined verification acceptability requirements will be reviewed and a path forward will be provided to correct the issue.

6. KEY PARTICIPANTS

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

Table 8: Key Participants for Fixed Seat: Non-Driver 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 Joseph R. Urda, DAC David A. Hullinger, DAC Brian D. Corner, PhD, MERS - SIAT Matthew P. Reed, Ph.D, UMTRI

7. PLANNED VERIFICATION RESOURCES

7.1 VERIFICATION RESOURCE REQUIREMENTS

Table 10 identifies the resources used to create the DEVCOM 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	M&S Developer and SME support	UMTRI
Fixed Eye Point Posture Prediction.6	M&S Developer and SME support	UMTRI
Fixed Eye Point: Driver Verification Plan	Verification Agent, M&S Developer and SME support	GVSC ACT
Fixed Eye Point: Driver Accommodation Model Build	M&S Developer and SME support	GVSC ACT
Fixed Eye Point: Driver Accommodation Model Verification packet completed	Verification Agent, Validation Agent, M&S Developer and SME support	GVSC ACT
Fixed Eye Point: Driver Model Release into PDMLink	M&S Developer	GVSC ACT
OPSEC of Fixed Eye Point: Driver Verification Report and CAD Model	M&S Proponent	GVSC ACT
Release of Fixed Eye Point: Driver Verification Report and CAD Model to the GVSC public website.	M&S Proponent	GVSC ACT

7.2 VERIFICATION MILESTONES AND TIMELINE

Table 11 identifies the major milestone achievements in the creation the FEP CAD model and estimated 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
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_Accommodation_Model.24 Excel spreadsheet	October 2020
Fixed Eye Point Posture Prediction.6 Excel spreadsheet	September 2020
Fixed Eye Point: Driver Verification Plan	December 2020
Fixed Eye Point: Driver CAD model complete	2QFY21
Fixed Eye Point: Driver CAD Model Verification Complete	2QFY21
Fixed Eye Point: Driver CAD Final Model Release into PDMLink	2QFY21
Verification Report (Final)	2QFY21

8. APPENDICES

8.1 APPENDIX A – REFERENCES

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8.2 APPENDIX B – 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
COTS	Commercial Off-The-Shelf
CSI	Center for System Integration
DAC	Data Analysis Center
EMD	Engineering Manufacturing and Development
ENC	Encumbered
ESAPI	Enhanced Small Arms Protective Insert
ESBI	Enhanced Side Ballistic Inserts
FEP	Fixed Eye Point
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
MERS	Marine Expeditionary Rifle Squad
MS	Milestone
M&S	Modeling and Simulation
OMT	Optionally Manned Tank
PPE	Personal Protective Equipment
SME	Subject Matter Experts
TAP	Tactical Assault Panel
UMTRI	University of Michigan Transportation Research Institute
USMC	United States Marine Corps
V&V	Verification and Validation
VV&A	Verification, Validation, and Accreditation

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