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Title: Fixed Seat: Non-Driver CAD Accommodation Model Verification Report (Version 1.0)

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13. SUPPLEMENTARY NOTES

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 second in a series of accommodation models being created is the Fixed Seat: Non-Driver accommodation model. Verification is intended to build confidence in the Fixed Seat: Non-Driver CAD model for use in ground vehicle design. This model is applicable to ground vehicles with fixed seating positions often located in the rear of the vehicle. The fixed seats have no horizontal or vertical seat track adjustment and likely include a seat back that is also stationary. The Fixed Seat: Non-Driver CAD model is intended to provide the composite boundaries representing the body of the defined user population, including posture prediction. 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 Seat, 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-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 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 Seat: Non-Driver CAD model. This model is applicable to ground vehicles with fixed seating positions often located in the rear of the vehicle. The fixed seats have no horizontal or vertical seat track adjustment and likely include a seat back that is also stationary. The occupant in this position has few seated tasks interacting with the rest of ground vehicle. The GVSC Fixed Seat: Non-Driver 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, 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). Direct vision zones have been added based on MIL-STD-1472G and SAE Recommended Practice J1050. The Fixed Seat: Non-Driver model is a statistical model created utilizing data collected in the *Seated Soldier Study* (Reed et al 2013) completed by the University of Michigan Transportation Research Institute (UMTRI). The original model, as provided by UMTRI, consists of a Microsoft Excel workbook. The CAD version of the model was created using PTC Creo® 3D CAD software and is a stand-alone geometric reproduction of the output found in the UMTRI Microsoft Excel spreadsheet.

This CAD accommodation model can be applied early in the vehicle design process to ensure accommodation requirements are met and help explore possible design tradeoffs when conflicts with other design parameters exist. Vehicle designers can use the GVSC Fixed Seat: Non-Driver 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 intention of verification is to build confidence in the CAD accommodation model. Model verification included ten test scenarios for comparing the Fixed Seat: Non Driver CAD model outputs against predefined requirements and acceptability criteria. Specifically, when given the same inputs, accommodation model geometry from the CAD model was compared to the outputs of the UMTRI *Soldier Squad Accommodation Models* (2019) spreadsheet; and boundary manikin hip and eye locations were compared to the outputs of the *Seated Soldier Posture Prediction* (2019) 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-1472G and that direct vision zones matched the agreed upon interpretation for combining concepts presented in MIL-STD-1472G and SAE Recommended Practice J1050 (2009).

No issues were discovered during the verification of the model. The final outcome from the review was team consensus that the Fixed Seat: Non-Driver 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, 2012). MIL-STD-1472G 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 second such CAD model to be developed is the Fixed Seat: Non-Driver CAD accommodation model, Figure 1.

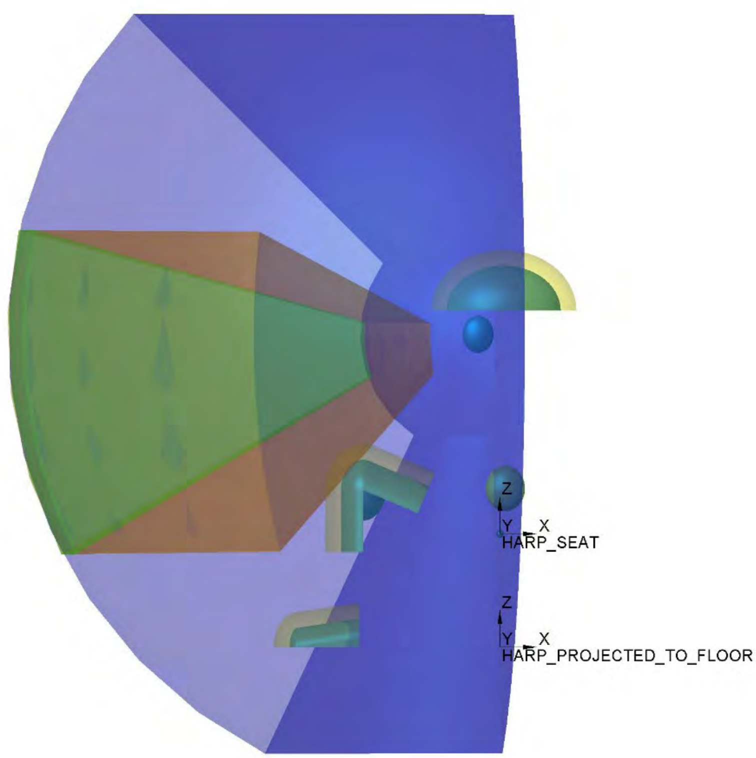

Figure 1: Fixed Seat: Non-Driver CAD Accommodation Model

2.1 INTENDED USE

The Fixed Seat: Non-Driver CAD model described in this verification report is applicable to ground vehicles with fixed seating positions often located in the rear of the vehicle. The fixed seats have no horizontal or vertical seat track adjustment and likely include a seat back that is also stationary. The user in this position has few seated tasks requiring interaction with the rest of the ground vehicle.

The Fixed Seat: Non-Driver CAD model is intended to provide the composite boundaries representing the bodies 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, 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). Direct vision zones have been added based on MIL-STD-1472G and SAE Recommended Practice J1050.

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

2.2 M&S OVERVIEW

The Fixed Seat: Non-Driver CAD model is a statistical model created utilizing data collected in the *Seated Soldier Study* (2013) 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 2012), the target population gender mix, the ensemble (clothing and equipment worn by the user), the desired level of accommodation (e.g. 90%), and the seat height and seat back angle. 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 Squad Automatic Weapon (SAW) Gunner kit, both of which are defined in the *Seated Soldier Study*. Ideally, the level of accommodation will be set at the central 90% of the target design population to be consistent with MIL-STD-1472G requirements. The only vehicle inputs to the model are the Human Accommodation Reference Point (HARP) (Section 2.3.1) and seat back angle. HARP can be measured using either a SAE J826 H-point manikin or the ISO 5353 Seat Index Point (SIP) tool (Reed et al 2014). 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 Fixed Seat: Non-Driver 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-1472G requirements. This eliminates the concern of inconsistent application of the MIL-STD by vehicle designers when creating the occupant workspace (Zielinski et al 2015).

2.3 M&S APPLICATION

The use of the Fixed Seat: Non-Driver 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 Fixed Seat: Non-Driver 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 Human Accommodation Reference Point (HARP), Figure 2, is the origin for the Fixed Seat: Non-Driver accommodation model. The HARP is a reference point for predicting human posture and position with respect to the seat. The HARP is defined and measured using either the SAE J826 H-point manikin with associated procedures or the ISO 5353 SIP device and the associated procedures presented in UMTRI-2014-33.

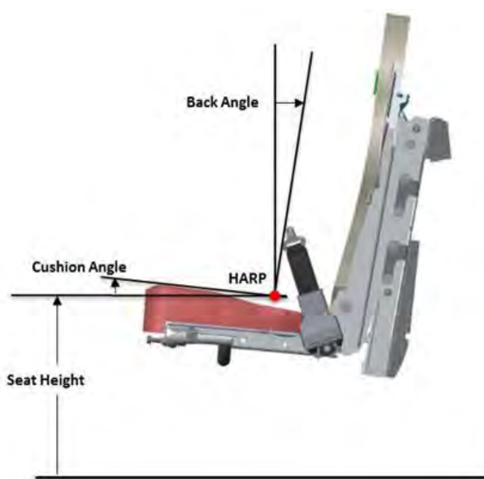

Figure 2: HARP Represented in Seat CAD

2.3.2 MODEL INPUTS

The Fixed Seat: Non-Driver accommodation model requires seven 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-1472G (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 + SAW Gunner
Seat Height	The height of the seat, as measured to the seat's HARP, above the heel rest surface (typically, the floor).
Seat Back Angle	The angle, from vertical, of the fixed seat back.
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 user population boundaries and preferred boundary manikin posture and position information for the vehicle designer to utilize when creating or assessing an occupant workspace. Model outputs are described below in Table 2 and shown in Figure 3.

Table 2: Fixed Seat: Non-Driver CAD Model Accommodation Boundary Outputs and Definitions

Eyellipse	The eyellipse (a contraction of the words "eye" and "ellipse") depicts the distribution of occupant eye locations in the vehicle (Reed, 2015).
Helmet Boundary	The helmet boundary depicts the distribution of target design population helmet locations in the vehicle. The Advanced Combat Helmet (ACH) was used in the development of all the accommodation models (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	The elbow boundary depicts the distribution of resting elbow locations of the occupant (Reed, 2016).
Boot Boundary	The boot boundary depicts the distribution of resting boot locations where the lower leg is vertical (ankle under knee). Based on boot measurements, a single boot is assumed to have a toe box that is 62.5 mm in height and 4.0 inches in width.

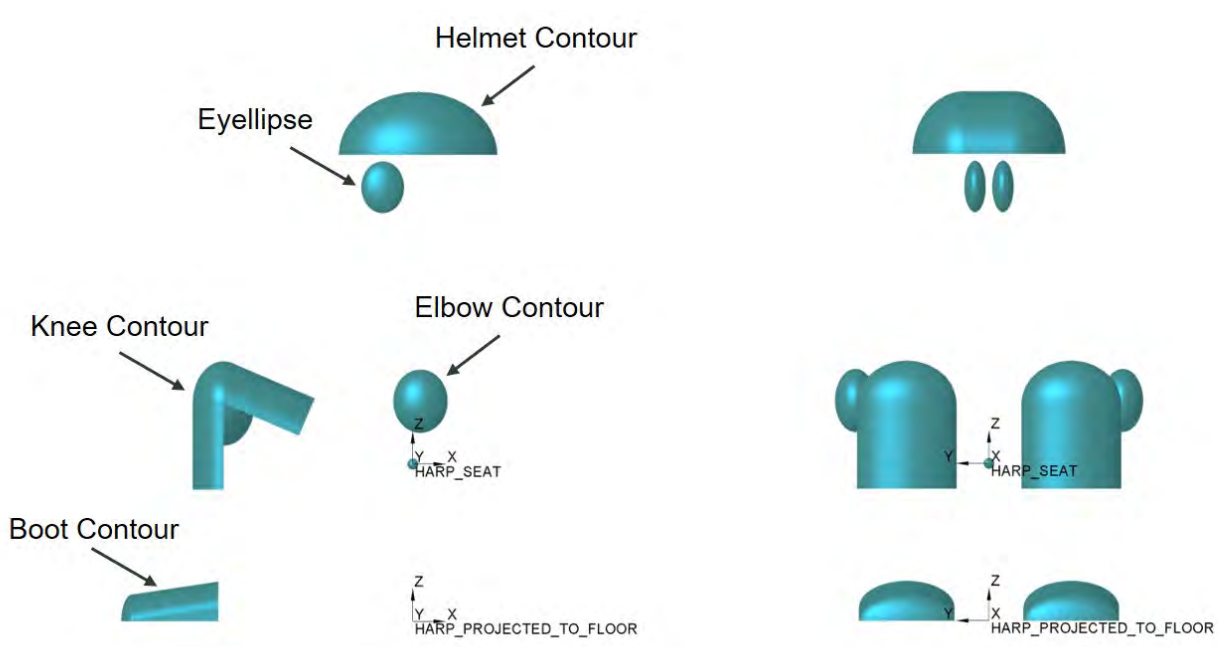

Figure 3: Fixed Seat: Non-Driver CAD Model Example Output

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

Clearance zones are included in the model to serve as a visual check for vehicle designers to utilize when creating the occupant workspace. Generally, 2 inches of clearance is required between the seated occupant and all vehicle structures and/or equipment. Model clearances are described below in Table 3 and shown in Figure 4.

Table 3: Fixed Seat: Non-Driver CAD Model Clearance Outputs and Definitions

Model Output	Description
Clearance Helmet	Helmet clearance consists of an additional 2 inches of space claim required between the helmet boundary and the vehicle ceiling and nearby equipment.

Clearance Knee with Leg and Thigh	Knee, leg, and thigh clearance consists of an additional 2 inches of space claim required 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	Elbow clearance consists of an additional 2 inches of lateral space claim required between the elbows, in a resting position, and nearby vehicle structures such as door trim.
Clearance Boot	Boot clearance consists of an additional 2 inches of space claim required between the boots and any surrounding components such as the structure of another seat or door trim. The space between the boots is included in the clearance zone.

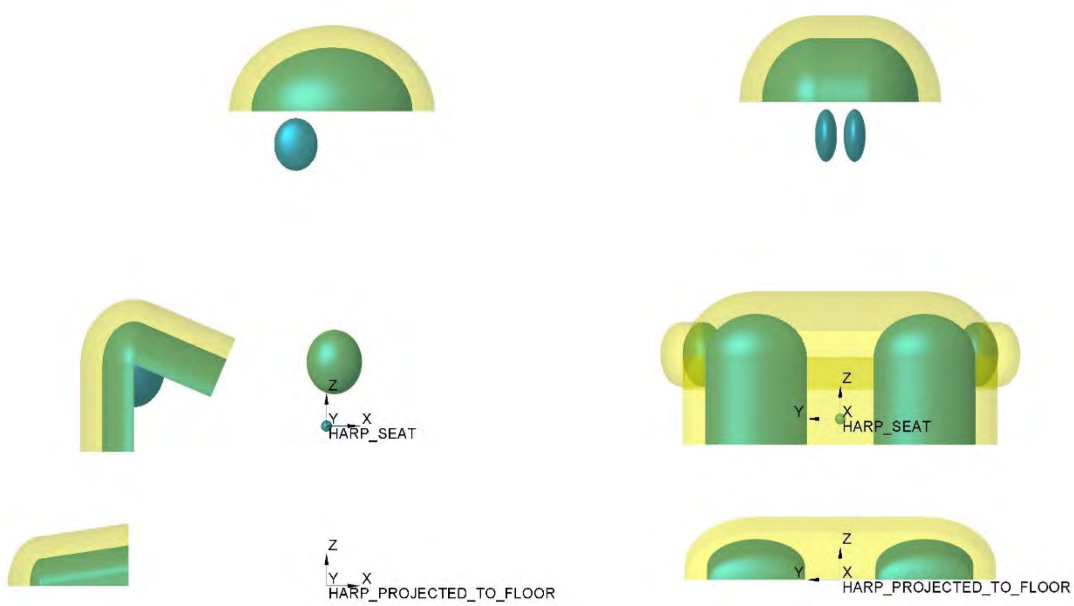

Figure 4: Fixed Seat: Non-Driver CAD Accommodation Model Clearance Zone Outputs

2.3.5 MODEL OUTPUTS - DIRECT FIELD OF VIEW BASED ON MIL-STD-1472 AND SAE J1050

The direct field of view has been divided into primary, secondary, and tertiary zones, Figure 5. The zones were developed with CCDC Data and Analysis Center (DAC) and UMTRI using a combination of vertical and horizontal visual fields described in MIL-STD-1472G and SAE J1050. When members of a population have different eye points, tangents to the eyellipse are used to determine field of view (Huston II et al 2016). Model outputs are described below in Table 4 and shown in Figure 6, Figure 7, and Figure 8.

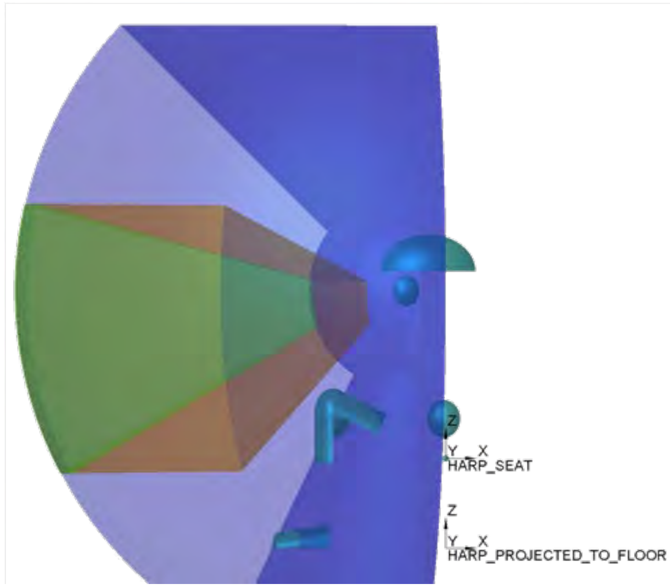

Figure 5: Fixed Seat: Non-Driver Accommodation Model Vision Zone Example

Table 4: FHP: Driver CAD Model Vision Zone Outputs and Definitions

Model Output	**Description**
Vision Zone, Primary	The primary vision zone (Figure 6) indicates space viewable by all occupants from at least one eye using a minimum of "easy" eye rotation. Combining the limits of MIL-STD-1472G and SAE J1050, "easy" eye rotation is defined laterally as 15 degrees side-to-side from the occupant's centerline and vertically as +15/-30 degrees from horizontal (Huston II et al 2016).
Vision Zone, Secondary	The secondary vision zone (Figure 7) includes both "easy" eye rotation and "easy" head turn. Combining the limits of MIL-STD-1472G and SAE J1050, "easy" eye rotation and "easy" head turn is defined laterally as 60 degrees side-to-side from the occupant's centerline (15 degrees eye + 45 degrees head) and vertically as +15/-30 degrees from horizontal (eye rotation only) (Huston II et al 2016).
Vision Zone, Tertiary	The tertiary vision zone (Figure 8) includes both "max" eye rotation and "max" head turn. Combining the limits of MIL-STD-1472G

	and SAE J1050, “max” eye rotation and “max” head turn is defined laterally as 95 degrees side-to-side from the occupant’s centerline (35 degrees eye + 60 degrees head) and vertically as +45 degrees/-65 degrees from horizontal (eye rotation only).

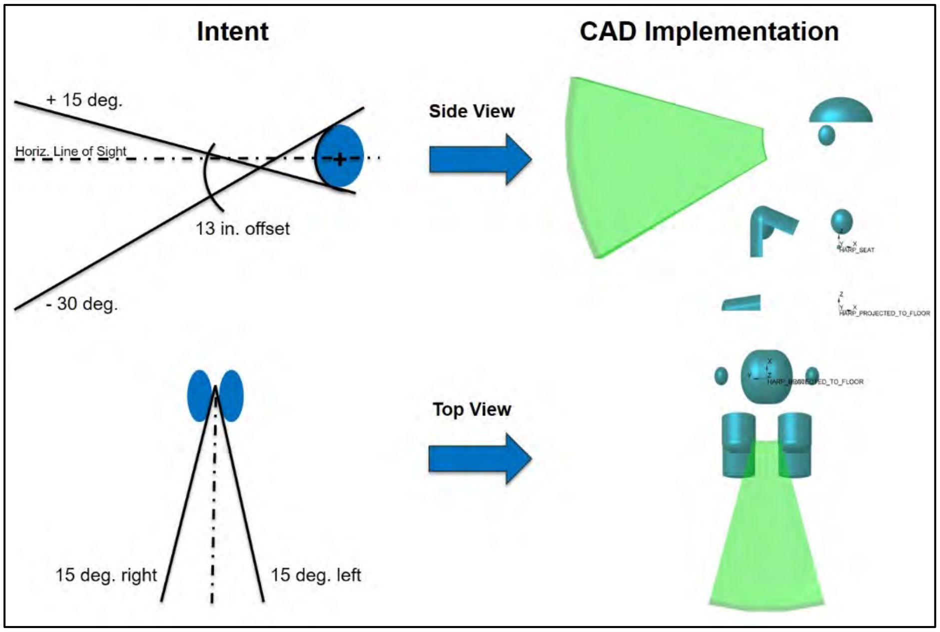

Figure 6: Primary Vision Using Eyellipse in Creo

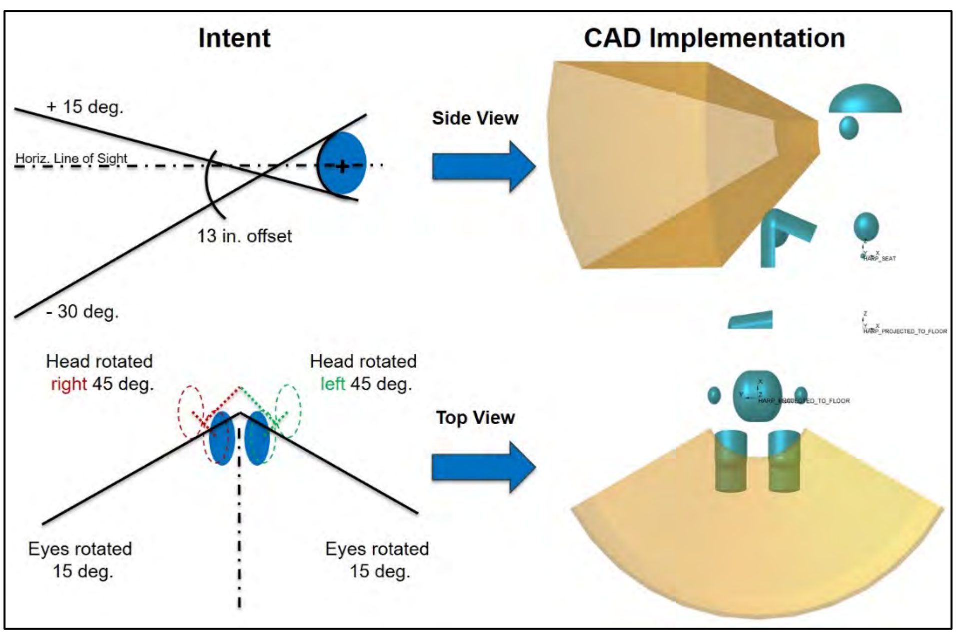

Figure 7: Secondary Vision Zone Using Eyellipse in Creo

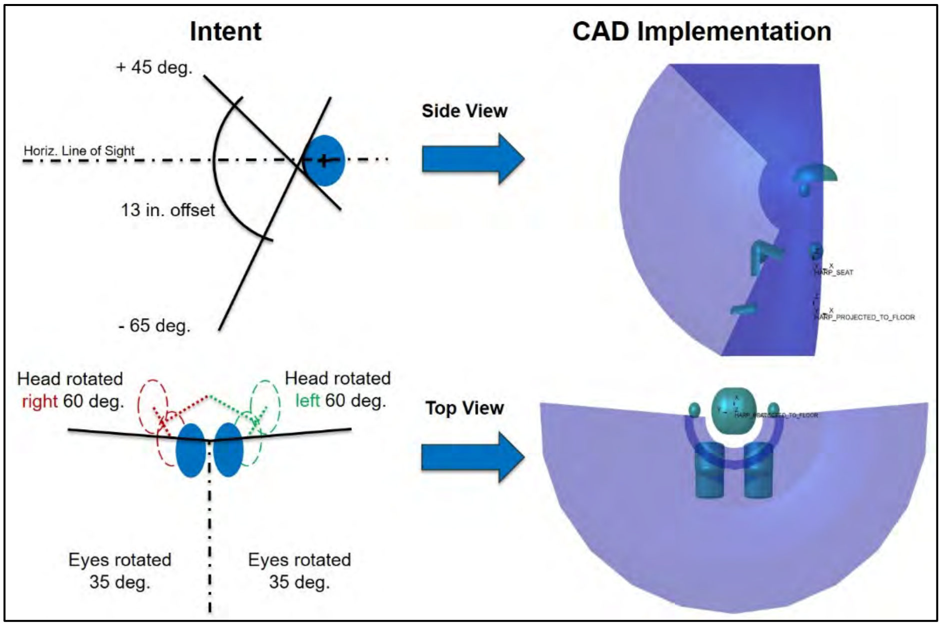

Figure 8: Tertiary Vision Zone Using Eyellipse in Creo

2.3.6 MODEL OUTPUTS - MANIKIN PLACEMENT

Using the same data underlying the creation of the accommodation boundaries, boundary manikins representing the anthropometric extremes of vehicle workstation design are placed in their nominal positions. This is helpful in understanding how specific individuals in the population fit into the vehicle and aids visualization for those unfamiliar with the accommodation boundaries (Huston II et al 2016). Model outputs are described below in Table 5 and shown in Figure 9.

Table 5: 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 predicts position and torso posture for a family of simulated occupants based on the vehicle configuration and the anthropometric inputs of stature, body weight, and erect sitting height (Reed, 2019).

Figure 9: Manikin Placement Using Posture Prediction Model

2.4 VERIFICATION SCOPE

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

Verification of the model was completed on 28 March 2020 by the Verification Agents listed in Table 9, Section 7. CCDC GVSC led the verification effort and requested review, feedback, and concurrence from the key participants listed in Table 9, Section 7.

The goal of verification was to evaluate the PTC Creo® 3D CAD version of the Fixed Seat: Non-Driver 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 *Soldier Squad Accommodation Models 2019-07-07*

2) Determine if the clearance zones (helmet, knees, legs, shins, and boots) calculated by the GVSC CAD model match the Subject Matter Expert (SME) interpretation of MIL-STD-1472G

3) Determine if the direct fields of view (primary, secondary, and tertiary) calculated by the GVSC CAD model match the SME interpretation of MIL-STD-1472G and SAE J1050

4) Determine if the hip and eye points calculated by the GVSC CAD model match those calculated by the UMTRI Microsoft Excel spreadsheet *Seated Soldier Posture Prediction 2019-07-08*

3. REQUIREMENTS AND ACCEPTABILITY CRITERIA

The Fixed Seat: Non-Driver CAD model shall meet the requirements shown in Table 6 below:

Table 6: Requirements Relationship Table for Accommodation Model

#	M&S Requirement	Acceptability Criteria	Metrics/Measures
1	Model allows for a target population input (e.g. 90%)	1.1 Target accommodation input option in model	1.1 Representative (Pass) / Non-Representative (Fail)
2	Model allows for input of the population gender mix (e.g. 85% Male : 15% Female)	2.1 Fraction male input option in model	2.1 Representative (Pass) / Non-Representative (Fail)
3	Model allows for selection of ensemble as either PPE or ENC	3.1 Ensemble selection of PPE in model	3.1 Representative (Pass) / Non-Representative (Fail)
		3.2 Ensemble selection of ENC in model	3.2 Representative (Pass) / Non-Representative (Fail)
4	Model allows for input of the seat height	4.1 Seat 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 input of the seat back angle	6.1 Seat back angle input option in model	6.1 Representative (Pass) / Non-Representative (Fail)
7	Model allows for selection of seat hydration pack relief in the seat	7.1 Hydration pack relief selection of "YES" in model	7.1 Representative (Pass) / Non-Representative (Fail)
		7.2 Hydration pack relief selection of "NO" in model	7.2 Representative (Pass) / Non-Representative (Fail)
8	Model predicts the dimensions and location of the eyellipse	8.1 Model outputs a left and right eyellipse for a given population and gender mix that adjusts with different inputs	8.1 Representative (Pass) / Non-Representative (Fail)
		8.2 CAD model matches the UMTRI spreadsheet	8.2 Representative (Pass) / Non-Representative (Fail)
9	Model predicts the helmet contour boundary (helmet locations) with respect to the eye location and fitted to the eyellipse	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 where the lower leg is vertical (ankle under knee).	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)
17	Model provides direct field of view (primary, secondary, and tertiary zones) based on MIL-STD-1472G and SAE J1050	17.1 Model outputs direct field of view from the eyellipse that adjusts with different inputs	17.1 Representative (Pass)/ Non-Representative (Fail)

Along with using the Fixed Seat: Non-Driver 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 7 below:

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

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

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

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

4.1 M&S CAPABILITIES

The Fixed Seat: Non-Driver 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-1472G and HFE recommendations
- FOV based on interpretation of MIL-STD-1472G and SAE J1050

4.2 M&S LIMITATIONS

The Fixed Seat: Non-Driver CAD model has limitations based on the ground vehicle requirements for the occupant workspace, as follows:

- Predicts fixed seat user conditions (e.g. squad, scouts, dismounts etc.) only and does not address other special positions with a fixed seat such as a gunner.
- Cannot be used if horizontal and vertical seat travel are integrated into the seat design.
- 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 Fixed Seat: Non-Driver 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 seating type environment in the back of a ground vehicle.
- 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 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 2013). The UMTRI documents capturing this work are listed below:

- *Seated Soldier Study: Posture and Body Shape in Vehicle Seats, Final Report UMTRI-2013-13*
- *Development of Accommodation Models for Soldiers in Vehicles: Squad, Final Report UMTRI-2014-39*
- *Seated Soldier Elbow Clearance Zones, 2016-12-10*
- *Soldier Squad Accommodation Models 2019-07-07*, UMTRI Excel spreadsheet
- *Seated Soldier Posture Prediction 2019-07-08*, UMTRI Excel spreadsheet

The information provided by UMTRI was utilized to create the Fixed Seat: Non-Driver 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 8, to compare outputs from the Fixed Seat: Non-Driver CAD model to the UMTRI Soldier Squad Accommodation (2019) spreadsheet and Seated Soldier Posture Prediction (2019) spreadsheets. The highlighted values in the table indicate which inputs were changed from the previous test.

Table 8: Fixed Seat: Non-Driver Accommodation Model Test Matrix

Test #	Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
1	90%	90%	PPE	13.8	0.0	SAE J826	No
2	90%	90%	PPE	15.0	20.0	SAE J826	No
3	90%	90%	PPE	15.8	15.0	ISO 5353	No
4	90%	90%	PPE	17.7	18.0	SAE J826	No
5	90%	90%	PPE	15.0	10.0	SAE J826	No
6	90%	90%	ACU	15.0	10.0	SAE J826	No
7	95%	90%	ENC	15.0	10.0	SAE J826	No
8	90%	50%	PPE	15.0	10.0	SAE J826	No
9	90%	50%	ACU	15.0	10.0	SAE J826	No
10	90%	50%	ENC	15.0	10.0	SAE J826	Yes

Tests #1-5 primarily explore the effects of varying the seat height and seat back angle

- Geometry for composite body boundaries (except knees) is constant, but position varies
- Knee Contour geometry and position are unique for each test to reflect changing thigh angles
- Changing the HARP measurement tool shifts all geometry in the X-direction

Tests #6-10 primarily explore the effects of varying Target Accommodation, gender mix (Fraction Male), and Ensemble

- With increased Target Accommodation, composite body boundaries increase in volume and Vision Zones decrease
- Geometry for composite body boundaries decreases in volume with a smaller proportion of males
- Position for composite body boundaries shifts in the X-direction with the chosen Ensemble
- Hydration Pack Relief only affects the ENC ensemble

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 screenshots showing how calculated numerical results were translated into CAD and compare to UMTRI's results. Please refer to the following appendices:

- Appendix B – Requirements and Acceptability Criteria Results
- Appendix G - Initial Task Analysis

6. VERIFICATION RECOMMENDATIONS

Team consensus from the verification package review is that the Fixed Seat: Non-Driver 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 9 identifies the participants involved in the verification effort, including their roles and responsibilities.

Table 9: 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, CCDC 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

8. ACTUAL VERIFICATION RESOURCES EXPENDED

8.1 VERIFICATION RESOURCES EXPENDED

Table 10 identifies the resources used to create the CCDC GVSP Fixed Seat: Non-Driver CAD model and complete associated activities, including verification.

Table 10: Verification Resources

Document/Deliverable	Required Resources	POC
The Seated Soldier Study: Posture and Body Shape in Vehicle Seats Final Report	M&S Developer and SME support	UMTRI
Seated Soldier Posture Prediction Excel Spreadsheet	M&S Developer and SME support	UMTRI

Development of Accommodation Models for Soldiers in Vehicles: Squad	M&S Developer and SME support	UMTRI
Accommodation Model Funding Approval for FY18	M&S Proponent	GVSC ACT
Fixed Seat: Non-Driver Verification Plan	Verification Agent, M&S Developer and SME support	GVSC ACT
Accommodation Model Funding Approval FY19	M&S Proponent	GVSC ACT
Fixed Seat: Non-Driver Accommodation Model Build	M&S Developer and SME support	GVSC ACT
Fixed Seat: Non-Driver Accommodation Model Verification packet completed	M&S Developer and Verification Agent	GVSC ACT, UMTRI
Fixed Seat: Non-Driver Model Release into PDMLink	M&S Developer	GVSC ACT
Fixed Seat: Non-Driver Verification Report Revision 1.0	Verification Agent, Validation Agent, M&S Developer and SME support	GVSC ACT
OPSEC of Fixed Seat: Non-Driver Verification Report and CAD Model	M&S Proponent	GVSC ACT
Release of Fixed Seat: Non-Driver Verification Report and CAD Model to the GVSC public website.	M&S Proponent	GVSC ACT

8.2 ACTUAL VERIFICATION MILESTONES AND TIMELINE

Table 11 identifies the major milestone achievements in the creation the Fixed Seat: Non-Driver CAD model and completion of associated activities, including verification.

Table 11: Verification Milestone Timeline

Document/Deliverable	Delivery Date
Draft Posture Prediction Spreadsheet	September 2014
Fixed Seat: Non-Driver Final Report from UMTRI	September 2014
Fixed Seat: Non-Driver data applied to Combat Vehicle Prototyping (CVP) concept	April 2015
Soldier Squad Accommodation Models 2015-01-05 from UMTRI	May 2015
Fixed Seat: Non-Driver CAD template development started	February 2018
Fixed Seat: Non-Driver data applied to CVP (updates)	January 2016
Soldier Squad Accommodation Models 2016-02-22a from UMTRI	February 2016
Fixed Seat: Non-Driver data applied to Armored Reconnaissance Vehicle (ARV)	January 2018
Soldier Squad Accommodation Models 2018-02-12a from UMTRI (elbows added to the model)	February 2018
Fixed Seat: Non-Driver CAD template updated with elbows	April 2019

Fixed Seat: Non-Driver data applied to Mission Enabler Technologies-Demonstrator (MET-D)	November 2018
Fixed Seat: Non-Driver Verification Plan	February 2019
Soldier Squad Accommodation Models 2019-04-02 from UMTRI (boot contour added to the model)	April 2019
Fixed Seat: Non-Driver CAD template updated with boot contour	July 2019
Soldier Squad Accommodation Models 2019-07-07 from UMTRI (final spread sheet with manikin positioning updates)	July 2019
Functional Posture integrated with CAD Boundary Manikins	August 2019
Fixed Seat: Non-Driver CAD model complete	September 2019
Fixed Seat: Non-Driver CAD Model Verification Complete	January 2020
Fixed Seat: Non-Driver CAD Final Model Release into PDMLink	January 2020
Verification Report (Final)	March 2020

9. VERIFICATION LESSONS LEARNED

Verification of the Fixed Seat: Non-Driver CAD model marks the second time that GVSC has verified such a product. Based on lessons learned from the first verification, the M&S Proponents and Developers determined that verifying CAD outputs against UMTRI's spreadsheet, given the number of calculations involved, would be too time intensive to complete in front of a live audience. Alternatively, a PowerPoint document (see Appendix G - Initial Task Analysis) 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, which is also applicable to the Fixed Seat position, is extracted from *Creation of the Driver Fixed Heel Point (FHP) CAD Accommodation Model for Military Ground Vehicle Design* (2016).

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, 2012). This analysis is available for the Fixed Seat: Non-Driver 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 *Seated Soldier Study* (Reed et al, 2013) was completed to capture Soldier preferred posture and position data in a fixed seat mockup while considering the unique ground vehicle workstation environment and the clothing and equipment ensembles worn by Soldiers.

The *Seated Soldier Study* gathered data on 145 enlisted men and women as drivers and fixed seating positions (e.g. dismounts) at three Army posts. 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 Fixed Seat: Non-Driver workstation. The test seat was set to two different combinations of back angle and cushion angle. Seat height was adjusted and 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 eyes, helmet, and knees. 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 Accommodation Models for Soldiers in Vehicle: Squad* (Zerehsaz et al, 2014).

The CAD version of the Fixed Seat: Non-Driver accommodation model was created by GVSC ACT using PTC Creo® 3D CAD software. Functionally, the foundation of the model is a stand-alone geometric reproduction of UMTRI's Microsoft Excel spreadsheets. Clearances between the Soldier population and surrounding interior vehicle surfaces were layered onto the model per the intent of MIL-STD-1472G, along with direct vision zones and a ground intercept tool that incorporate concepts from both MIL-STD-1472G and SAE Recommended Practice J1050, *Describing and Measuring the Driver's Field of View*, 2009. To aid in understanding how workstation design affects individuals, boundary manikins representing the anthropometric extremes for workstation design were placed in their predicted postures.

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

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

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

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

10.1.2 M&S USE HISTORY

The data for the Fixed Seat: Non-Driver CAD model was pulled ahead to apply to Combat Vehicle Prototyping (CVP), Mission Enabler Technologies-Demonstrator (MET-D), and the Armored Reconnaissance Vehicle (ARV) 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 Fixed Seat: Non-Driver CAD accommodation model and upload the latest version.

The Fixed Seat: Non-Driver 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:
12632884 GVSC Fixed Seat Non-Driver 19207_12632884

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

CCDC GVSC Advanced Concepts Team
6501 E. 11 Mile Road
Bldg. 200, FCDD-GVR-MSS
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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 12 and Table 13, respectively. Metrics are noted as pass or fail. None of the metrics produced a failing result, so no corrective action plans are required.

Table 12: Accommodation Model Requirements Results

#	M&S Requirement	Acceptability Criteria	Metrics/Measures
1	Model allows for a target population input (e.g. 90%)	1.1 Target accommodation input option in model	1.1 Representative (Pass) / Non-Representative (Fail)
2	Model allows for input of the population gender mix (e.g. 85% Male : 15% Female)	2.1 Fraction male input option in model	2.1 Representative (Pass) / Non-Representative (Fail)
3	Model allows for selection of ensemble as either PPE or ENC	3.1 Ensemble selection of PPE in model	3.1 Representative (Pass) / Non-Representative (Fail)
		3.2 Ensemble selection of ENC in model	3.2 Representative (Pass) / Non-Representative (Fail)
4	Model allows for input of the seat height	4.1 Seat 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 input of the seat back angle	6.1 Seat back angle input option in model	6.1 Representative (Pass) / Non-Representative (Fail)
7	Model allows for selection of seat hydration pack relief in the seat	7.1 Hydration pack relief selection of "YES" in model	7.1 Representative (Pass) / Non-Representative (Fail)
		7.2 Hydration pack relief selection of "NO" in model	7.2 Representative (Pass) / Non-Representative (Fail)
8	Model predicts the dimensions and location of the eyellipse	8.1 Model outputs a left and right eyellipse for a given population and gender mix that adjusts with different inputs	8.1 Representative (Pass) / Non-Representative (Fail)
		8.2 CAD model matches the UMTRI spreadsheet	8.2 Representative (Pass) / Non-Representative (Fail)
9	Model predicts the helmet contour boundary (helmet locations) with respect to the eye location and fitted to the eyellipse	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 where the lower leg is vertical (ankle under knee).	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 MIL-STD-1472H draft 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 MIL-STD-1472H draft 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 MIL-STD-1472H draft 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)
17	Model provides direct field of view (primary, secondary, and tertiary zones) based on MIL-STD-1472G and SAE J1050	17.1 Model outputs direct field of view from the eyellipse that adjusts with different inputs	17.1 Representative (Pass)/ Non-Representative (Fail)

Table 13: Posture Prediction Model Results

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

10.2.1 TEST #1 – NUMERICAL RESULTS

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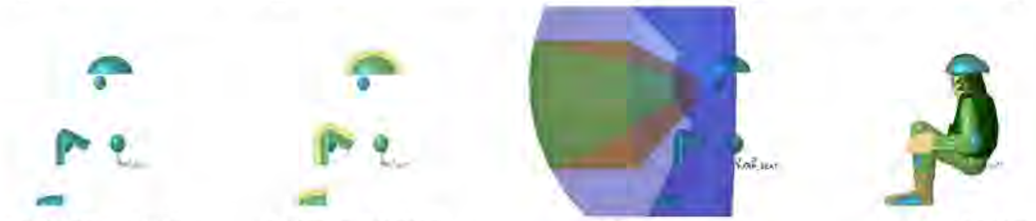
TEST #1: BASELINE FOR TESTS #1-5

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	90%	PPE	13.8	0.0	SAE J826	No



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

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

Largest Observed Differences

Basic Accommodation:
0.004 inches
0.000 degrees

Manikin Placement:
0.000 inches

Values in agreement

For complete results, including calculated numerical values and their translation into CAD, see pages 34 - 70.

Note: Test #1 results include construction details for accommodation geometry.

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TEST #1: RESULTS, ACCOMMODATION

HARP

	UMTRI Value		GVSC Value		Difference	
HARP_X	0.000	in	0.000	in	0.000	in
HARP_Z	13.800	in	13.800	in	0.000	in

Eyellipse

	UMTRI Value		GVSC Value		Difference	
EYELLIPSE_CENTROID_X	-5.966	in	-5.966	in	0.000	in
EYELLIPSE_CENTROID_Y (+/-)	1.280	in	1.280	in	0.000	in
EYELLIPSE_CENTROID_Z	39.487	in	39.488	in	0.001	in
EYELLIPSE_X_AXIS_LENGTH	3.907	in	3.909	in	0.002	in
EYELLIPSE_Y_AXIS_LENGTH	1.988	in	1.990	in	0.001	in
EYELLIPSE_Z_AXIS_LENGTH	4.595	in	4.596	in	0.001	in

Helmet Contour

	UMTRI Value		GVSC Value		Difference	
HELMET_CONTOUR_CENTROID_X	-2.716	in	-2.718	in	0.000	in
HELMET_CONTOUR_CENTROID_Y (+/-)	2.185	in	2.185	in	0.000	in
HELMET_CONTOUR_CENTROID_Z	42.471	in	42.472	in	0.001	in
HELMET_CONTOUR_X_AXIS_LENGTH	14.509	in	14.512	in	0.002	in
HELMET_CONTOUR_Y_AXIS_LENGTH	9.657	in	9.659	in	0.001	in
HELMET_CONTOUR_Z_AXIS_LENGTH	11.366	in	11.368	in	0.001	in

Knee Contour

	UMTRI Value		GVSC Value		Difference	
KNEE_CONTOUR_WEIGHTED_CENT_X	-17.228	in	-17.228	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Y (+/-)	7.594	in	7.594	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Z	20.765	in	20.765	in	0.000	in
KNEE_CONTOUR_X_AXIS_LENGTH	5.628	in	5.630	in	0.002	in
KNEE_CONTOUR_Y_AXIS_LENGTH	9.035	in	9.037	in	0.002	in
KNEE_CONTOUR_Z_AXIS_LENGTH	7.529	in	7.529	in	0.001	in
KNEE_SHIN_ANGLE	0.000	deg	0.000	deg	0.000	deg
KNEE_THIGH_ANGLE	27.111	deg	27.111	deg	0.000	deg

Elbow Contour

	UMTRI Value		GVSC Value		Difference	
ELBOW_WEIGHTED_CENT_X	-0.300	in	-0.300	in	0.000	in
ELBOW_WEIGHTED_CENT_Y	12.079	in	12.079	in	0.000	in
ELBOW_WEIGHTED_CENT_Z	19.891	in	19.891	in	0.000	in
ELBOW_X_AXIS_LENGTH	4.996	in	5.000	in	0.004	in
ELBOW_Y_AXIS_LENGTH	3.683	in	3.684	in	0.001	in
ELBOW_Z_AXIS_LENGTH	5.779	in	5.782	in	0.003	in

Boot Contour

	UMTRI Value		GVSC Value		Difference	
BOOT_TOE_WEIGHTED_CENT_X	-25.619	in	-25.619	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Y	7.594	in	7.594	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Z	0.000	in	0.000	in	0.000	in
BOOT_TOE_X_AXIS_LENGTH	1.889	in	1.890	in	0.001	in
BOOT_TOE_Y_AXIS_LENGTH	8.704	in	8.706	in	0.002	in
BOOT_TOE_Z_AXIS_LENGTH	4.921	in	4.921	in	0.000	in

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

Largest Observed Differences:
0.004 inches
0.000 degrees

Values in agreement

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Test #1: Results, Manikin Positioning

	UMTRI Value		GVSC Value		Difference	
Small Overall Female						
POSTURE_DHM1_HIP_X	-1.915	in	-1.915	in	0.000	in
POSTURE_DHM1_HIP_Z	13.184	in	13.184	in	0.000	in
POSTURE_DHM1_EYE_X	-4.713	in	-4.713	in	0.000	in
POSTURE_DHM1_EYE_Z	35.545	in	35.545	in	0.000	in
Small Overall Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM2_HIP_X	-2.177	in	-2.177	in	0.000	in
POSTURE_DHM2_HIP_Z	13.289	in	13.289	in	0.000	in
POSTURE_DHM2_EYE_X	-5.422	in	-5.422	in	0.000	in
POSTURE_DHM2_EYE_Z	37.443	in	37.443	in	0.000	in
Average Size Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM3_HIP_X	-2.175	in	-2.175	in	0.000	in
POSTURE_DHM3_HIP_Z	13.288	in	13.288	in	0.000	in
POSTURE_DHM3_EYE_X	-6.163	in	-6.163	in	0.000	in
POSTURE_DHM3_EYE_Z	39.792	in	39.792	in	0.000	in
Widest Shoulders Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM4_HIP_X	-2.148	in	-2.148	in	0.000	in
POSTURE_DHM4_HIP_Z	13.278	in	13.278	in	0.000	in
POSTURE_DHM4_EYE_X	-6.537	in	-6.537	in	0.000	in
POSTURE_DHM4_EYE_Z	41.147	in	41.147	in	0.000	in
Longest Torso Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM5_HIP_X	-2.134	in	-2.134	in	0.000	in
POSTURE_DHM5_HIP_Z	13.272	in	13.272	in	0.000	in
POSTURE_DHM5_EYE_X	-6.546	in	-6.546	in	0.000	in
POSTURE_DHM5_EYE_Z	42.322	in	42.322	in	0.000	in
Longest Legs Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM6_HIP_X	-2.309	in	-2.303	in	0.000	in
POSTURE_DHM6_HIP_Z	13.340	in	13.340	in	0.000	in
POSTURE_DHM6_EYE_X	-6.728	in	-6.728	in	0.000	in
POSTURE_DHM6_EYE_Z	40.153	in	40.153	in	0.000	in
Large Overall Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM7_HIP_X	-2.535	in	-2.535	in	0.000	in
POSTURE_DHM7_HIP_Z	13.433	in	13.433	in	0.000	in
POSTURE_DHM7_EYE_X	-7.004	in	-7.004	in	0.000	in
POSTURE_DHM7_EYE_Z	42.141	in	42.141	in	0.000	in

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

Largest Observed Differences:
0.000 inches

Values in agreement

10.2.2 TEST #2 – NUMERICAL RESULTS

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TEST #2: VARY SEATING HEIGHT/ANGLE

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	90%	PPE	15.0	20.0	SAE J826	No

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

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

Largest Observed Differences

Basic Accommodation:
0.004 inches
0.000 degrees

Manikin Placement:
0.000 inches

Values in agreement

For complete results, including calculated numerical values and their translation into CAD, see pages 71 - 105.

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TEST #2: RESULTS, ACCOMMODATION

HARP

	UMTRI Value		GVSC Value		Difference	
HARP_X	0.000	in	0.000	in	0.000	in
HARP_Z	15.000	in	15.000	in	0.000	in

Eyellipse

	UMTRI Value		GVSC Value		Difference	
EYELLIPSE_CENTROID_X	0.372	in	0.372	in	0.000	in
EYELLIPSE_CENTROID_Y (+/-)	1.280	in	1.280	in	0.000	in
EYELLIPSE_CENTROID_Z	40.253	in	40.254	in	0.001	in
EYELLIPSE_X_AXIS_LENGTH	3.907	in	3.909	in	0.003	in
EYELLIPSE_Y_AXIS_LENGTH	1.988	in	1.990	in	0.001	in
EYELLIPSE_Z_AXIS_LENGTH	4.594	in	4.596	in	0.002	in

Helmet Contour

	UMTRI Value		GVSC Value		Difference	
HELMET_CONTOUR_CENTROID_X	3.620	in	3.620	in	0.000	in
HELMET_CONTOUR_CENTROID_Y (+/-)	2.185	in	2.185	in	0.000	in
HELMET_CONTOUR_CENTROID_Z	43.238	in	43.238	in	0.001	in
HELMET_CONTOUR_X_AXIS_LENGTH	14.509	in	14.512	in	0.003	in
HELMET_CONTOUR_Y_AXIS_LENGTH	9.657	in	9.659	in	0.001	in
HELMET_CONTOUR_Z_AXIS_LENGTH	11.366	in	11.368	in	0.002	in

Knee Contour

	UMTRI Value		GVSC Value		Difference	
KNEE_CONTOUR_WEIGHTED_CENT_X	-17.610	in	-17.610	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Y (+/-)	7.594	in	7.594	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Z	19.311	in	19.311	in	0.000	in
KNEE_CONTOUR_X_AXIS_LENGTH	5.628	in	5.630	in	0.002	in
KNEE_CONTOUR_Y_AXIS_LENGTH	9.035	in	9.037	in	0.002	in
KNEE_CONTOUR_Z_AXIS_LENGTH	7.529	in	7.529	in	0.001	in
KNEE_SHIN_ANGLE	0.000	deg	0.000	deg	0.000	deg
KNEE_THIGH_ANGLE	19.296	deg	19.296	deg	0.000	deg

Elbow Contour

	UMTRI Value		GVSC Value		Difference	
ELBOW_WEIGHTED_CENT_X	1.739	in	1.739	in	0.000	in
ELBOW_WEIGHTED_CENT_Y	12.517	in	12.517	in	0.000	in
ELBOW_WEIGHTED_CENT_Z	20.506	in	20.506	in	0.000	in
ELBOW_X_AXIS_LENGTH	4.996	in	5.000	in	0.004	in
ELBOW_Y_AXIS_LENGTH	3.683	in	3.684	in	0.001	in
ELBOW_Z_AXIS_LENGTH	5.779	in	5.782	in	0.003	in

Boot Contour

	UMTRI Value		GVSC Value		Difference	
BOOT_TOE_WEIGHTED_CENT_X	-26.002	in	-26.002	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Y	7.594	in	7.594	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Z	0.000	in	0.000	in	0.000	in
BOOT_TOE_X_AXIS_LENGTH	1.889	in	1.890	in	0.001	in
BOOT_TOE_Y_AXIS_LENGTH	8.704	in	8.706	in	0.002	in
BOOT_TOE_Z_AXIS_LENGTH	4.921	in	4.921	in	0.000	in

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

Largest Observed Differences:
0.004 inches
0.000 degrees

Values in agreement

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TEST #2: RESULTS, MANIKIN POSITIONING

Small Overall Female

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM1_HIP_X	-0.552	in	-0.552	in	0.000	in
POSTURE_DHM1_HIP_Z	14.384	in	14.384	in	0.000	in
POSTURE_DHM1_EYE_X	1.626	in	1.626	in	0.000	in
POSTURE_DHM1_EYE_Z	36.312	in	36.312	in	0.000	in

Small Overall Male

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM2_HIP_X	-0.815	in	-0.815	in	0.000	in
POSTURE_DHM2_HIP_Z	14.489	in	14.489	in	0.000	in
POSTURE_DHM2_EYE_X	0.917	in	0.917	in	0.000	in
POSTURE_DHM2_EYE_Z	38.209	in	38.209	in	0.000	in

Average Size Male

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM3_HIP_X	-0.813	in	-0.813	in	0.000	in
POSTURE_DHM3_HIP_Z	14.488	in	14.488	in	0.000	in
POSTURE_DHM3_EYE_X	0.176	in	0.176	in	0.000	in
POSTURE_DHM3_EYE_Z	40.558	in	40.558	in	0.000	in

Widest Shoulders Male

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM4_HIP_X	-0.786	in	-0.786	in	0.000	in
POSTURE_DHM4_HIP_Z	14.478	in	14.478	in	0.000	in
POSTURE_DHM4_EYE_X	-0.198	in	-0.198	in	0.000	in
POSTURE_DHM4_EYE_Z	41.914	in	41.914	in	0.000	in

Longest Torso Male

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM5_HIP_X	-0.772	in	-0.772	in	0.000	in
POSTURE_DHM5_HIP_Z	14.472	in	14.472	in	0.000	in
POSTURE_DHM5_EYE_X	-0.208	in	-0.208	in	0.000	in
POSTURE_DHM5_EYE_Z	43.088	in	43.088	in	0.000	in

Longest Legs Male

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM6_HIP_X	-0.941	in	-0.941	in	0.000	in
POSTURE_DHM6_HIP_Z	14.540	in	14.540	in	0.000	in
POSTURE_DHM6_EYE_X	-0.390	in	-0.390	in	0.000	in
POSTURE_DHM6_EYE_Z	40.920	in	40.920	in	0.000	in

Large Overall Male

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM7_HIP_X	-1.173	in	-1.173	in	0.000	in
POSTURE_DHM7_HIP_Z	14.633	in	14.633	in	0.000	in
POSTURE_DHM7_EYE_X	-0.666	in	-0.666	in	0.000	in
POSTURE_DHM7_EYE_Z	42.908	in	42.908	in	0.000	in

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

Largest Observed Differences:
0.000 inches

Values in agreement

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10.2.3 TEST #3 – NUMERICAL RESULTS

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TEST #3: VARY SEATING HEIGHT/ANGLE AND HARP TOOL

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	90%	PPE	15.8	15.0	ISO 5353	No

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

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

Largest Observed Differences

Basic Accommodation:
0.004 inches
0.000 degrees

Manikin Placement:
0.000 inches

Values in agreement

For complete results, including calculated numerical values and their translation into CAD, see pages 106 - 140.

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TEST #3: RESULTS, ACCOMMODATION

HARP

	UMTRI Value		GVSC Value		Difference	
HARP_X	0.000	in	0.000	in	0.000	in
HARP_Z	15.900	in	15.900	in	0.000	in

Eyellipse

	UMTRI Value		GVSC Value		Difference	
EYELLIPSE_CENTROID_X	-1.409	in	-1.409	in	0.000	in
EYELLIPSE_CENTROID_Y (+/-)	1.280	in	1.280	in	0.000	in
EYELLIPSE_CENTROID_Z	41.251	in	41.252	in	0.001	in
EYELLIPSE_X_AXIS_LENGTH	3.907	in	3.909	in	0.003	in
EYELLIPSE_Y_AXIS_LENGTH	1.988	in	1.990	in	0.001	in
EYELLIPSE_Z_AXIS_LENGTH	4.595	in	4.596	in	0.001	in

Helmet Contour

	UMTRI Value		GVSC Value		Difference	
HELMET_CONTOUR_CENTROID_X	1.839	in	1.639	in	0.000	in
HELMET_CONTOUR_CENTROID_Y (+/-)	2.185	in	2.185	in	0.000	in
HELMET_CONTOUR_CENTROID_Z	44.235	in	44.236	in	0.001	in
HELMET_CONTOUR_X_AXIS_LENGTH	14.509	in	14.512	in	0.003	in
HELMET_CONTOUR_Y_AXIS_LENGTH	9.657	in	9.659	in	0.001	in
HELMET_CONTOUR_Z_AXIS_LENGTH	11.366	in	11.368	in	0.001	in

Knee Contour

	UMTRI Value		GVSC Value		Difference	
KNEE_CONTOUR_WEIGHTED_CENT_X	18.062	in	18.062	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Y (+/-)	7.594	in	7.594	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Z	19.764	in	19.764	in	0.000	in
KNEE_CONTOUR_X_AXIS_LENGTH	5.628	in	5.630	in	0.002	in
KNEE_CONTOUR_Y_AXIS_LENGTH	9.035	in	9.037	in	0.002	in
KNEE_CONTOUR_Z_AXIS_LENGTH	7.529	in	7.529	in	0.001	in
KNEE_SHIN_ANGLE	0.000	deg	0.000	deg	0.000	deg
KNEE_THIGH_ANGLE	17.855	deg	17.855	deg	0.000	deg

Elbow Contour

	UMTRI Value		GVSC Value		Difference	
ELBOW_WEIGHTED_CENT_X	1.032	in	1.032	in	0.000	in
ELBOW_WEIGHTED_CENT_Y	12.407	in	12.407	in	0.000	in
ELBOW_WEIGHTED_CENT_Z	21.450	in	21.450	in	0.000	in
ELBOW_X_AXIS_LENGTH	4.996	in	5.000	in	0.004	in
ELBOW_Y_AXIS_LENGTH	3.683	in	3.684	in	0.001	in
ELBOW_Z_AXIS_LENGTH	5.779	in	5.782	in	0.003	in

Boot Contour

	UMTRI Value		GVSC Value		Difference	
BOOT_TOE_WEIGHTED_CENT_X	-26.454	in	-26.454	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Y	7.594	in	7.594	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Z	0.000	in	0.000	in	0.000	in
BOOT_TOE_X_AXIS_LENGTH	1.889	in	1.890	in	0.001	in
BOOT_TOE_Y_AXIS_LENGTH	8.704	in	8.706	in	0.002	in
BOOT_TOE_Z_AXIS_LENGTH	4.921	in	4.921	in	0.000	in

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

Largest Observed Differences:
0.004 inches
0.000 degrees

Values in agreement

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Test #3: Results, Manikin Positioning

Small Overall Female	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM1_HIP_X	-0.893	in	-0.893	in	0.000	in
POSTURE_DHM1_HIP_Z	15.184	in	15.184	in	0.000	in
POSTURE_DHM1_EYE_X	0.041	in	0.041	in	0.000	in
POSTURE_DHM1_EYE_Z	37.309	in	37.309	in	0.000	in

Small Overall Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM2_HIP_X	-1.155	in	-1.155	in	0.000	in
POSTURE_DHM2_HIP_Z	15.289	in	15.289	in	0.000	in
POSTURE_DHM2_EYE_X	-0.668	in	-0.668	in	0.000	in
POSTURE_DHM2_EYE_Z	39.207	in	39.207	in	0.000	in

Average Size Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM3_HIP_X	-1.153	in	-1.153	in	0.000	in
POSTURE_DHM3_HIP_Z	15.288	in	15.288	in	0.000	in
POSTURE_DHM3_EYE_X	-1.409	in	-1.409	in	0.000	in
POSTURE_DHM3_EYE_Z	41.556	in	41.556	in	0.000	in

Widest Shoulders Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM4_HIP_X	-1.127	in	-1.127	in	0.000	in
POSTURE_DHM4_HIP_Z	15.278	in	15.278	in	0.000	in
POSTURE_DHM4_EYE_X	-1.783	in	-1.783	in	0.000	in
POSTURE_DHM4_EYE_Z	42.911	in	42.911	in	0.000	in

Longest Torso Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM5_HIP_X	-1.112	in	-1.112	in	0.000	in
POSTURE_DHM5_HIP_Z	15.272	in	15.272	in	0.000	in
POSTURE_DHM5_EYE_X	-1.792	in	-1.792	in	0.000	in
POSTURE_DHM5_EYE_Z	44.096	in	44.096	in	0.000	in

Longest Legs Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM6_HIP_X	-1.281	in	-1.281	in	0.000	in
POSTURE_DHM6_HIP_Z	15.340	in	15.340	in	0.000	in
POSTURE_DHM6_EYE_X	-1.974	in	-1.974	in	0.000	in
POSTURE_DHM6_EYE_Z	41.917	in	41.917	in	0.000	in

Large Overall Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM7_HIP_X	-1.513	in	-1.513	in	0.000	in
POSTURE_DHM7_HIP_Z	15.433	in	15.433	in	0.000	in
POSTURE_DHM7_EYE_X	-2.250	in	-2.250	in	0.000	in
POSTURE_DHM7_EYE_Z	43.905	in	43.905	in	0.000	in

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

Largest Observed Differences:
0.000 inches

Values in agreement

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10.2.4 TEST #4 – NUMERICAL RESULTS

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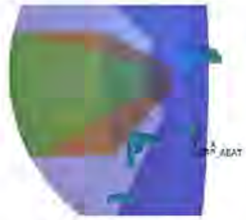
TEST #4: VARY SEATING HEIGHT/ANGLE

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	90%	PPE	17.7	18.0	SAE J826	No

Basic Accommodation

Clearance (2.0 inches)



Vision Zones

Boundary Manikins

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

Largest Observed Differences

Basic Accommodation:
0.004 inches
0.000 degrees

Manikin Placement:
0.000 inches

Values in agreement

For complete results, including calculated numerical values and their translation into CAD, see pages 141 - 175.

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TEST #4: RESULTS, ACCOMMODATION

HARP	UMTRI Value		GVSC Value		Difference	
HARP_X	0.000	in	0.000	in	0.000	in
HARP_Z	17.700	in	17.700	in	0.000	in

Eyellipse	UMTRI Value		GVSC Value		Difference	
EYELLIPSE_CENTROID_X	-0.262	in	-0.262	in	0.000	in
EYELLIPSE_CENTROID_Y (+/-)	1.280	in	1.280	in	0.000	in
EYELLIPSE_CENTROID_Z	43.225	in	43.226	in	0.001	in
EYELLIPSE_X_AXIS_LENGTH	3.907	in	3.909	in	0.003	in
EYELLIPSE_Y_AXIS_LENGTH	1.988	in	1.990	in	0.001	in
EYELLIPSE_Z_AXIS_LENGTH	4.595	in	4.596	in	0.001	in

Helmet Contour	UMTRI Value		GVSC Value		Difference	
HELMET_CONTOUR_CENTROID_X	2.986	in	2.986	in	0.000	in
HELMET_CONTOUR_CENTROID_Y (+/-)	2.185	in	2.185	in	0.000	in
HELMET_CONTOUR_CENTROID_Z	46.209	in	46.210	in	0.001	in
HELMET_CONTOUR_X_AXIS_LENGTH	14.509	in	14.512	in	0.003	in
HELMET_CONTOUR_Y_AXIS_LENGTH	9.657	in	9.659	in	0.001	in
HELMET_CONTOUR_Z_AXIS_LENGTH	11.366	in	11.368	in	0.001	in

Knee Contour	UMTRI Value		GVSC Value		Difference	
KNEE_CONTOUR_WEIGHTED_CENT_X	18.472	in	18.472	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Y (+/-)	7.594	in	7.594	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Z	19.685	in	19.685	in	0.000	in
KNEE_CONTOUR_X_AXIS_LENGTH	5.628	in	5.630	in	0.002	in
KNEE_CONTOUR_Y_AXIS_LENGTH	9.035	in	9.037	in	0.002	in
KNEE_CONTOUR_Z_AXIS_LENGTH	7.529	in	7.529	in	0.001	in
KNEE_SHIN_ANGLE	0.000	deg	0.000	deg	0.000	deg
KNEE_THIGH_ANGLE	11.743	deg	11.743	deg	0.000	deg

Elbow Contour	UMTRI Value		GVSC Value		Difference	
ELBOW_WEIGHTED_CENT_X	1.535	in	1.535	in	0.000	in
ELBOW_WEIGHTED_CENT_Y	12.473	in	12.473	in	0.000	in
ELBOW_WEIGHTED_CENT_Z	23.264	in	23.264	in	0.000	in
ELBOW_X_AXIS_LENGTH	4.996	in	5.000	in	0.004	in
ELBOW_Y_AXIS_LENGTH	3.683	in	3.684	in	0.001	in
ELBOW_Z_AXIS_LENGTH	5.779	in	5.782	in	0.003	in

Boot Contour	UMTRI Value		GVSC Value		Difference	
BOOT_TOE_WEIGHTED_CENT_X	-26.863	in	-26.863	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Y	7.594	in	7.594	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Z	0.000	in	0.000	in	0.000	in
BOOT_TOE_X_AXIS_LENGTH	1.889	in	1.890	in	0.001	in
BOOT_TOE_Y_AXIS_LENGTH	8.704	in	8.706	in	0.002	in
BOOT_TOE_Z_AXIS_LENGTH	4.921	in	4.921	in	0.000	in

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

Largest Observed Differences:
0.004 inches
0.000 degrees

Values in agreement

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TEST #4: RESULTS, MANIKIN POSITIONING

DEVCOM

	UMTRI Value		GVSC Value		Difference	
Small Overall Female						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM1_HIP_X	-0.689	in	-0.689	in	0.000	in
POSTURE_DHM1_HIP_Z	17.084	in	17.084	in	0.000	in
POSTURE_DHM1_EYE_X	0.992	in	0.992	in	0.000	in
POSTURE_DHM1_EYE_Z	39.283	in	39.283	in	0.000	in
Small Overall Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM2_HIP_X	-0.951	in	-0.951	in	0.000	in
POSTURE_DHM2_HIP_Z	17.189	in	17.189	in	0.000	in
POSTURE_DHM2_EYE_X	0.283	in	0.283	in	0.000	in
POSTURE_DHM2_EYE_Z	41.181	in	41.181	in	0.000	in
Average Size Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM3_HIP_X	-0.949	in	-0.949	in	0.000	in
POSTURE_DHM3_HIP_Z	17.188	in	17.188	in	0.000	in
POSTURE_DHM3_EYE_X	-0.458	in	-0.458	in	0.000	in
POSTURE_DHM3_EYE_Z	43.530	in	43.530	in	0.000	in
Widest Shoulders Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM4_HIP_X	-0.922	in	-0.922	in	0.000	in
POSTURE_DHM4_HIP_Z	17.178	in	17.178	in	0.000	in
POSTURE_DHM4_EYE_X	-0.832	in	-0.832	in	0.000	in
POSTURE_DHM4_EYE_Z	44.885	in	44.885	in	0.000	in
Longest Torso Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM5_HIP_X	-0.908	in	-0.908	in	0.000	in
POSTURE_DHM5_HIP_Z	17.172	in	17.172	in	0.000	in
POSTURE_DHM5_EYE_X	-0.842	in	-0.642	in	0.000	in
POSTURE_DHM5_EYE_Z	46.060	in	46.060	in	0.000	in
Longest Legs Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM6_HIP_X	-1.077	in	-1.077	in	0.000	in
POSTURE_DHM6_HIP_Z	17.240	in	17.240	in	0.000	in
POSTURE_DHM6_EYE_X	-1.024	in	-1.024	in	0.000	in
POSTURE_DHM6_EYE_Z	43.891	in	43.891	in	0.000	in
Large Overall Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM7_HIP_X	-1.309	in	-1.309	in	0.000	in
POSTURE_DHM7_HIP_Z	17.333	in	17.333	in	0.000	in
POSTURE_DHM7_EYE_X	-1.299	in	-1.299	in	0.000	in
POSTURE_DHM7_EYE_Z	45.879	in	45.879	in	0.000	in

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

Largest Observed Differences:
0.000 inches

Values in agreement

10.2.5 TEST #5 – NUMERICAL RESULTS

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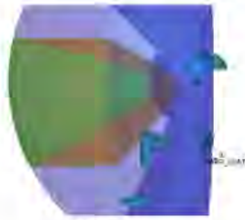
TEST #5: VARY SEATING HEIGHT/ANGLE

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	90%	PPE	15.0	10.0	SAE J826	No

Basic Accommodation

Clearance (2.0 inches)



Vision Zones

Boundary Manikins

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

Largest Observed Differences

Basic Accommodation:
0.004 inches
0.000 degrees

Manikin Placement:
0.000 inches

Values in agreement

For complete results, including calculated numerical values and their translation into CAD, see pages 176 - 210.

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TEST #5: RESULTS, ACCOMMODATION

HARP	UMTRI Value		GVSC Value		Difference	
HARP_X	0.000	in	0.000	in	0.000	in
HARP_Z	15.000	in	15.000	in	0.000	in

Eyellipse	UMTRI Value		GVSC Value		Difference	
EYELLIPSE_CENTROID_X	-2.797	in	-2.797	in	0.000	in
EYELLIPSE_CENTROID_Y (+/-)	1.280	in	1.280	in	0.000	in
EYELLIPSE_CENTROID_Z	40.519	in	40.519	in	0.001	in
EYELLIPSE_X_AXIS_LENGTH	3.907	in	3.909	in	0.002	in
EYELLIPSE_Y_AXIS_LENGTH	1.988	in	1.990	in	0.001	in
EYELLIPSE_Z_AXIS_LENGTH	4.594	in	4.596	in	0.002	in

Helmet Contour	UMTRI Value		GVSC Value		Difference	
HELMET_CONTOUR_CENTROID_X	0.451	in	0.451	in	0.000	in
HELMET_CONTOUR_CENTROID_Y (+/-)	2.185	in	2.185	in	0.000	in
HELMET_CONTOUR_CENTROID_Z	43.505	in	43.504	in	0.001	in
HELMET_CONTOUR_X_AXIS_LENGTH	14.509	in	14.512	in	0.002	in
HELMET_CONTOUR_Y_AXIS_LENGTH	9.657	in	9.659	in	0.001	in
HELMET_CONTOUR_Z_AXIS_LENGTH	11.366	in	11.368	in	0.002	in

Knee Contour	UMTRI Value		GVSC Value		Difference	
KNEE_CONTOUR_WEIGHTED_CENT_X	-17.610	in	-17.610	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Y (+/-)	7.594	in	7.594	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Z	20.087	in	20.087	in	0.000	in
KNEE_CONTOUR_X_AXIS_LENGTH	5.628	in	5.630	in	0.002	in
KNEE_CONTOUR_Y_AXIS_LENGTH	9.035	in	9.037	in	0.002	in
KNEE_CONTOUR_Z_AXIS_LENGTH	7.529	in	7.529	in	0.001	in
KNEE_SHIN_ANGLE	0.000	deg	0.000	deg	0.000	deg
KNEE_THIGH_ANGLE	21.513	deg	21.513	deg	0.000	deg

Elbow Contour	UMTRI Value		GVSC Value		Difference	
ELBOW_WEIGHTED_CENT_X	0.719	in	0.719	in	0.000	in
ELBOW_WEIGHTED_CENT_Y	12.298	in	12.298	in	0.000	in
ELBOW_WEIGHTED_CENT_Z	20.794	in	20.794	in	0.000	in
ELBOW_X_AXIS_LENGTH	4.996	in	5.000	in	0.004	in
ELBOW_Y_AXIS_LENGTH	3.683	in	3.684	in	0.001	in
ELBOW_Z_AXIS_LENGTH	5.779	in	5.782	in	0.003	in

Boot Contour	UMTRI Value		GVSC Value		Difference	
BOOT_TOE_WEIGHTED_CENT_X	-26.002	in	-26.002	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Y	7.594	in	7.594	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Z	0.000	in	0.000	in	0.000	in
BOOT_TOE_X_AXIS_LENGTH	1.889	in	1.890	in	0.001	in
BOOT_TOE_Y_AXIS_LENGTH	8.704	in	8.706	in	0.002	in
BOOT_TOE_Z_AXIS_LENGTH	4.921	in	4.921	in	0.000	in

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

Largest Observed Differences:
0.004 inches
0.000 degrees

Values in agreement

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Test #5: Results, Manikin Positioning

Small Overall Female	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM1_HIP_X	-1.233	in	-1.233	in	0.000	in
POSTURE_DHM1_HIP_Z	14.384	in	14.384	in	0.000	in
POSTURE_DHM1_EYE_X	-1.544	in	-1.544	in	0.000	in
POSTURE_DHM1_EYE_Z	36.577	in	36.577	in	0.000	in

Small Overall Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM2_HIP_X	-1.496	in	-1.496	in	0.000	in
POSTURE_DHM2_HIP_Z	14.489	in	14.489	in	0.000	in
POSTURE_DHM2_EYE_X	-2.253	in	-2.253	in	0.000	in
POSTURE_DHM2_EYE_Z	38.474	in	38.474	in	0.000	in

Average Size Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM3_HIP_X	-1.494	in	-1.494	in	0.000	in
POSTURE_DHM3_HIP_Z	14.488	in	14.488	in	0.000	in
POSTURE_DHM3_EYE_X	-2.994	in	-2.994	in	0.000	in
POSTURE_DHM3_EYE_Z	40.824	in	40.824	in	0.000	in

Widest Shoulders Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM4_HIP_X	-1.467	in	-1.467	in	0.000	in
POSTURE_DHM4_HIP_Z	14.478	in	14.478	in	0.000	in
POSTURE_DHM4_EYE_X	-3.368	in	-3.368	in	0.000	in
POSTURE_DHM4_EYE_Z	42.179	in	42.179	in	0.000	in

Longest Torso Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM5_HIP_X	-1.453	in	-1.453	in	0.000	in
POSTURE_DHM5_HIP_Z	14.472	in	14.472	in	0.000	in
POSTURE_DHM5_EYE_X	-3.377	in	-3.377	in	0.000	in
POSTURE_DHM5_EYE_Z	43.354	in	43.354	in	0.000	in

Longest Legs Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM6_HIP_X	-1.622	in	-1.622	in	0.000	in
POSTURE_DHM6_HIP_Z	14.540	in	14.540	in	0.000	in
POSTURE_DHM6_EYE_X	-3.559	in	-3.559	in	0.000	in
POSTURE_DHM6_EYE_Z	41.185	in	41.185	in	0.000	in

Large Overall Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM7_HIP_X	-1.854	in	-1.854	in	0.000	in
POSTURE_DHM7_HIP_Z	14.633	in	14.633	in	0.000	in
POSTURE_DHM7_EYE_X	-3.835	in	-3.835	in	0.000	in
POSTURE_DHM7_EYE_Z	43.173	in	43.173	in	0.000	in

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

Largest Observed Differences:
0.000 inches

Values in agreement

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10.2.6 TEST #6 – NUMERICAL RESULTS

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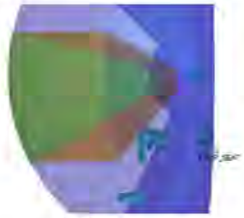
TEST #6: VARY ENSEMBLE

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	90%	ACU	15.0	10.0	SAE J826	No

Basic Accommodation

Clearance (2.0 inches)



Vision Zones

Boundary Manikins

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

Largest Observed Differences

Basic Accommodation:
0.004 inches
0.000 degrees

Manikin Placement:
0.000 inches

Values in agreement

For complete results, including calculated numerical values and their translation into CAD, see pages 211 - 242.

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TEST #6: RESULTS, ACCOMMODATION

HARP

	UMTRI Value		GVSC Value		Difference	
HARP_X	0.000	in	0.000	in	0.000	in
HARP_Z	15.000	in	15.000	in	0.000	in

Eyellipse

	UMTRI Value		GVSC Value		Difference	
EYELLIPSE_CENTROID_X	-0.750	in	-0.750	in	0.000	in
EYELLIPSE_CENTROID_Y (+/-)	1.280	in	1.280	in	0.000	in
EYELLIPSE_CENTROID_Z	40.519	in	40.519	in	0.001	in
EYELLIPSE_X_AXIS_LENGTH	3.907	in	3.909	in	0.003	in
EYELLIPSE_Y_AXIS_LENGTH	1.988	in	1.990	in	0.001	in
EYELLIPSE_Z_AXIS_LENGTH	4.594	in	4.596	in	0.002	in

Helmet Contour

The ACU ensemble does not include a helmet

Knee Contour

	UMTRI Value		GVSC Value		Difference	
KNEE_CONTOUR_WEIGHTED_CENT_X	-16.469	in	-16.469	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Y (+/-)	7.594	in	7.594	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Z	20.087	in	20.087	in	0.000	in
KNEE_CONTOUR_X_AXIS_LENGTH	5.628	in	5.630	in	0.002	in
KNEE_CONTOUR_Y_AXIS_LENGTH	9.035	in	9.037	in	0.002	in
KNEE_CONTOUR_Z_AXIS_LENGTH	7.529	in	7.529	in	0.001	in
KNEE_SHIN_ANGLE	0.000	deg	0.000	deg	0.000	deg
KNEE_THIGH_ANGLE	22.855	deg	22.855	deg	0.000	deg

Elbow Contour

	UMTRI Value		GVSC Value		Difference	
ELBOW_WEIGHTED_CENT_X	2.412	in	2.412	in	0.000	in
ELBOW_WEIGHTED_CENT_Y	11.595	in	11.595	in	0.000	in
ELBOW_WEIGHTED_CENT_Z	20.097	in	20.097	in	0.000	in
ELBOW_X_AXIS_LENGTH	4.996	in	5.000	in	0.004	in
ELBOW_Y_AXIS_LENGTH	3.683	in	3.684	in	0.001	in
ELBOW_Z_AXIS_LENGTH	5.779	in	5.782	in	0.003	in

Boot Contour

	UMTRI Value		GVSC Value		Difference	
BOOT_TOE_WEIGHTED_CENT_X	-24.860	in	-24.860	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Y	7.594	in	7.594	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Z	0.000	in	0.000	in	0.000	in
BOOT_TOE_X_AXIS_LENGTH	1.889	in	1.890	in	0.001	in
BOOT_TOE_Y_AXIS_LENGTH	8.704	in	8.706	in	0.002	in
BOOT_TOE_Z_AXIS_LENGTH	4.921	in	4.921	in	0.000	in

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

Largest Observed Differences:
0.004 inches
0.000 degrees

Values in agreement

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TEST #6: RESULTS, MANIKIN POSITIONING

Small Overall Female	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM1_HIP_X	-0.092	in	-0.092	in	0.000	in
POSTURE_DHM1_HIP_Z	14.384	in	14.384	in	0.000	in
POSTURE_DHM1_EYE_X	0.504	in	0.504	in	0.000	in
POSTURE_DHM1_EYE_Z	36.577	in	36.577	in	0.000	in

Small Overall Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM2_HIP_X	-0.354	in	-0.354	in	0.000	in
POSTURE_DHM2_HIP_Z	14.489	in	14.489	in	0.000	in
POSTURE_DHM2_EYE_X	-0.206	in	-0.206	in	0.000	in
POSTURE_DHM2_EYE_Z	38.474	in	38.474	in	0.000	in

Average Size Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM3_HIP_X	-0.352	in	-0.352	in	0.000	in
POSTURE_DHM3_HIP_Z	14.488	in	14.488	in	0.000	in
POSTURE_DHM3_EYE_X	-0.946	in	-0.946	in	0.000	in
POSTURE_DHM3_EYE_Z	40.824	in	40.824	in	0.000	in

Widest Shoulders Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM4_HIP_X	-0.325	in	-0.325	in	0.000	in
POSTURE_DHM4_HIP_Z	14.478	in	14.478	in	0.000	in
POSTURE_DHM4_EYE_X	-1.320	in	-1.320	in	0.000	in
POSTURE_DHM4_EYE_Z	42.179	in	42.179	in	0.000	in

Longest Torso Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM5_HIP_X	-0.311	in	-0.311	in	0.000	in
POSTURE_DHM5_HIP_Z	14.472	in	14.472	in	0.000	in
POSTURE_DHM5_EYE_X	-1.330	in	-1.330	in	0.000	in
POSTURE_DHM5_EYE_Z	43.354	in	43.354	in	0.000	in

Longest Legs Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM6_HIP_X	-0.480	in	-0.480	in	0.000	in
POSTURE_DHM6_HIP_Z	14.540	in	14.540	in	0.000	in
POSTURE_DHM6_EYE_X	-1.512	in	-1.512	in	0.000	in
POSTURE_DHM6_EYE_Z	41.185	in	41.185	in	0.000	in

Large Overall Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM7_HIP_X	-0.712	in	-0.712	in	0.000	in
POSTURE_DHM7_HIP_Z	14.633	in	14.633	in	0.000	in
POSTURE_DHM7_EYE_X	-1.788	in	-1.788	in	0.000	in
POSTURE_DHM7_EYE_Z	43.173	in	43.173	in	0.000	in

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

Largest Observed Differences:
0.000 inches

Values in agreement

10.2.7 TEST #7 – NUMERICAL RESULTS

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TEST #7: VARY TARGET ACCOMMODATION AND ENSEMBLE

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
95%	90%	ENC	15.0	10.0	SAE J826	No

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

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

Largest Observed Differences

Basic Accommodation:
0.005 inches
0.000 degrees

Manikin Placement:
0.000 inches

Values in agreement

For complete results, including calculated numerical values and their translation into CAD, see pages 243 - 277.

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TEST #7: RESULTS, ACCOMMODATION

HARP	UMTRI Value		GVSC Value		Difference	
HARP_X	0.000	in	0.000	in	0.000	in
HARP_Z	15.000	in	15.000	in	0.000	in
Eyellipse	UMTRI Value		GVSC Value		Difference	
EYELLIPSE_CENTROID_X	-5.196	in	-5.196	in	0.000	in
EYELLIPSE_CENTROID_Y (+/-)	1.280	in	1.280	in	0.000	in
EYELLIPSE_CENTROID_Z	40.483	in	40.485	in	0.002	in
EYELLIPSE_X_AXIS_LENGTH	4.656	in	4.656	in	0.001	in
EYELLIPSE_Y_AXIS_LENGTH	2.369	in	2.369	in	0.001	in
EYELLIPSE_Z_AXIS_LENGTH	5.492	in	5.490	in	0.002	in
Helmet Contour	UMTRI Value		GVSC Value		Difference	
HELMET_CONTOUR_CENTROID_X	-1.948	in	-1.948	in	0.000	in
HELMET_CONTOUR_CENTROID_Y (+/-)	2.185	in	2.185	in	0.000	in
HELMET_CONTOUR_CENTROID_Z	43.468	in	43.469	in	0.002	in
HELMET_CONTOUR_X_AXIS_LENGTH	15.258	in	15.259	in	0.001	in
HELMET_CONTOUR_Y_AXIS_LENGTH	10.038	in	10.039	in	0.001	in
HELMET_CONTOUR_Z_AXIS_LENGTH	12.264	in	12.262	in	0.002	in
Knee Contour	UMTRI Value		GVSC Value		Difference	
KNEE_CONTOUR_WEIGHTED_CENT_X	-19.303	in	-19.303	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Y (+/-)	7.594	in	7.594	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Z	20.087	in	20.087	in	0.000	in
KNEE_CONTOUR_X_AXIS_LENGTH	6.348	in	6.348	in	0.001	in
KNEE_CONTOUR_Y_AXIS_LENGTH	9.951	in	9.951	in	0.000	in
KNEE_CONTOUR_Z_AXIS_LENGTH	9.354	in	8.348	in	0.005	in
KNEE_SHIN_ANGLE	0.000	deg	0.000	deg	0.000	deg
KNEE_THIGH_ANGLE	19.778	deg	19.778	deg	0.000	deg
Elbow Contour	UMTRI Value		GVSC Value		Difference	
ELBOW_WEIGHTED_CENT_X	-3.611	in	-3.611	in	0.000	in
ELBOW_WEIGHTED_CENT_Y	14.530	in	14.530	in	0.000	in
ELBOW_WEIGHTED_CENT_Z	23.242	in	23.242	in	0.000	in
ELBOW_X_AXIS_LENGTH	5.955	in	5.955	in	0.002	in
ELBOW_Y_AXIS_LENGTH	4.409	in	4.407	in	0.001	in
ELBOW_Z_AXIS_LENGTH	6.624	in	6.625	in	0.001	in

Boot Contour	UMTRI Value		GVSC Value		Difference	
BOOT_TOE_WEIGHTED_CENT_X	-27.695	in	-27.695	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Y	7.594	in	7.594	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Z	0.000	in	0.000	in	0.000	in
BOOT_TOE_X_AXIS_LENGTH	2.199	in	2.200	in	0.001	in
BOOT_TOE_Y_AXIS_LENGTH	9.620	in	9.620	in	0.000	in
BOOT_TOE_Z_AXIS_LENGTH	4.921	in	4.921	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
0.000 degrees

Values in agreement

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Test #7: Results, Manikin Positioning

	UMTRI Value		GVSC Value		Difference	
Small Overall Female						
POSTURE_DHM1_HIP_X	-2.926	in	-2.926	in	0.000	in
POSTURE_DHM1_HIP_Z	14.384	in	14.384	in	0.000	in
POSTURE_DHM1_EYE_X	-3.945	in	-3.945	in	0.000	in
POSTURE_DHM1_EYE_Z	36.577	in	36.577	in	0.000	in
Small Overall Male						
POSTURE_DHM2_HIP_X	-3.189	in	-3.189	in	0.000	in
POSTURE_DHM2_HIP_Z	14.489	in	14.489	in	0.000	in
POSTURE_DHM2_EYE_X	-4.654	in	-4.654	in	0.000	in
POSTURE_DHM2_EYE_Z	38.474	in	38.474	in	0.000	in
Average Size Male						
POSTURE_DHM3_HIP_X	-3.187	in	-3.187	in	0.000	in
POSTURE_DHM3_HIP_Z	14.488	in	14.488	in	0.000	in
POSTURE_DHM3_EYE_X	-5.395	in	-5.395	in	0.000	in
POSTURE_DHM3_EYE_Z	40.824	in	40.824	in	0.000	in
Widest Shoulders Male						
POSTURE_DHM4_HIP_X	-3.160	in	-3.160	in	0.000	in
POSTURE_DHM4_HIP_Z	14.478	in	14.478	in	0.000	in
POSTURE_DHM4_EYE_X	-5.769	in	-5.769	in	0.000	in
POSTURE_DHM4_EYE_Z	42.179	in	42.179	in	0.000	in
Longest Torso Male						
POSTURE_DHM5_HIP_X	-3.146	in	-3.146	in	0.000	in
POSTURE_DHM5_HIP_Z	14.472	in	14.472	in	0.000	in
POSTURE_DHM5_EYE_X	-5.779	in	-5.779	in	0.000	in
POSTURE_DHM5_EYE_Z	43.354	in	43.354	in	0.000	in
Longest Legs Male						
POSTURE_DHM6_HIP_X	-3.315	in	-3.315	in	0.000	in
POSTURE_DHM6_HIP_Z	14.540	in	14.540	in	0.000	in
POSTURE_DHM6_EYE_X	-5.961	in	-5.961	in	0.000	in
POSTURE_DHM6_EYE_Z	41.185	in	41.185	in	0.000	in
Large Overall Male						
POSTURE_DHM7_HIP_X	-3.547	in	-3.547	in	0.000	in
POSTURE_DHM7_HIP_Z	14.633	in	14.633	in	0.000	in
POSTURE_DHM7_EYE_X	-6.236	in	-6.236	in	0.000	in
POSTURE_DHM7_EYE_Z	43.173	in	43.173	in	0.000	in

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

Largest Observed Differences:
0.000 inches

Values in agreement

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10.2.8 TEST #8 – NUMERICAL RESULTS

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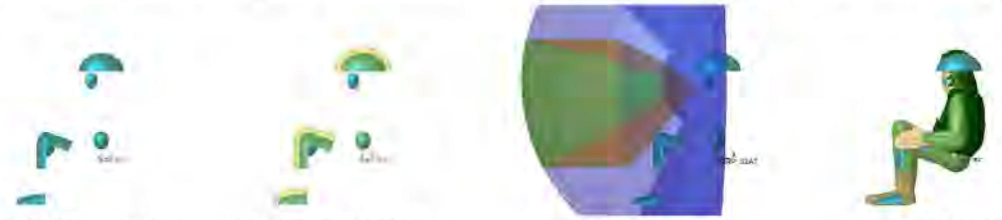
TEST #8: VARY GENDER MIX

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	50%	PPE	15.0	10.0	SAE J826	No



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

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

Largest Observed Differences

Basic Accommodation:
0.003 inches
0.000 degrees

Manikin Placement:
0.000 inches

Values in agreement

For complete results, including calculated numerical values and their translation into CAD, see pages 278 - 312

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TEST #8: RESULTS, ACCOMMODATION

HARP	UMTRI Value		GVSC Value		Difference	
HARP_X	0.000	in	0.000	in	0.000	in
HARP_Z	15.000	in	15.000	in	0.000	in
Eyellipse						
EYELLIPSE_CENTROID_X	-2.540	in	-2.540	in	0.000	in
EYELLIPSE_CENTROID_Y (+/-)	1.280	in	1.280	in	0.000	in
EYELLIPSE_CENTROID_Z	39.880	in	39.880	in	0.000	in
EYELLIPSE_X_AXIS_LENGTH	3.993	in	3.995	in	0.002	in
EYELLIPSE_Y_AXIS_LENGTH	1.988	in	1.990	in	0.001	in
EYELLIPSE_Z_AXIS_LENGTH	5.098	in	5.097	in	0.000	in
Helmet Contour						
HELMET_CONTOUR_CENTROID_X	0.708	in	0.708	in	0.000	in
HELMET_CONTOUR_CENTROID_Y (+/-)	2.185	in	2.185	in	0.000	in
HELMET_CONTOUR_CENTROID_Z	42.865	in	42.865	in	0.000	in
HELMET_CONTOUR_X_AXIS_LENGTH	14.596	in	14.597	in	0.002	in
HELMET_CONTOUR_Y_AXIS_LENGTH	9.657	in	9.659	in	0.001	in
HELMET_CONTOUR_Z_AXIS_LENGTH	11.869	in	11.869	in	0.000	in
Knee Contour						
KNEE_CONTOUR_WEIGHTED_CENT_X	-17.097	in	-17.097	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Y (+/-)	7.135	in	7.135	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Z	19.425	in	19.425	in	0.000	in
KNEE_CONTOUR_X_AXIS_LENGTH	6.029	in	6.029	in	0.000	in
KNEE_CONTOUR_Y_AXIS_LENGTH	9.212	in	9.214	in	0.001	in
KNEE_CONTOUR_Z_AXIS_LENGTH	7.843	in	7.843	in	0.000	in
KNEE_SHIN_ANGLE	0.000	deg	0.000	deg	0.000	deg
KNEE_THIGH_ANGLE	20.167	deg	20.167	deg	0.000	deg
Elbow Contour						
ELBOW_WEIGHTED_CENT_X	0.582	in	0.582	in	0.000	in
ELBOW_WEIGHTED_CENT_Y	11.852	in	11.852	in	0.000	in
ELBOW_WEIGHTED_CENT_Z	20.539	in	20.539	in	0.000	in
ELBOW_X_AXIS_LENGTH	5.006	in	5.009	in	0.003	in
ELBOW_Y_AXIS_LENGTH	3.857	in	3.857	in	0.000	in
ELBOW_Z_AXIS_LENGTH	5.843	in	5.845	in	0.002	in

Boot Contour	UMTRI Value		GVSC Value		Difference	
BOOT_TOE_WEIGHTED_CENT_X	-25.302	in	-25.302	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Y	7.135	in	7.135	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Z	0.000	in	0.000	in	0.000	in
BOOT_TOE_X_AXIS_LENGTH	2.989	in	2.989	in	0.001	in
BOOT_TOE_Y_AXIS_LENGTH	8.882	in	8.883	in	0.001	in
BOOT_TOE_Z_AXIS_LENGTH	4.921	in	4.921	in	0.000	in

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

Largest Observed Differences:
0.003 inches
0.000 degrees

Values in agreement

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TEST #8: RESULTS, MANIKIN POSITIONING

Small Overall Female						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM1_HIP_X	-1.233	in	-1.233	in	0.000	in
POSTURE_DHM1_HIP_Z	14.384	in	14.384	in	0.000	in
POSTURE_DHM1_EYE_X	-1.544	in	-1.544	in	0.000	in
POSTURE_DHM1_EYE_Z	36.577	in	36.577	in	0.000	in

Small Overall Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM2_HIP_X	-1.496	in	-1.496	in	0.000	in
POSTURE_DHM2_HIP_Z	14.489	in	14.489	in	0.000	in
POSTURE_DHM2_EYE_X	-2.253	in	-2.253	in	0.000	in
POSTURE_DHM2_EYE_Z	38.474	in	38.474	in	0.000	in

Average Size Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM3_HIP_X	-1.494	in	-1.494	in	0.000	in
POSTURE_DHM3_HIP_Z	14.488	in	14.488	in	0.000	in
POSTURE_DHM3_EYE_X	-2.994	in	-2.994	in	0.000	in
POSTURE_DHM3_EYE_Z	40.824	in	40.824	in	0.000	in

Widest Shoulders Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM4_HIP_X	-1.467	in	-1.467	in	0.000	in
POSTURE_DHM4_HIP_Z	14.478	in	14.478	in	0.000	in
POSTURE_DHM4_EYE_X	-3.368	in	-3.368	in	0.000	in
POSTURE_DHM4_EYE_Z	42.179	in	42.179	in	0.000	in

Longest Torso Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM5_HIP_X	-1.453	in	-1.453	in	0.000	in
POSTURE_DHM5_HIP_Z	14.472	in	14.472	in	0.000	in
POSTURE_DHM5_EYE_X	-3.377	in	-3.377	in	0.000	in
POSTURE_DHM5_EYE_Z	43.354	in	43.354	in	0.000	in

Longest Legs Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM6_HIP_X	-1.622	in	-1.622	in	0.000	in
POSTURE_DHM6_HIP_Z	14.540	in	14.540	in	0.000	in
POSTURE_DHM6_EYE_X	-3.559	in	-3.559	in	0.000	in
POSTURE_DHM6_EYE_Z	41.185	in	41.185	in	0.000	in

Large Overall Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM7_HIP_X	-1.854	in	-1.854	in	0.000	in
POSTURE_DHM7_HIP_Z	14.633	in	14.633	in	0.000	in
POSTURE_DHM7_EYE_X	-3.835	in	-3.835	in	0.000	in
POSTURE_DHM7_EYE_Z	43.173	in	43.173	in	0.000	in

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

Largest Observed Differences:
0.000 inches

Values in agreement

10.2.9 TEST #9 – NUMERICAL RESULTS

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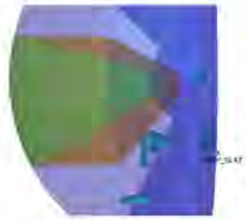
TEST #9: VARY GENDER MIX

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	50%	ACU	15.0	10.0	SAE J826	No


Basic Accommodation


Clearance (2.0 inches)


Vision Zones


Boundary Manikins

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

Largest Observed Differences

Basic Accommodation:
0.003 inches
0.000 degrees

Manikin Placement:
0.000 inches

Values in agreement

For complete results, including calculated numerical values and their translation into CAD, see pages 313 - 344.

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TEST #9: RESULTS, ACCOMMODATION

HARP

	UMTRI Value		GVSC Value		Difference	
HARP_X	0.000	in	0.000	in	0.000	in
HARP_Z	15.000	in	15.000	in	0.000	in

Eyellipse

	UMTRI Value		GVSC Value		Difference	
EYELLIPSE_CENTROID_X	-0.493	in	-0.493	in	0.000	in
EYELLIPSE_CENTROID_Y (+/-)	1.280	in	1.280	in	0.000	in
EYELLIPSE_CENTROID_Z	39.880	in	39.880	in	0.000	in
EYELLIPSE_X_AXIS_LENGTH	3.993	in	3.995	in	0.002	in
EYELLIPSE_Y_AXIS_LENGTH	1.988	in	1.990	in	0.001	in
EYELLIPSE_Z_AXIS_LENGTH	5.098	in	5.097	in	0.000	in

Helmet Contour

The ACU ensemble does not include a helmet

Knee Contour

	UMTRI Value		GVSC Value		Difference	
KNEE_CONTOUR_WEIGHTED_CENT_X	-15.955	in	-15.955	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Y (+/-)	7.135	in	7.135	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Z	19.425	in	19.425	in	0.000	in
KNEE_CONTOUR_X_AXIS_LENGTH	6.029	in	6.029	in	0.000	in
KNEE_CONTOUR_Y_AXIS_LENGTH	9.212	in	9.214	in	0.001	in
KNEE_CONTOUR_Z_AXIS_LENGTH	7.843	in	7.843	in	0.000	in
KNEE_SHIN_ANGLE	0.000	deg	0.000	deg	0.000	deg
KNEE_THIGH_ANGLE	21.482	deg	21.482	deg	0.000	deg

Elbow Contour

	UMTRI Value		GVSC Value		Difference	
ELBOW_WEIGHTED_CENT_X	2.274	in	2.274	in	0.000	in
ELBOW_WEIGHTED_CENT_Y	11.139	in	11.139	in	0.000	in
ELBOW_WEIGHTED_CENT_Z	19.842	in	19.842	in	0.000	in
ELBOW_X_AXIS_LENGTH	5.006	in	5.009	in	0.003	in
ELBOW_Y_AXIS_LENGTH	3.857	in	3.857	in	0.000	in
ELBOW_Z_AXIS_LENGTH	5.843	in	5.845	in	0.002	in

Boot Contour

	UMTRI Value		GVSC Value		Difference	
BOOT_TOE_WEIGHTED_CENT_X	-24.160	in	-24.160	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Y	7.135	in	7.135	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Z	0.000	in	0.000	in	0.000	in
BOOT_TOE_X_AXIS_LENGTH	2.988	in	2.989	in	0.001	in
BOOT_TOE_Y_AXIS_LENGTH	8.882	in	8.883	in	0.001	in
BOOT_TOE_Z_AXIS_LENGTH	4.921	in	4.921	in	0.000	in

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

Largest Observed Differences:
0.003 inches
0.000 degrees

Values in agreement

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TEST #9: RESULTS, MANIKIN POSITIONING

DEVCOM

	UMTRI Value		GVSC Value		Difference	
Small Overall Female						
POSTURE_DHM1_HIP_X	-0.092	in	-0.092	in	0.000	in
POSTURE_DHM1_HIP_Z	14.384	in	14.384	in	0.000	in
POSTURE_DHM1_EYE_X	0.504	in	0.504	in	0.000	in
POSTURE_DHM1_EYE_Z	36.577	in	36.577	in	0.000	in
Small Overall Male						
POSTURE_DHM2_HIP_X	-0.354	in	-0.354	in	0.000	in
POSTURE_DHM2_HIP_Z	14.489	in	14.489	in	0.000	in
POSTURE_DHM2_EYE_X	-0.206	in	-0.206	in	0.000	in
POSTURE_DHM2_EYE_Z	38.474	in	38.474	in	0.000	in
Average Size Male						
POSTURE_DHM3_HIP_X	-0.352	in	-0.352	in	0.000	in
POSTURE_DHM3_HIP_Z	14.488	in	14.488	in	0.000	in
POSTURE_DHM3_EYE_X	-0.946	in	-0.946	in	0.000	in
POSTURE_DHM3_EYE_Z	40.824	in	40.824	in	0.000	in
Widest Shoulders Male						
POSTURE_DHM4_HIP_X	-0.325	in	-0.325	in	0.000	in
POSTURE_DHM4_HIP_Z	14.478	in	14.478	in	0.000	in
POSTURE_DHM4_EYE_X	-1.320	in	-1.320	in	0.000	in
POSTURE_DHM4_EYE_Z	42.179	in	42.179	in	0.000	in
Longest Torso Male						
POSTURE_DHM5_HIP_X	-0.311	in	-0.311	in	0.000	in
POSTURE_DHM5_HIP_Z	14.472	in	14.472	in	0.000	in
POSTURE_DHM5_EYE_X	-1.330	in	-1.330	in	0.000	in
POSTURE_DHM5_EYE_Z	43.354	in	43.354	in	0.000	in
Longest Legs Male						
POSTURE_DHM6_HIP_X	-0.480	in	-0.480	in	0.000	in
POSTURE_DHM6_HIP_Z	14.540	in	14.540	in	0.000	in
POSTURE_DHM6_EYE_X	-1.512	in	-1.512	in	0.000	in
POSTURE_DHM6_EYE_Z	41.185	in	41.185	in	0.000	in
Large Overall Male						
POSTURE_DHM7_HIP_X	-0.712	in	-0.712	in	0.000	in
POSTURE_DHM7_HIP_Z	14.633	in	14.633	in	0.000	in
POSTURE_DHM7_EYE_X	-1.788	in	-1.788	in	0.000	in
POSTURE_DHM7_EYE_Z	43.173	in	43.173	in	0.000	in

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

Largest Observed Differences:
0.000 inches

Values in agreement

10.2.10 TEST #10 – NUMERICAL RESULTS

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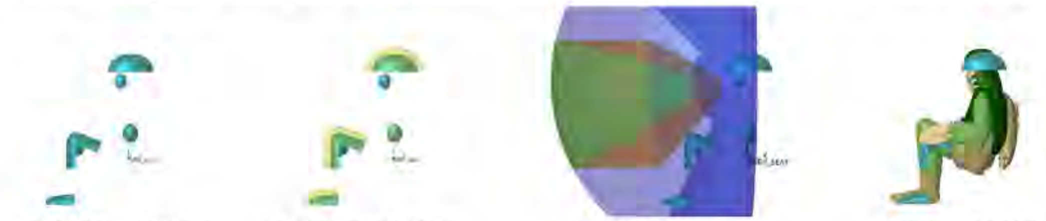
Test #10: Provide Hydration Pack Relief

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	50%	ENC	15.0	10.0	SAE J826	Yes



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

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

Largest Observed Differences

Basic Accommodation:
0.003 inches
0.000 degrees

Manikin Placement:
0.000 inches

Values in agreement

For complete results, including calculated numerical values and their translation into CAD, see pages 345 - 379.

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Test #10: Results, Accommodation

HARP	UMTRI Value		GVSC Value		Difference	
HARP_X	0.000	in	0.000	in	0.000	in
HARP_Z	15.000	in	15.000	in	0.000	in

Eyellipse	UMTRI Value		GVSC Value		Difference	
EYELLIPSE_CENTROID_X	-2.540	in	-2.540	in	0.000	in
EYELLIPSE_CENTROID_Y (+/-)	1.280	in	1.280	in	0.000	in
EYELLIPSE_CENTROID_Z	39.880	in	39.880	in	0.000	in
EYELLIPSE_X_AXIS_LENGTH	3.993	in	3.995	in	0.002	in
EYELLIPSE_Y_AXIS_LENGTH	1.988	in	1.990	in	0.001	in
EYELLIPSE_Z_AXIS_LENGTH	5.098	in	5.097	in	0.000	in

Helmet Contour	UMTRI Value		GVSC Value		Difference	
HELMET_CONTOUR_CENTROID_X	0.708	in	0.708	in	0.000	in
HELMET_CONTOUR_CENTROID_Y (+/-)	2.185	in	2.185	in	0.000	in
HELMET_CONTOUR_CENTROID_Z	42.865	in	42.865	in	0.000	in
HELMET_CONTOUR_X_AXIS_LENGTH	14.596	in	14.597	in	0.002	in
HELMET_CONTOUR_Y_AXIS_LENGTH	9.657	in	9.659	in	0.001	in
HELMET_CONTOUR_Z_AXIS_LENGTH	11.869	in	11.869	in	0.000	in

Knee Contour	UMTRI Value		GVSC Value		Difference	
KNEE_CONTOUR_WEIGHTED_CENT_X	-17.097	in	-17.097	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Y (+/-)	7.135	in	7.135	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Z	19.425	in	19.425	in	0.000	in
KNEE_CONTOUR_X_AXIS_LENGTH	6.029	in	6.029	in	0.000	in
KNEE_CONTOUR_Y_AXIS_LENGTH	9.212	in	9.214	in	0.001	in
KNEE_CONTOUR_Z_AXIS_LENGTH	7.843	in	7.843	in	0.000	in
KNEE_SHIN_ANGLE	0.000	deg	0.000	deg	0.000	deg
KNEE_THIGH_ANGLE	20.167	deg	20.167	deg	0.000	deg

Elbow Contour	UMTRI Value		GVSC Value		Difference	
ELBOW_WEIGHTED_CENT_X	0.582	in	0.582	in	0.000	in
ELBOW_WEIGHTED_CENT_Y	14.084	in	14.084	in	0.000	in
ELBOW_WEIGHTED_CENT_Z	22.988	in	22.988	in	0.000	in
ELBOW_X_AXIS_LENGTH	5.006	in	5.009	in	0.003	in
ELBOW_Y_AXIS_LENGTH	3.857	in	3.857	in	0.000	in
ELBOW_Z_AXIS_LENGTH	5.843	in	5.845	in	0.002	in

Boot Contour	UMTRI Value		GVSC Value		Difference	
BOOT_TOE_WEIGHTED_CENT_X	-25.302	in	-25.302	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Y	7.135	in	7.135	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Z	0.000	in	0.000	in	0.000	in
BOOT_TOE_X_AXIS_LENGTH	2.988	in	2.989	in	0.001	in
BOOT_TOE_Y_AXIS_LENGTH	8.882	in	8.883	in	0.001	in
BOOT_TOE_Z_AXIS_LENGTH	4.321	in	4.321	in	0.000	in

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

Largest Observed Differences:
0.003 inches
0.000 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	-1.233	in	-1.233	in	0.000	in
POSTURE_DHM1_HIP_Z	14.384	in	14.384	in	0.000	in
POSTURE_DHM1_EYE_X	-1.544	in	-1.544	in	0.000	in
POSTURE_DHM1_EYE_Z	36.577	in	36.577	in	0.000	in

Small Overall Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM2_HIP_X	-1.496	in	-1.496	in	0.000	in
POSTURE_DHM2_HIP_Z	14.489	in	14.489	in	0.000	in
POSTURE_DHM2_EYE_X	-2.253	in	-2.253	in	0.000	in
POSTURE_DHM2_EYE_Z	38.474	in	38.474	in	0.000	in

Average Size Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM3_HIP_X	-1.494	in	-1.494	in	0.000	in
POSTURE_DHM3_HIP_Z	14.488	in	14.488	in	0.000	in
POSTURE_DHM3_EYE_X	-2.994	in	-2.994	in	0.000	in
POSTURE_DHM3_EYE_Z	40.824	in	40.824	in	0.000	in

Widest Shoulders Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM4_HIP_X	-1.467	in	-1.467	in	0.000	in
POSTURE_DHM4_HIP_Z	14.478	in	14.478	in	0.000	in
POSTURE_DHM4_EYE_X	-3.368	in	-3.368	in	0.000	in
POSTURE_DHM4_EYE_Z	42.179	in	42.179	in	0.000	in

Longest Torso Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM5_HIP_X	-1.453	in	-1.453	in	0.000	in
POSTURE_DHM5_HIP_Z	14.472	in	14.472	in	0.000	in
POSTURE_DHM5_EYE_X	-3.377	in	-3.377	in	0.000	in
POSTURE_DHM5_EYE_Z	43.354	in	43.354	in	0.000	in

Longest Legs Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM6_HIP_X	-1.622	in	-1.622	in	0.000	in
POSTURE_DHM6_HIP_Z	14.540	in	14.540	in	0.000	in
POSTURE_DHM6_EYE_X	-3.559	in	-3.559	in	0.000	in
POSTURE_DHM6_EYE_Z	41.185	in	41.185	in	0.000	in

Large Overall Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM7_HIP_X	-1.854	in	-1.854	in	0.000	in
POSTURE_DHM7_HIP_Z	14.633	in	14.633	in	0.000	in
POSTURE_DHM7_EYE_X	-3.835	in	-3.835	in	0.000	in
POSTURE_DHM7_EYE_Z	43.173	in	43.173	in	0.000	in

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

Largest Observed Differences:
0.000 inches

Values in agreement

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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
CAD	Computer-Aided Design
CCDC	Combat Capabilities Development Command
COTS	Commercial Off-The-Shelf
CSI	Center for System Integration
DAC	Data and Analysis Center
EMD	Engineering Manufacturing and Development
ENC	Encumbered
ESAPI	Enhanced Small Arms Protective Insert
ESBI	Enhanced Side Ballistic Inserts
FOV	Field-of-View
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
OCP	Occupant Centric Platform
PPE	Personal Protective Equipment
SAW	Squad Automatic Weapon
SIP	Seat Index Point
SME	Subject Matter Experts
TAP	Tactical Assault Panel
TECD	Technology Capability Demonstration
UMTRI	University of Michigan Transportation Research Institute

10.5 APPENDIX E – DISTRIBUTION LIST

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10.6 APPENDIX F – VERIFICATION PLAN

The *Fixed Seat: Non-Driver CAD Accommodation Model Verification Plan* (2019) can be found on the CCDC 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. (2019). U.S. Army Combat Capabilities Development Command (CCDC) Ground Vehicle Systems Center (GVSC) Fixed Seat: Non-Driver CAD Accommodation Model Verification Plan. http://www.usarmygvsc.com/index.php/accommodation-models/. U.S. Army CCDC GVSC, Warren, MI.

10.7 APPENDIX G - INITIAL TASK ANALYSIS

Ten different test scenarios were completed for the verification package sent out on 4 February 2020. This section outlines each test scenario and compares GVSC's CAD results to UMTRI's Microsoft Excel results. The model geometry was adjusted by changing values assigned to the input parameter table in the CAD top assembly and then regenerating the model.

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PURPOSE

DEVCOM

Verify the GVSC™ Fixed Seat: Non-Driver CAD accommodation model

What is verification?

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.

Does the GVSC™ Fixed Seat: Non-Driver CAD accommodation model output match the UMTRI accommodation model spreadsheet output?

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DEFINING IN-VEHICLE OCCUPANT POSITIONING POSTURE PREDICTION AND ACCOMMODATION MODELS

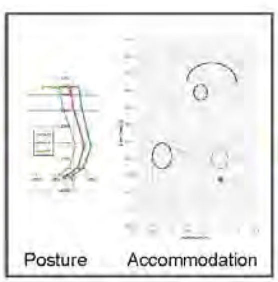
DEVCOM

Empirical Soldier data is being used to develop CAD tools that realistically posture and position boundary manikins and predict population body boundaries for crew and squad

- Results, which are repeatable, allow for vehicle design from the occupant outward
- Trades between the vehicle and its occupants are data driven and quantifiable

UMTRI Seated Soldier Study

Soldier preferred posture and positioning, while wearing varying levels of encumbrance, were recorded in driver and squad mockups



UMTRI Posture Prediction

Statistical analysis of the data summarized in Excel-based posture prediction (individuals) and accommodation models (populations)

GVSC CAD Integration

Morphing parametric CAD models created that respond to user inputs for Soldier population, accommodation level, and vehicle environment

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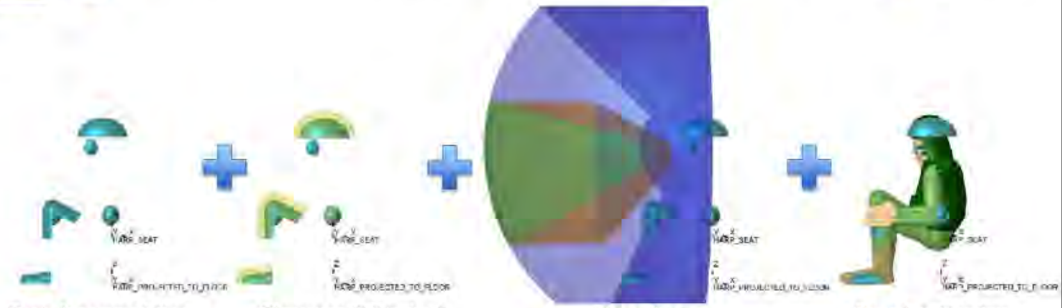
ACCOMMODATION TOOLS, A LAYERED APPROACH



The GVSC™ Fixed Seat: Non-Driver CAD Accommodation Model consists of the following:

Basic Accommodation
Population body boundaries representing the aggregate of all occupant positions in the vehicle environment for the target design population

Basic accommodation is calculated by the CAD model using equations from the UMTRI Microsoft Excel spreadsheet *Soldier Squad Accommodation Models 2019-07-07*

Clearance (2.0 inches)
Clearance between the target design population and the surrounding vehicle environment

Clearances are added to the CAD model by layering a second set of geometry in which basic accommodation values are increased (e.g. helmet contour axis values) or shifted (e.g. elbow contour centroids) as needed

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ACCOMMODATION TOOLS, A LAYERED APPROACH

Vision Zones
The direct field of view (divided into primary, secondary, and tertiary zones) using a combination of vertical and horizontal visual fields from MIL-STD-1472 and SAE J1050

Vision zones are created geometrically by applying vision zone principles (e.g. 15 degree lateral eye rotation) to basic accommodation output representing the target population's eyes

Boundary Manikins
Positioned boundary manikins provide another reference for design

The 2015 Boundary Manikins are nominally positioned as follows:

- Hip and eye point locations are calculated by the CAD model using equations from UMTRI's Excel spreadsheet *Seated Soldier Posture Prediction 2019-07-08*
- Torso angles are calculated to allow manikins to simultaneously hold hip and eye points, using the following assumptions:
  - the torso is in a functional posture
  - the head is held level
  - angle differences between the head and torso are evenly split between the top and bottom of the neck
- Leg angles are calculated such that the lower legs are vertical with feet flat on the floor and knees are splayed to the mean knee locations (by gender)
- Arm angles are calculated such that lower arms are parallel to ground, upper arms are perpendicular to lower arms, and elbows are splayed to the mean elbow locations (by gender)

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MANIKIN VARIABLES

DEVCOM

Inputs

Vehicle Environment
- Seat Height, via HARP
- Seat Back Angle (A40)

Boundary Manikin Anthropometry
- Stature
- Body Weight
- Erect Seating Height

Outputs

Hip Locator Coordinates

Eye Locator Coordinates

Anthropometric values, used for all test cases, are as follows:

DHM #1 Small Overall Female		
Stature	1507	mm
Body Weight	50.2	kg
Erect Sitting Height	779	mm
DHM #2 Small Overall Male		
Stature	1643	mm
Body Weight	66	kg
Erect Sitting Height	842	mm
DHM #3 Average Size Male		
Stature	1804	mm
Body Weight	79.5	kg
Erect Sitting Height	920	mm
DHM #4 Widest Shoulders Male		
Stature	1887	mm
Body Weight	86.1	kg
Erect Sitting Height	965	mm
DHM #5 longest Torso Male		
Stature	1890	mm
Body Weight	85.9	kg
Erect Sitting Height	1004	mm
DHM #6 Longest Legs Male		
Stature	1918	mm
Body Weight	94.4	kg
Erect Sitting Height	932	mm
DHM #7 large Overall Male		
Stature	1962	mm
Body Weight	108	kg
Erect Sitting Height	998	mm

WHAT IS THE SCOPE OF THE VERIFICATION?

DEVCOM

The GVSC™ Fixed Seat: Non-Driver CAD accommodation model will be audited to determine the following, which is based on Soldier data and SME guidance:

1) Determine if the accommodation boundaries generated by the GVSC™ CAD model matches the UMTRI Microsoft Excel spreadsheet *Soldier Squad Accommodation Models 2019-07-07*
2) Determine if the clearance zones (helmet, elbows, knees, legs, shins, and boots) match what Subject Matter Experts (SME) interpreted using MIL-STD-1472G
3) Determine if direct field of view (primary, secondary, and tertiary) matches what SMEs interpreted using MIL-STD-1472G and SAE J1050
4) Determine if the hip and eye point of the CAD boundary manikins match the UMTRI Microsoft Excel spreadsheet *Seated Soldier Posture Prediction 2019-07-08*

ACCEPTABILITY CRITERIA

Inputs

#	M&S Requirement	Acceptability Criteria	Metrics/Measures
1	Model allows for selection of seat hydration pack relief in the seat	1.1 Hydration pack relief selection of "yes" in model	1.1 Representative (Pass) / Non-Representative (Fail)
		1.2 Hydration pack relief selection of "no" in model	1.2 Representative (Pass) / Non-Representative (Fail)
2	Model allows for selection of either SAE J826 or ISO 5353 for the Human Accommodation Reference Point (HARP) measurement tool	2.1 HARP measurement tool selection of SAE J826 in model	2.1 Representative (Pass) / Non-Representative (Fail)
		2.2 HARP measurement tool selection of ISO 5353 in model	2.2 Representative (Pass) / Non-Representative (Fail)
3	Model allows for input of the population gender mix (e.g. 85% Male : 15% Female)	3.1 Fraction male input option in model	3.1 Representative (Pass) / Non-Representative (Fail)
4	Model allows for selection of ensemble as either PPE or ENC	4.1 Ensemble selection of PPE in model	4.1 Representative (Pass) / Non-Representative (Fail)
		4.2 Ensemble selection of ENC in model	4.2 Representative (Pass) / Non-Representative (Fail)
5	Model allows for a target population input (e.g. 90%)	5.1 Target accommodation input option in model	5.1 Representative (Pass) / Non-Representative (Fail)
6	Model allows for input of the seat height	6.1 Seat height input option in model	6.1 Representative (Pass) / Non-Representative (Fail)
7	Model allows for input of the seat back angle	7.1 Seat back angle input option in model	7.1 Representative (Pass) / Non-Representative (Fail)

Outputs

#	M&S Requirement	Acceptability Criteria	Metrics/Measures
8	Model predicts the dimensions and location of the eyellipse	8.1 Model outputs a left and right eyellipse for a given population and	8.1 Representative (Pass) / Non-Representative (Fail)
9			
10			

#	M&S Requirement	Acceptability Criteria	Metrics/Measures
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	12.1 Representative (Pass) / Non-Representative (Fail)
		11.2 TARDEC CAD model matches the UMTRI spreadsheet	12.2 Representative (Pass) / Non-Representative (Fail)
12	Model provides a clearance zone for the head (helmet) to roof line based on a base calculation from MIL-STD- 1472G requirements	12.1 Model outputs a 2" clearance zone from the top of the helmet contour that adjusts with the different inputs	12.1 Representative (Pass) / Non-Representative (Fail)
13	Model provides a clearance zone for the knee, leg and thigh based on MIL-STD-1472H draft recommendations	13.1 Model outputs a 2" 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) and adjusts with different inputs	13.1 Representative (Pass) / Non-Representative (Fail)
14	Model provides a lateral clearance zone for the elbow contours based on MIL-STD-1472H draft recommendations	14.1 Model output provides a 2" clearance zone laterally for the resting elbow contours	14.1 Representative (Pass) / Non-Representative (Fail)
15	Model provides direct field of view (primary zones) based on MIL-STD-1472G and SAE J1050	15.1 Model outputs primary vision zone that adjusts with model inputs	15.1 Representative (Pass) / Non-Representative (Fail)

Boundary Manikin Placement

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

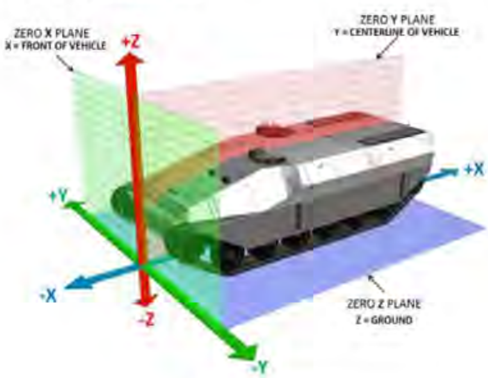
- GVSC CAD values to agree with UMTRI spreadsheet values within ±0.100 inches and ±0.100 degrees
- GVSC CAD geometry to display in full without error (e.g. missing geometry or inversions)

AXIS SYSTEM REVIEW

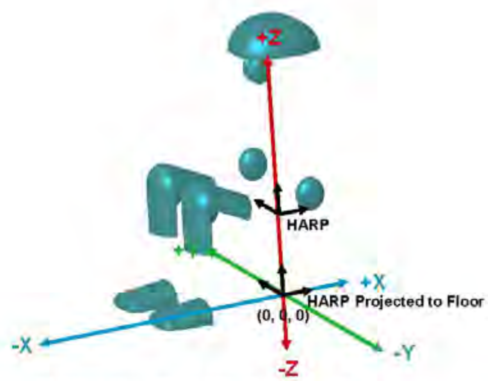
Vehicles are designed in CAD with respect to a global axis system, as described below

- X-Plane: vertical plane through the front edge of the bumper
- Y-Plane: vertical plane through the centerline of the vehicle
- Z-Plane: horizontal plane through the bottom of the tires/track (ground)

Subsystems within the vehicle are positioned using local axis systems. The GVSC™ Fixed Seat: Non-Driver model has an axis system located at its origin (0, 0, 0), the Human Accommodation Reference Point (HARP). There is also a secondary system, HARP Projected to Floor, that is more suitable for inserting results into the vehicle environment.



Vehicle Axis System



GVSC™ Fixed Seat: Non-Driver Axis System

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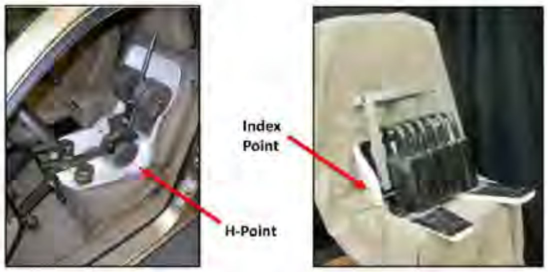
MODEL INPUTS – VEHICLE DESCRIPTION

Human Accommodation Reference Point (HARP) Measurement Tool
HARP is a seat reference from which sitter hip locations and other aspects of posture can be calculated. Both the SAE J826 H-point manikin and the ISO 5353 SIP Tool can be used.

Seat Height Z (in.), (H30, vertical)
The height of the seat, as measured to the seat's HARP, above the heel rest surface (typically, the floor).

Seat Back Angle (deg.), (A40)
The angle, from vertical, of the fixed seat back.

Hydration Pack Relief Availability
Indicates the presence of an opening in the seat back that fully accommodates a donned hydration pack, such that the occupant's position in the seat would be the same with or without the hydration pack.



SAE J826 H-point Manikin   ISO 5353 SIP Tool

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MODEL INPUTS – TARGET DESIGN POPULATION

Fraction Male
The expected percentage of males in the defined target design population.

Ensemble
The clothing and equipment that will be worn. The following ensembles are available in the model:

- Personal Protective Equipment (PPE)
  PPE includes the Advanced Combat Uniform (ACU), Improved Outer Tactical Vest (IOTV) and Advanced Combat Helmet (ACH)
- Encumbered (ENC)
  ENC includes all clothing and equipment in PPE plus a rifleman equipment kit as defined in UMTRI-2013-13

Personal Protective Equipment (PPE)

Encumbered (ENC)

Target Accommodation
The percentage of the defined target design population to be accommodated. Those not accommodated are evenly split between the smaller and larger extremes of the population. In MIL-STD-1472G, the accommodation target has been set at the central 90%.

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TEST MATRIX

DEVCOM

Test #	Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
1	90%	90%	PPE	13.8	0.0	SAE J826	No
2	90%	90%	PPE	15.0	20.0	SAE J826	No
3	90%	90%	PPE	15.8	15.0	ISO 5353	No
4	90%	90%	PPE	17.7	18.0	SAE J826	No
5	90%	90%	PPE	15.0	10.0	SAE J826	No
6	90%	90%	ACU	15.0	10.0	SAE J826	No
7	95%	90%	ENC	15.0	10.0	SAE J826	No
8	90%	50%	PPE	15.0	10.0	SAE J826	No
9	90%	50%	ACU	15.0	10.0	SAE J826	No
10	90%	50%	ENC	15.0	10.0	SAE J826	Yes

Note: Highlighted values differ from the previous test.

Tests #1-5 primarily explore the effect of varying the Seat Height and Seat Back Angle

- Geometry for composite body boundaries (except knees) is constant, but position varies
- Knee Contour geometry and position are unique for each test to reflect changing thigh angles
- Changing the HARP measurement tool shifts all geometry in the X-direction

Tests #6-10 primarily explore the effects of varying Target Accommodation, gender mix (Fraction Male), and Ensemble

- With increased Target Accommodation, composite body boundaries increase in volume and Vision Zones decrease
- Geometry for composite body boundaries decreases in volume with a smaller proportion of males
- Position for composite body boundaries shifts in the X-direction with the chosen Ensemble
- Hydration Pack Relief only affects the ENC ensemble

GVSC™ Fixed Seat: Non-Driver CAD accommodation model is verified based on all tests meeting or exceeding the acceptability criteria

DEVCOM

Summary Test Results

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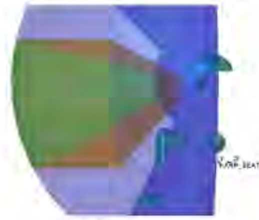
Test #1: Baseline for Tests #1-5

DEVCOM

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	90%	PPE	13.8	0.0	SAE J826	No

Basic Accommodation

Clearance (2.0 inches)



Vision Zones

Boundary Manikins

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

Largest Observed Differences

Basic Accommodation:
0.004 inches
0.000 degrees

Manikin Placement:
0.000 inches

Values in agreement

For complete results, including calculated numerical values and their translation into CAD, see pages 34 - 70.

Note: Test #1 results include construction details for accommodation geometry.

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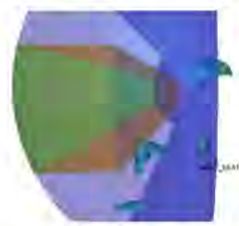
Test #2: Vary Seating Height/Angle

DEVCOM

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	90%	PPE	15.0	20.0	SAE J826	No

Basic Accommodation

Clearance (2.0 inches)



Vision Zones

Boundary Manikins

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

Largest Observed Differences

Basic Accommodation:
0.004 inches
0.000 degrees

Manikin Placement:
0.000 inches

Values in agreement

For complete results, including calculated numerical values and their translation into CAD, see pages 71 - 105.

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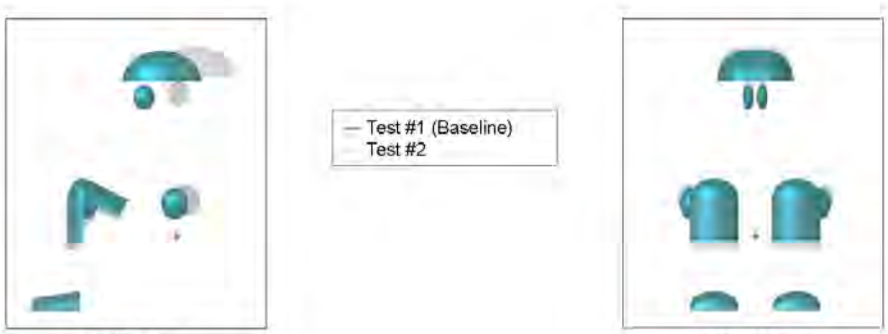
Test #2: Comparison to Baseline

Test #	Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
1	90%	90%	PPE	13.8	0.0	SAE J826	No
2	90%	90%	PPE	15.0	20.0	SAE J826	No

Note: Highlighted values differ from comparison test



Side View

Front View

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 16

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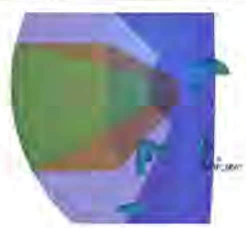
Test #3: Vary Seating Height/Angle and HARP Tool

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	90%	PPE	15.8	15.0	ISO 5353	No

Basic Accommodation

Clearance (2.0 inches)



Vision Zones

Boundary Manikins

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

Largest Observed Differences

Basic Accommodation:
0.004 inches
0.000 degrees

Manikin Placement:
0.000 inches

Values in agreement

For complete results, including calculated numerical values and their translation into CAD, see pages 106 - 140.

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 17

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TEST #3: COMPARISON TO BASELINE

Test #	Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
1	90%	90%	PPE	13.8	0.0	SAE J826	No
3	90%	90%	PPE	15.8	15.0	ISO 5353	No

Note: Highlighted values differ from comparison test.

Observations/Notes

- The HARP Measurement Tool does not affect the relationship between the occupant and the seat. However, because composite body boundaries are provided with respect to HARP, care must be taken when inserting results into the vehicle environment.

Side View

— Test #1 (Baseline)
Test #3

Front View

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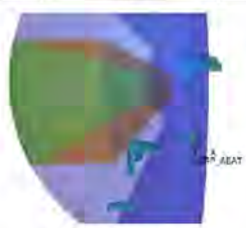
TEST #4: VARY SEATING HEIGHT/ANGLE

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	90%	PPE	17.7	18.0	SAE J826	No

Basic Accommodation

Clearance (2.0 inches)



Vision Zones

Boundary Manikins

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

Largest Observed Differences

Basic Accommodation:
0.004 inches
0.000 degrees

Manikin Placement:
0.000 inches

Values in agreement

For complete results, including calculated numerical values and their translation into CAD, see pages 141 - 175.

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TEST #4: COMPARISON TO BASELINE

Test #	Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
1	90%	90%	PPE	13.8	0.0	SAE J826	No
4	90%	90%	PPE	17.7	18.0	SAE J826	No

Note: Highlighted values differ from comparison test

Side View

Front View

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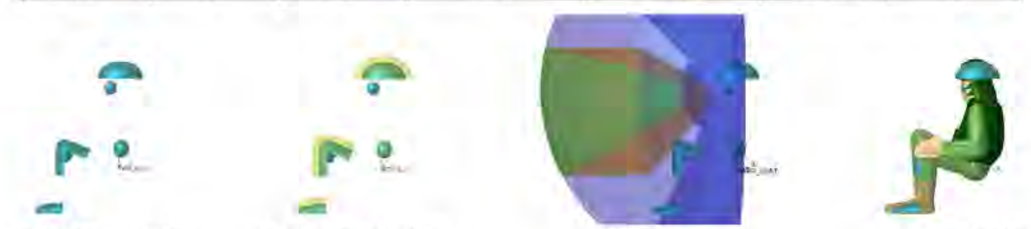
TEST #5: VARY SEATING HEIGHT/ANGLE

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	90%	PPE	15.0	10.0	SAE J826	No



Basic Accommodation

Clearance (2.0 inches)

Vision Zones

Boundary Manikins

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

Largest Observed Differences

Basic Accommodation:
0.004 inches
0.000 degrees

Manikin Placement:
0.000 inches

Values in agreement

For complete results, including calculated numerical values and their translation into CAD, see pages 176 - 210.

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TEST #5: COMPARISON TO BASELINE

Test #	Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
1	90%	90%	PPE	13.8	0.0	SAE J826	No
5	90%	90%	PPE	15.0	10.0	SAE J826	No

Note: Highlighted values differ from comparison test

Side View

— Test #1 (Baseline)
Test #5

Front View

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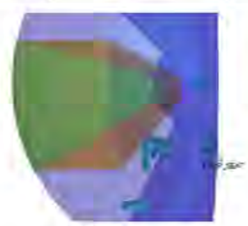
TEST #6: VARY ENSEMBLE

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	90%	ACU	15.0	10.0	SAE J826	No

Basic Accommodation

Clearance (2.0 inches)



Vision Zones

Boundary Manikins

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

Largest Observed Differences

Basic Accommodation:
0.004 inches
0.000 degrees

Manikin Placement:
0.000 inches

Values in agreement

For complete results, including calculated numerical values and their translation into CAD, see pages 211 - 242.

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TEST #6: ENSEMBLE EFFECTS

Test #	Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
5	90%	90%	PPE	15.0	10.0	SAE J826	No
6	90%	90%	ACU	15.0	10.0	SAE J826	No

Note: Highlighted values differ from comparison test.

Observations/Notes

- For a given seat, Soldiers wearing ACU are able to sit further rearward and are able to rest their elbows closer to the body than those wearing PPE.

Side View

Front View

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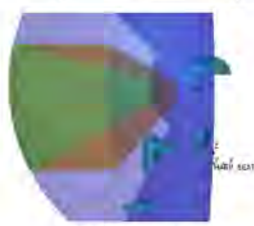
TEST #7: VARY TARGET ACCOMMODATION AND ENSEMBLE

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
95%	90%	ENC	15.0	10.0	SAE J826	No

Basic Accommodation

Clearance (2.0 inches)



Vision Zones

Boundary Manikins

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

Largest Observed Differences

Basic Accommodation:
0.005 inches
0.000 degrees

Manikin Placement:
0.000 inches

Values in agreement

For complete results, including calculated numerical values and their translation into CAD, see pages 243 - 277.

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Test #7: Target Accommodation and Ensemble Effects

Test #	Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
5	90%	90%	PPE	15.0	10.0	SAE J826	No
7	95%	90%	ENC	15.0	10.0	SAE J826	No

Note: Highlighted values differ from comparison test.

Observations/Notes

- For a given seat, Soldiers wearing ENC sit further forward and rest their elbows further outward from the body than those wearing PPE.
- Increasing Target Accommodation results in larger composite body boundaries.

Side View

— Test #5
Test #7

Front View

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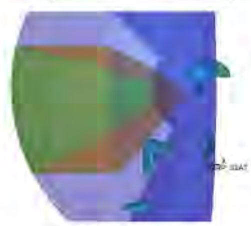
Test #8: Vary Gender Mix

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	50%	PPE	15.0	10.0	SAE J826	No

Basic Accommodation

Clearance (2.0 inches)



Vision Zones

Boundary Manikins

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

Largest Observed Differences

Basic Accommodation:
0.003 inches
0.000 degrees

Manikin Placement:
0.000 inches

Values in agreement

For complete results, including calculated numerical values and their translation into CAD, see pages 278 - 312.

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TEST #8: GENDER MIX EFFECTS

Test #	Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
5	90%	90%	PPE	15.0	10.0	SAE J826	No
8	90%	50%	PPE	15.0	10.0	SAE J826	No

Note: Highlighted values differ from comparison test.

Observations/Notes

- Because females are physically smaller than males, decreasing the percentage of males decreases the overall resultant occupant space.

Side View

— Test #5
Test #8

Front View

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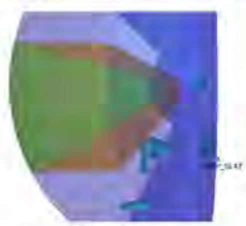
TEST #9: VARY GENDER MIX

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	50%	ACU	15.0	10.0	SAE J826	No

Basic Accommodation

Clearance (2.0 inches)



Vision Zones

Boundary Manikins

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

Largest Observed Differences

Basic Accommodation:
0.003 inches
0.000 degrees

Manikin Placement:
0.000 inches

Values in agreement

For complete results, including calculated numerical values and their translation into CAD, see pages 313 - 344.

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TEST #9: GENDER MIX EFFECTS

Test #	Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
6	90%	90%	ACU	15.0	10.0	SAE J826	No
9	90%	50%	ACU	15.0	10.0	SAE J826	No

Note: Highlighted values differ from comparison test

Observations/Notes

- Because females are physically smaller than males, decreasing the percentage of males decreases the overall resultant occupant space.

Side View　　Front View

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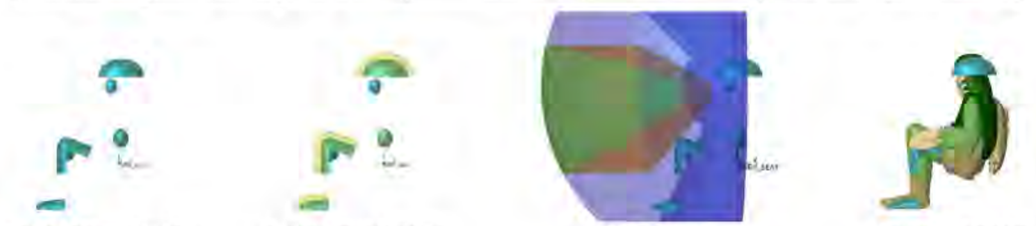
TEST #10: PROVIDE HYDRATION PACK RELIEF

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	50%	ENC	15.0	10.0	SAE J826	Yes



Basic Accommodation　　Clearance (2.0 inches)　　Vision Zones　　Boundary Manikins

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

Largest Observed Differences

Basic Accommodation:
0.003 inches
0.000 degrees

Manikin Placement:
0.000 inches

Values in agreement

For complete results, including calculated numerical values and their translation into CAD, see pages 345 - 379.

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TEST #10: HYDRATION PACK RELIEF EFFECTS

Test #	Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
8	90%	50%	PPE	15.0	10.0	SAE J826	No
10	90%	50%	ENC	15.0	10.0	SAE J826	Yes

Note: Highlighted values differ from comparison test.

Observations/Notes

- The model assumes that providing Hydration Pack Relief completely negates the fore/aft offset that otherwise exists between the PPE and ENC ensembles.

Side View Front View

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Complete Test Results

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10.7.1 TEST #1 – BASELINE FOR TESTS #1-5

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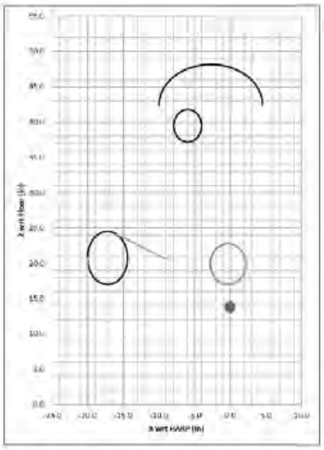
TEST #1: BASELINE FOR TESTS #1-5

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	90%	PPE	13.8	0.0	SAE J826	No

Basic Accommodation



UMTRI Spreadsheet

GVSC CAD Model

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TEST #1: RESULTS, ACCOMMODATION

HARP	UMTRI Value		GVSC Value		Difference	
HARP_X	0.000	in	0.000	in	0.000	in
HARP_Z	13.800	in	13.800	in	0.000	in

Eyellipse	UMTRI Value		GVSC Value		Difference	
EYELLIPSE_CENTROID_X	-5.966	in	-5.966	in	0.000	in
EYELLIPSE_CENTROID_Y (+/-)	1.280	in	1.280	in	0.000	in
EYELLIPSE_CENTROID_Z	39.487	in	39.488	in	0.001	in
EYELLIPSE_X_AXIS_LENGTH	3.907	in	3.909	in	0.002	in
EYELLIPSE_Y_AXIS_LENGTH	1.988	in	1.990	in	0.001	in
EYELLIPSE_Z_AXIS_LENGTH	4.595	in	4.596	in	0.001	in

Helmet Contour	UMTRI Value		GVSC Value		Difference	
HELMET_CONTOUR_CENTROID_X	-2.718	in	-2.718	in	0.000	in
HELMET_CONTOUR_CENTROID_Y (+/-)	2.185	in	2.185	in	0.000	in
HELMET_CONTOUR_CENTROID_Z	42.471	in	42.472	in	0.001	in
HELMET_CONTOUR_X_AXIS_LENGTH	14.509	in	14.512	in	0.002	in
HELMET_CONTOUR_Y_AXIS_LENGTH	9.657	in	9.659	in	0.001	in
HELMET_CONTOUR_Z_AXIS_LENGTH	11.366	in	11.368	in	0.001	in

Knee Contour	UMTRI Value		GVSC Value		Difference	
KNEE_CONTOUR_WEIGHTED_CENT_X	-17.228	in	-17.228	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Y (+/-)	7.594	in	7.594	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Z	20.765	in	20.765	in	0.000	in
KNEE_CONTOUR_X_AXIS_LENGTH	5.628	in	5.630	in	0.002	in
KNEE_CONTOUR_Y_AXIS_LENGTH	9.035	in	9.037	in	0.002	in
KNEE_CONTOUR_Z_AXIS_LENGTH	7.529	in	7.529	in	0.001	in
KNEE_SHIN_ANGLE	0.000	deg	0.000	deg	0.000	deg
KNEE_THIGH_ANGLE	27.111	deg	27.111	deg	0.000	deg

Elbow Contour	UMTRI Value		GVSC Value		Difference	
ELBOW_WEIGHTED_CENT_X	-0.300	in	-0.300	in	0.000	in
ELBOW_WEIGHTED_CENT_Y	12.079	in	12.079	in	0.000	in
ELBOW_WEIGHTED_CENT_Z	19.891	in	19.891	in	0.000	in
ELBOW_X_AXIS_LENGTH	4.996	in	5.000	in	0.004	in
ELBOW_Y_AXIS_LENGTH	3.683	in	3.684	in	0.001	in
ELBOW_Z_AXIS_LENGTH	5.779	in	5.782	in	0.003	in

Boot Contour	UMTRI Value		GVSC Value		Difference	
BOOT_TOE_WEIGHTED_CENT_X	-25.619	in	-25.619	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Y	7.594	in	7.594	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Z	0.000	in	0.000	in	0.000	in
BOOT_TOE_X_AXIS_LENGTH	1.889	in	1.890	in	0.001	in
BOOT_TOE_Y_AXIS_LENGTH	8.704	in	8.706	in	0.002	in
BOOT_TOE_Z_AXIS_LENGTH	4.921	in	4.921	in	0.000	in

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

Largest Observed Differences:
0.004 inches
0.000 degrees

Values in agreement

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 35

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TEST #1: SEAT HARP

DEVCOM

The Human Accommodation Reference Point (HARP) is a seat reference from which sitter hip locations and other aspects of posture can be calculated.

Usage
Seats should be positioned in the vehicle environment such that the HARP of the seat is aligned with the HARP shown in the model.

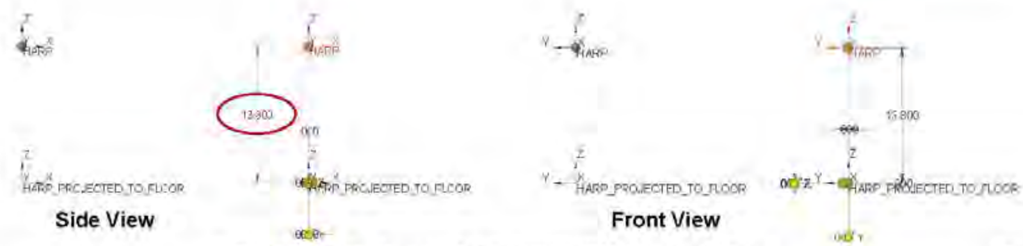
UMTRI Spreadsheet Calculations

	X (in)	Z (in)
HARP	0.000	13.800

GVSC CAD Model Calculations

HARP_X	0.000	in
HARP_Z	13.800	in

GVSC CAD Model Geometry



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TEST #1: EYELLIPSE

DEVCOM

The eyellipse (a contraction of the words "eye" and "ellipse") depicts the distribution of occupant eye locations in the vehicle.

Usage
The eyellipse is used to conduct vision analyses for the target design population.

UMTRI Spreadsheet Calculations

Eyellipse Centroids	X (in)	Y (in)	Z (in)
Right	-5.966	1.280*	39.487
Left	-5.966	-1.280*	39.487

Side View of Eyellipses (X, Z)		
Axis Length (X)	3.907	in
Axis Length (Z)	4.595	in

Rear View of Eyellipses (Y, Z)		
Axis Length (Y)	1.988	in
Axis Length (Z)	4.595	in

GVSC CAD Model Calculations

EYELLIPSE_CENTROID_X	-5.966	in
EYELLIPSE_CENTROID_Y	1.280*	in
EYELLIPSE_CENTROID_Z	39.488	in
EYELLIPSE_X_AXIS_LENGTH	3.909	in
EYELLIPSE_Y_AXIS_LENGTH	1.990	in
EYELLIPSE_Z_AXIS_LENGTH	4.596	in

*Given value, not calculated

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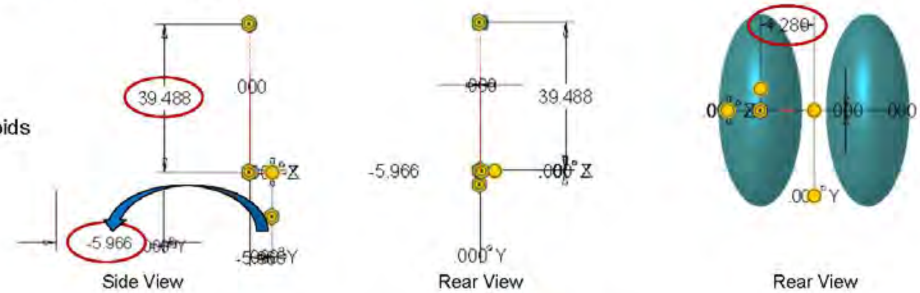
TEST #1: EYELLIPSE (CONT.)

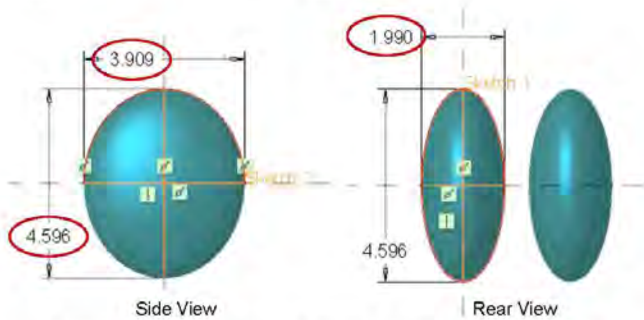
DEVCOM

GVSC CAD Model Geometry

Centroids



Axis Lengths



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TEST #1: HELMET CONTOUR

DEVCOM

The helmet contour depicts the distribution of helmet locations for the target design population. The Advanced Combat Helmet (ACH) was used.

Usage

The helmet contour is used as reference for providing clearance to surrounding components, such as the ceiling.

UMTRI Spreadsheet Calculations

Construction Centroids	X (in)	Y (in)	Z (in)
Right	-2.718	2.185*	42.471
Left	-2.718	-2.185*	42.471

Side View of Helmet Contour (X, Z)		
Axis Length (X)	14.509	in
Axis Length (Z)	11.366	in

Rear View of Helmet Contour (Y, Z)		
Axis Length (Y)	9.657	in
Axis Length (Z)	11.366	in

GVSC CAD Model Calculations

HELMET_CONTOUR_CENTROID_X	-2.718	in
HELMET_CONTOUR_CENTROID_Y	2.185*	in
HELMET_CONTOUR_CENTROID_Z	42.472	in
HELMET_CONTOUR_X_AXIS_LENGTH	14.512	in
HELMET_CONTOUR_Y_AXIS_LENGTH	9.659	in
HELMET_CONTOUR_Z_AXIS_LENGTH	11.368	in

*Given value, not calculated

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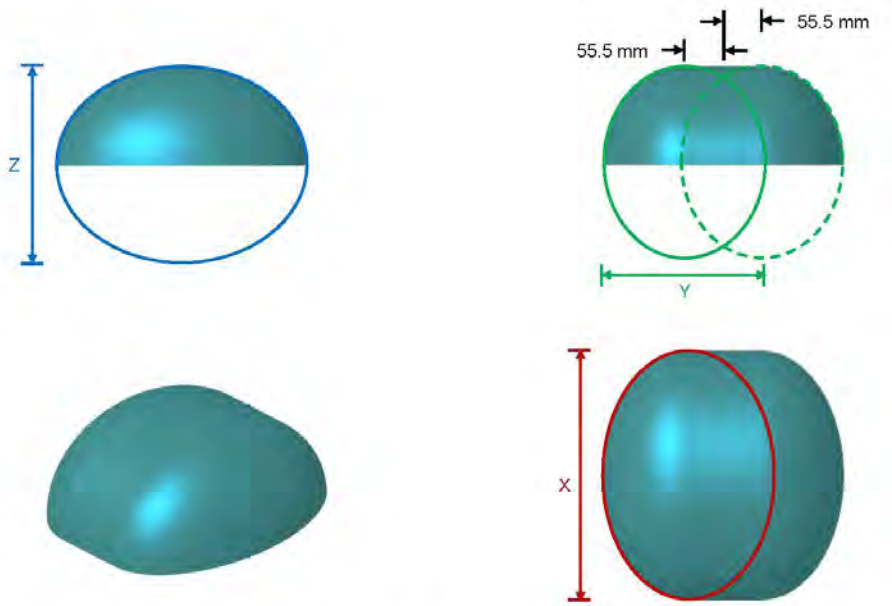
TEST #1: HELMET CONTOUR (CONT.)

Construction Details



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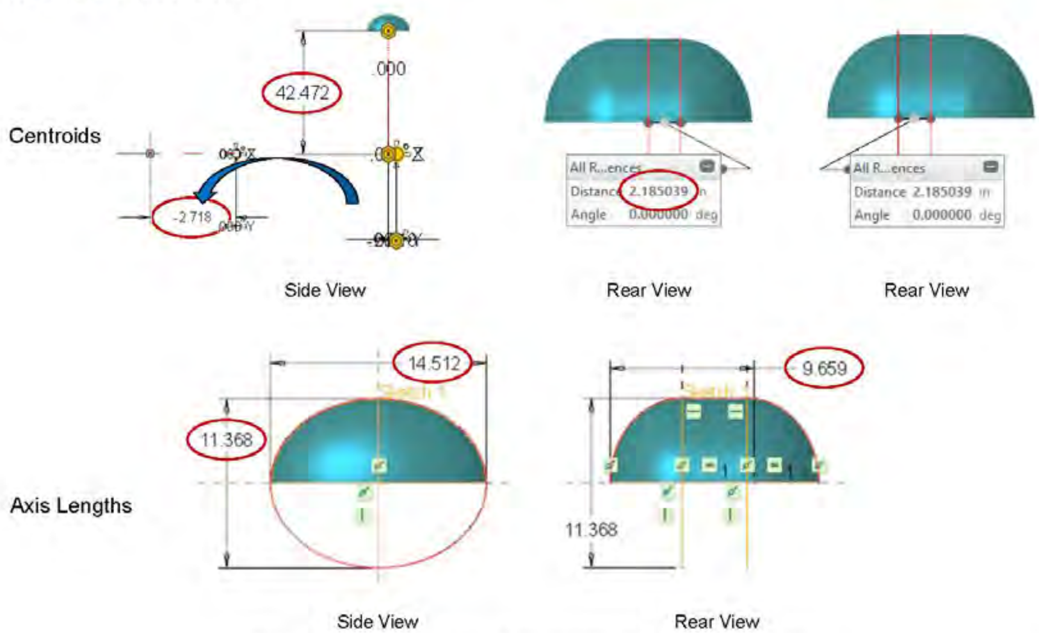
TEST #1: HELMET CONTOUR (CONT.)

GVSC CAD Model Result



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TEST #1: KNEE CONTOUR

The knee contour depicts the top, forward, and lateral distribution of resting knee locations for the target design population. Segments of the thigh and shin are also provided.

Usage

The knee contour is used as reference for providing clearance to Soldiers and surrounding rigid components.

UMTRI Spreadsheet Calculations

Knee Centroids	X (in)	Y (in)	Z (in)
Right	-17.228	7.594	20.765
Left	-17.228	-7.594	20.765

Side View of Knee Contours (X, Z)		
Axis Length (X)	5.628	in
Axis Length (Z)	7.529	in
Rear View of Knee Contours (Y, Z)		
Axis Length (Y)	9.035	in
Axis Length (Z)	7.529	in
Leg Segment Angle wrt Vertical	0.000*	deg
Thigh Segment Angle wrt Horizontal	27.111	deg

GVSC CAD Model Calculations

KNEE_CONTOUR_WEIGHTED_CENT_X	-17.228	in
KNEE_CONTOUR_WEIGHTED_CENT_Y	7.594	in
KNEE_CONTOUR_WEIGHTED_CENT_Z	20.765	in
KNEE_CONTOUR_X_AXIS_LENGTH	5.630	in
KNEE_CONTOUR_Y_AXIS_LENGTH	9.037	in
KNEE_CONTOUR_Z_AXIS_LENGTH	7.529	in
KNEE_SHIN_ANGLE	0.000*	deg
KNEE_THIGH_ANGLE	27.111	deg

*Given value, not calculated

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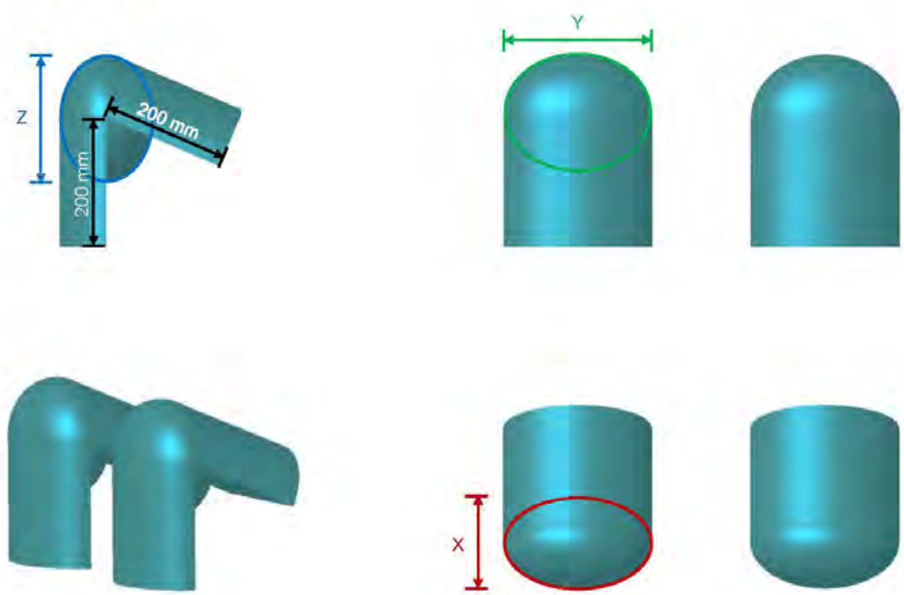
TEST #1: KNEE CONTOUR (CONT.)

Construction Details



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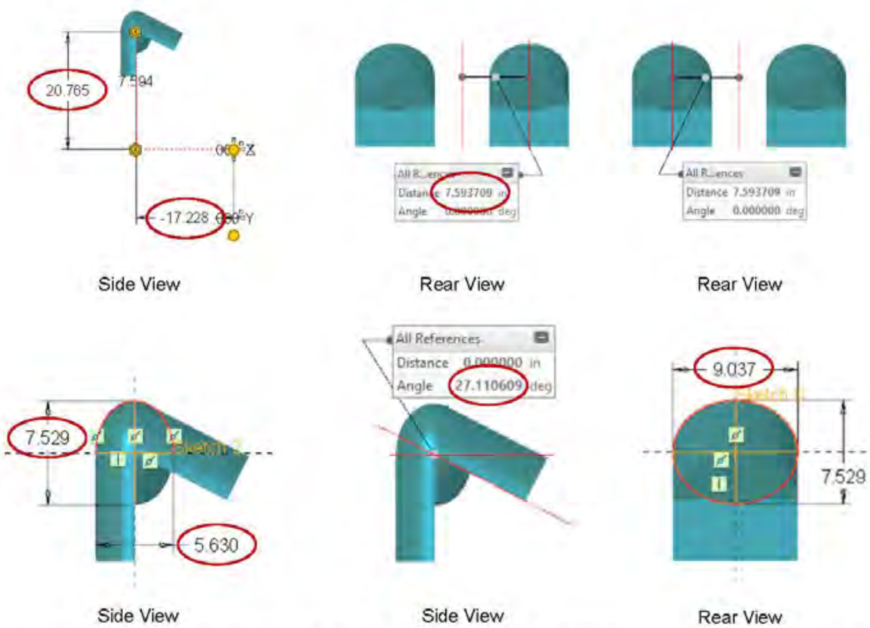
TEST #1: KNEE CONTOUR (CONT.)

GVSC CAD Model Result

Centroids

Axis Lengths
Shin/Thigh Angles



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TEST #1: ELBOW CONTOUR

The elbow contour depicts the distribution of resting elbow locations for the target design population.

Usage
The elbow contour is used as reference for providing clearance to surrounding Soldiers and rigid components such as door trim and equipment racks.

UMTRI Spreadsheet Calculations

Elbow Centroids	X (in)	Y (in)	Z (in)
Right	-0.300	12.079	19.881
Left	-0.300	-12.079	19.881

Side View of Elbow Contours (X, Z)		
Axis Length (X)	4.996	in
Axis Length (Z)	5.779	in

Rear View of Elbow Contours (Y, Z)		
Axis Length (Y)	3.683	in
Axis Length (Z)	5.779	in

GVSC CAD Model Calculations

ELBOW_WEIGHTED_CENT_X	-0.300	in
ELBOW_WEIGHTED_CENT_Y	12.079	in
ELBOW_WEIGHTED_CENT_Z	19.881	in
ELBOW_X_AXIS_LENGTH	5.000	in
ELBOW_Y_AXIS_LENGTH	3.684	in
ELBOW_Z_AXIS_LENGTH	5.782	in

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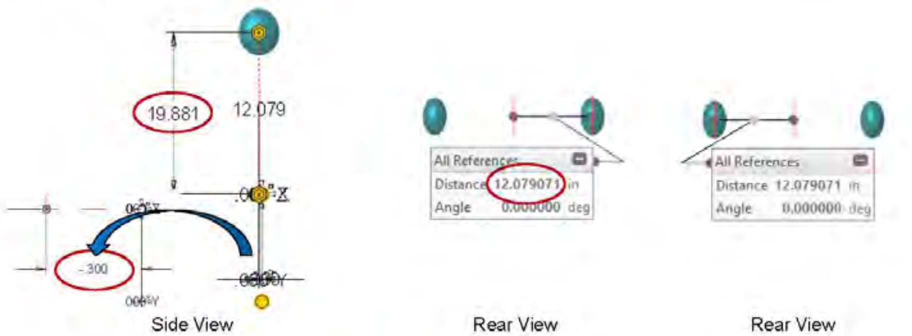
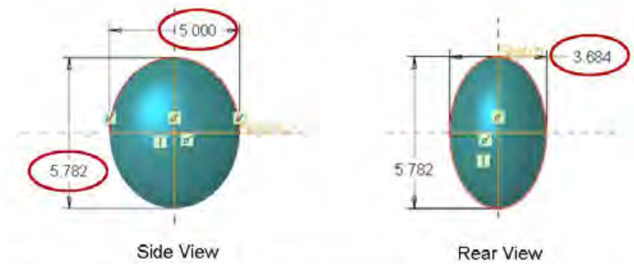
TEST #1: ELBOW CONTOUR (CONT.)

GVSC CAD Model Result

Centroids



Axis Lengths



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TEST #1: BOOT CONTOUR

The boot contour depicts the distribution of resting foot locations for the target design population that result when the lower legs are positioned vertically and the feet are flat on the floor.

Usage

The boot contour is used as reference for providing clearance to surrounding rigid components such as walls and seats with collapsing energy absorption features.

UMTRI Spreadsheet Calculations

Boot Centroids	X (in)	Y (in)	Z (in)
Right	-25.619	7.594	0.000
Left	-25.619	-7.594	0.000

Side View of Boot Contours (X, Z)		
Axis Length (X)	1.889	in
Axis Length (Z)	4.921	in

Rear View of Boot Contours (Y, Z)		
Axis Length (Y)	8.704	in
Axis Length (Z)	4.921	in

GVSC CAD Model Calculations

BOOT_TOE_WEIGHTED_CENT_X	-25.619	in
BOOT_TOE_WEIGHTED_CENT_Y	7.594	in
BOOT_TOE_WEIGHTED_CENT_Z	0.000	in
BOOT_TOE_X_AXIS_LENGTH	1.890	in
BOOT_TOE_Y_AXIS_LENGTH	8.706	in
BOOT_TOE_Z_AXIS_LENGTH	4.921	in

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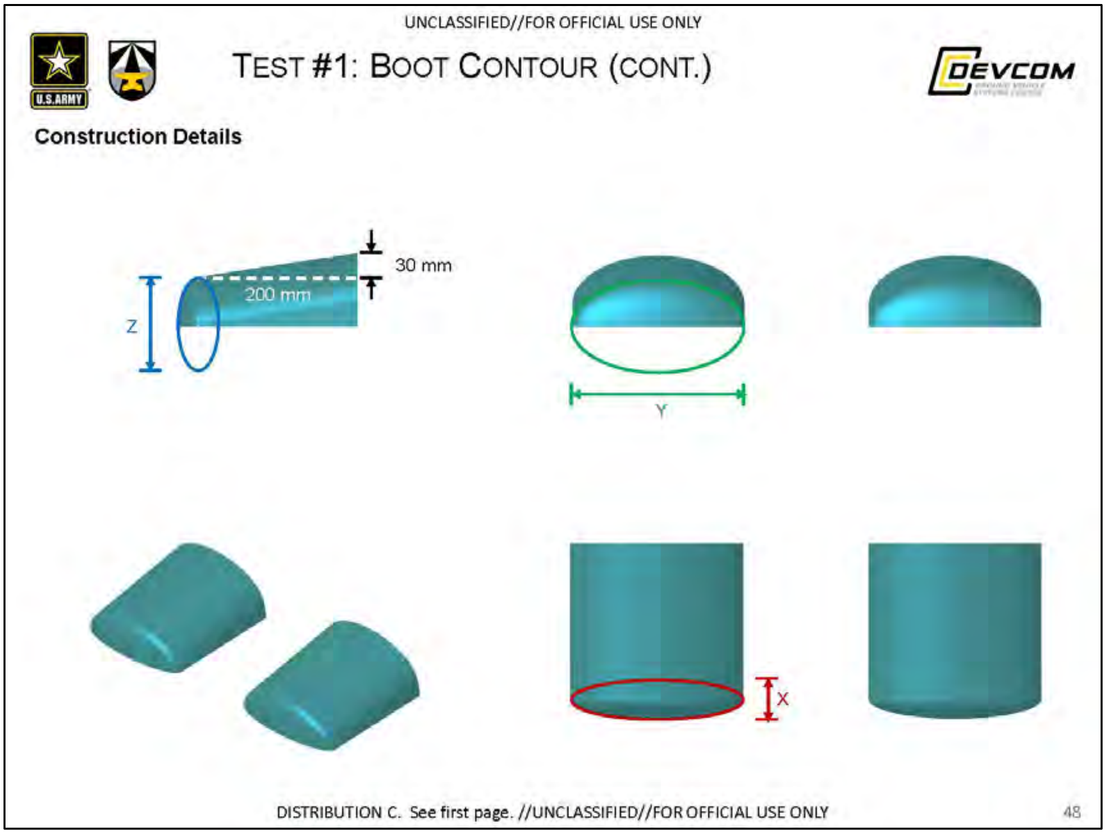
UNCLASSIFIED//FOR OFFICIAL USE ONLY
TEST #1: BOOT CONTOUR (CONT.)
Construction Details
30 mm
200 mm
Z
Y
X
DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY
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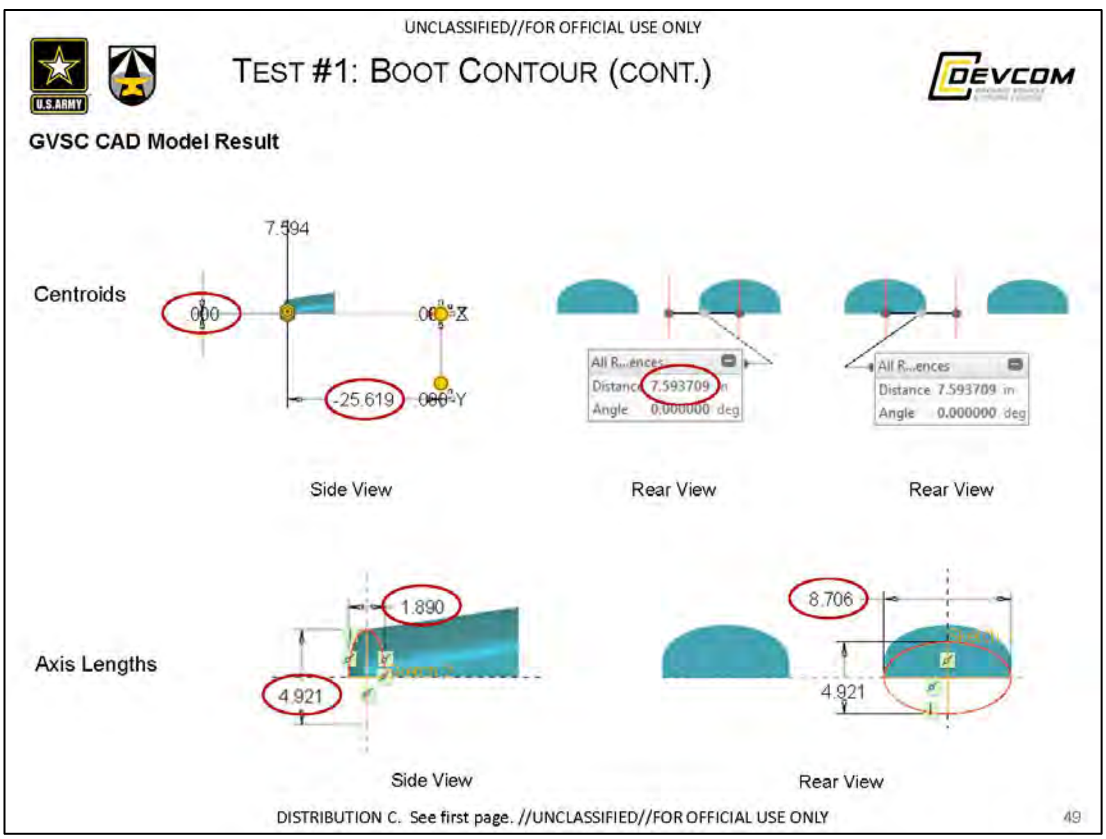
UNCLASSIFIED//FOR OFFICIAL USE ONLY
TEST #1: BOOT CONTOUR (CONT.)
GVSC CAD Model Result
Centroids
7.594
.000
-25.619
Side View
Distance 7.593709 in
Angle 0.000000 deg
Rear View
Distance 7.593709 in
Angle 0.000000 deg
Rear View
Axis Lengths
1.890
4.921
Side View
8.706
4.921
Rear View
DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY
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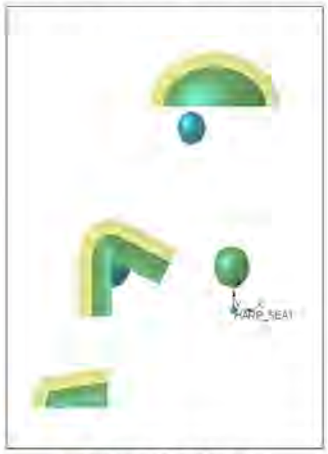
TEST #1: BASELINE FOR TESTS #1-5

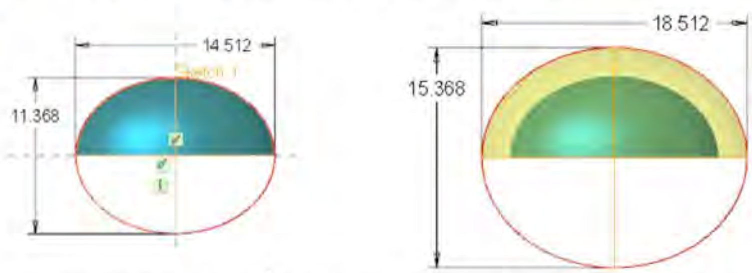
Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	90%	PPE	13.8	0.0	SAE J826	No

Clearance (2.0 inches), Shown in Yellow



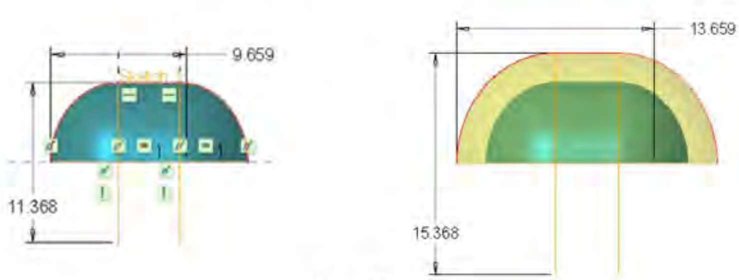
GVSC CAD Model

TEST #1: CLEARANCE, HELMET CONTOUR

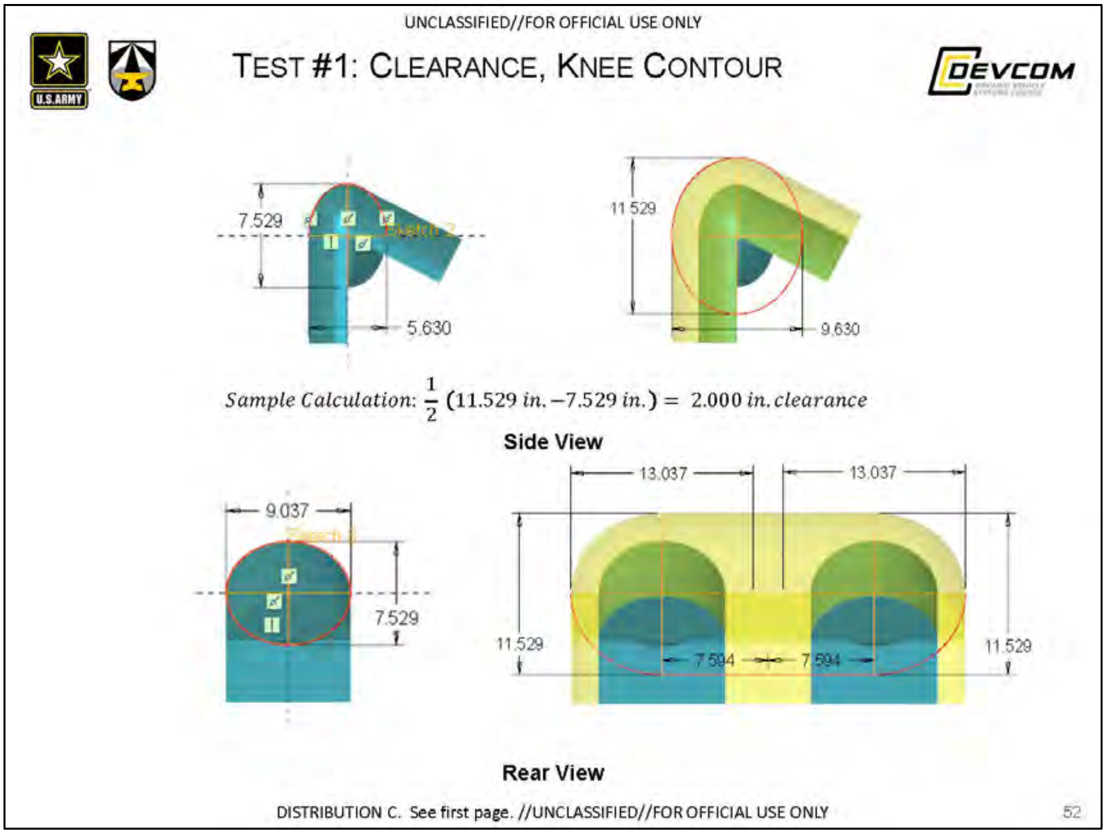


$$\textit{Sample Calculation: } \frac{1}{2}\,(18.512\,in. - 14.512\,in.) = 2.000\,in.\,clearance$$

Side View



Rear View


UNCLASSIFIED//FOR OFFICIAL USE ONLY
TEST #1: CLEARANCE, KNEE CONTOUR
DEVCOM
7.529
5.630
11.529
9.630
Sample Calculation: $\frac{1}{2}$ (11.529 in. − 7.529 in.) = 2.000 in. clearance
Side View
9.037
7.529
13.037
13.037
11.529
7.594
7.594
11.529
Rear View
DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY
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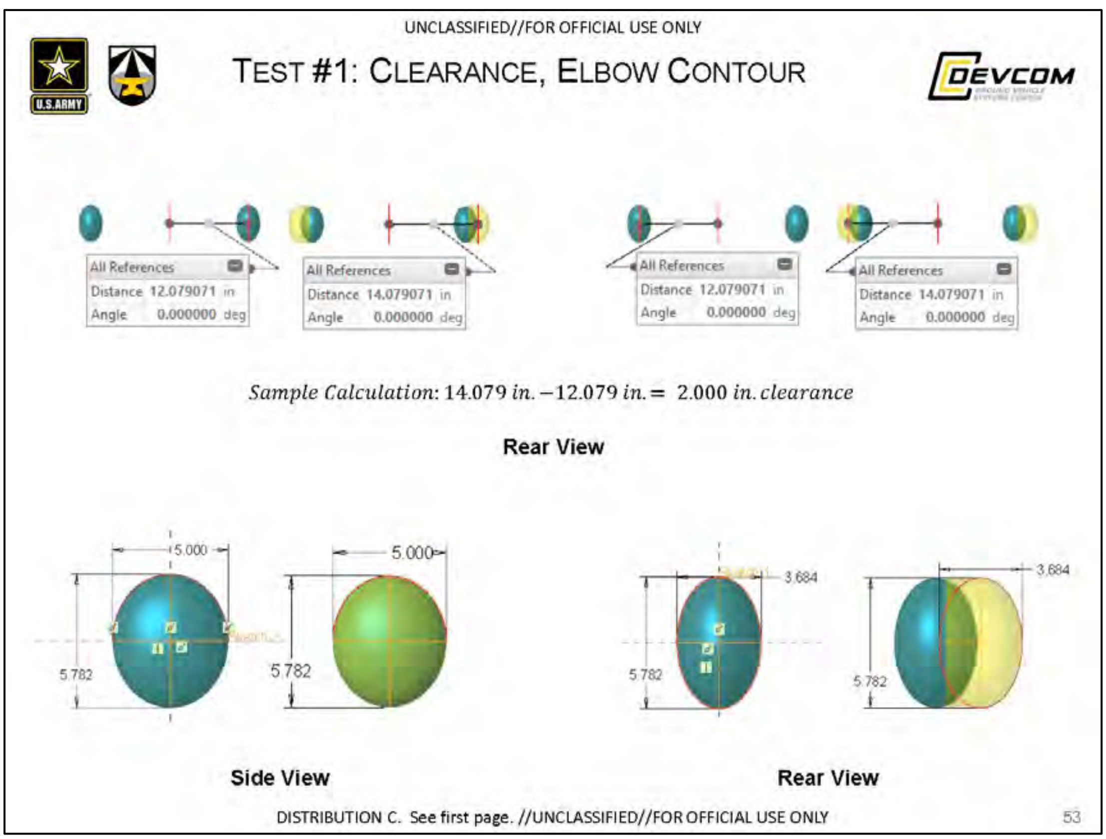
UNCLASSIFIED//FOR OFFICIAL USE ONLY
TEST #1: CLEARANCE, ELBOW CONTOUR
DEVCOM
All References
Distance 12.079071 in
Angle 0.000000 deg
All References
Distance 14.079071 in
Angle 0.000000 deg
All References
Distance 12.079071 in
Angle 0.000000 deg
All References
Distance 14.079071 in
Angle 0.000000 deg
Sample Calculation: 14.079 in. − 12.079 in. = 2.000 in. clearance
Rear View
5.000
5.000
5.782
5.782
3.684
5.782
3.684
5.782
Side View
Rear View
DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY
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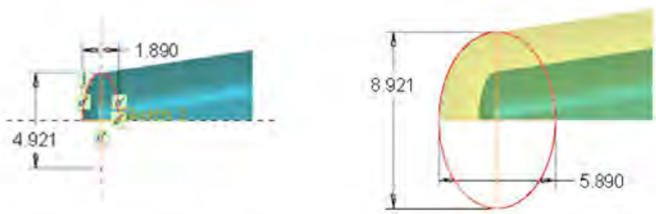
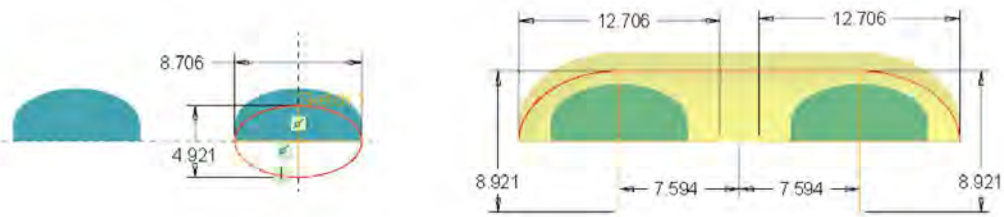
TEST #1: CLEARANCE, BOOT CONTOUR



$$Sample\ Calculation: \frac{1}{2}(8.921\ in. - 4.921\ in.) = 2.000\ in.\ clearance$$

Side View



Rear View

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 54

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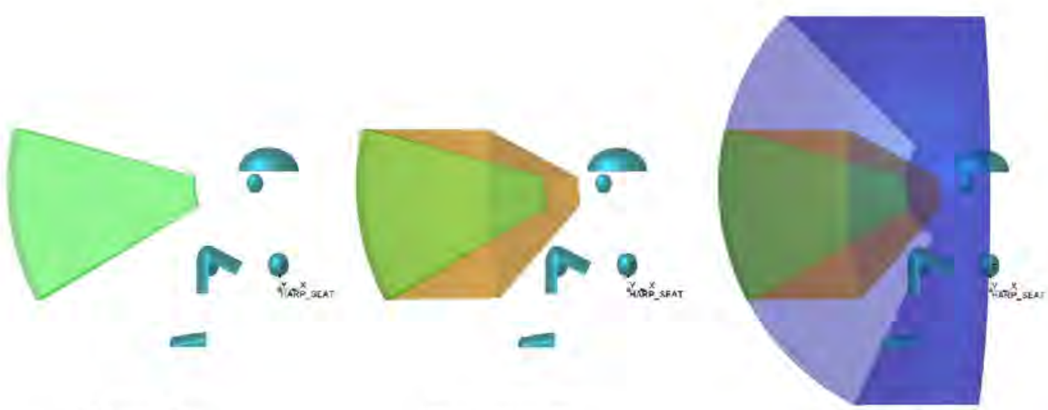
TEST #1: BASELINE FOR TESTS #1-5

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	90%	PPE	13.8	0.0	SAE J826	No

Vision Zones

Vison zones are constructed geometrically; no calculations are involved.



Primary Zone Secondary Zone Tertiary Zone

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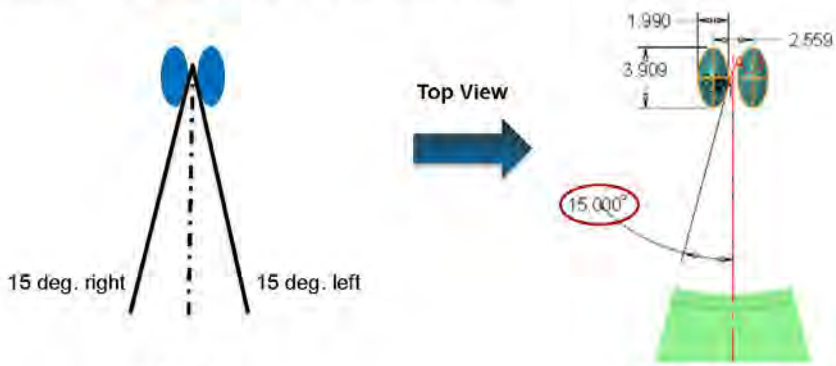
TEST #1: PRIMARY VISION ZONE

The primary vision zone indicates a space viewable by all occupants using a minimum of easy rotation from at least one eye (ambinocular vision).

Usage
Warning lights and displays are to be placed in the primary vision zone.

Zone Construction
Combining the limits MIL-STD-1472 G and SAE J1050, easy eye rotation is defined laterally as 15 degrees side-to-side from the occupant's centerline and vertically as +15/-30 degrees from horizontal.

The effective viewing distance shall not be less than 13 inches.



Intent **CAD Implementation**

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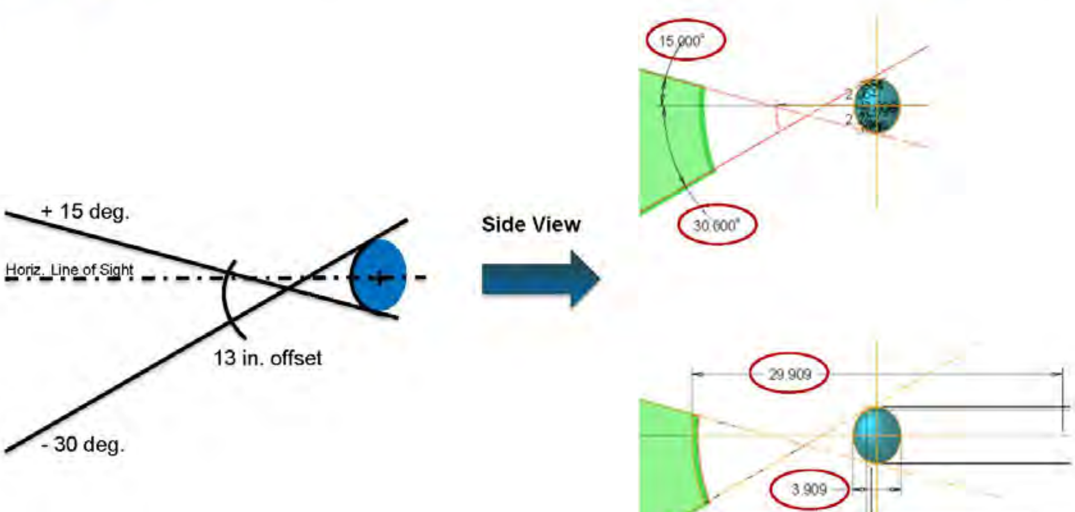
TEST #1: PRIMARY VISION ZONE (CONT.)



$$\frac{1}{2}(29.909\ in. - 3.909\ in.) = 13.000\ in.$$

Intent **CAD Implementation**

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TEST #1: SECONDARY VISION ZONE

The secondary vision zone indicates a space viewable by all occupants using both “easy” eye and “easy” head rotation.

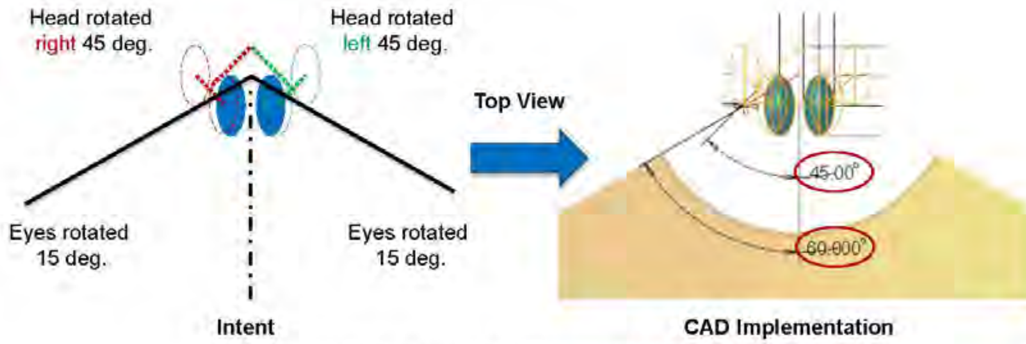
Usage

The secondary vision zone is suitable for cautions and alerts not able to be placed in the primary vision zone.

Zone Construction

Combining the limits MIL-STD-1472 G and SAE J1050, easy eye rotation and easy head turn is defined laterally as 60 degrees side-to-side from the occupant’s centerline (15 degrees eye rotation + 45 degrees head rotation) and vertically as +15/-30 degrees from horizontal (eye rotation only).

The effective viewing distance shall not be less than 13 inches.



DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 58

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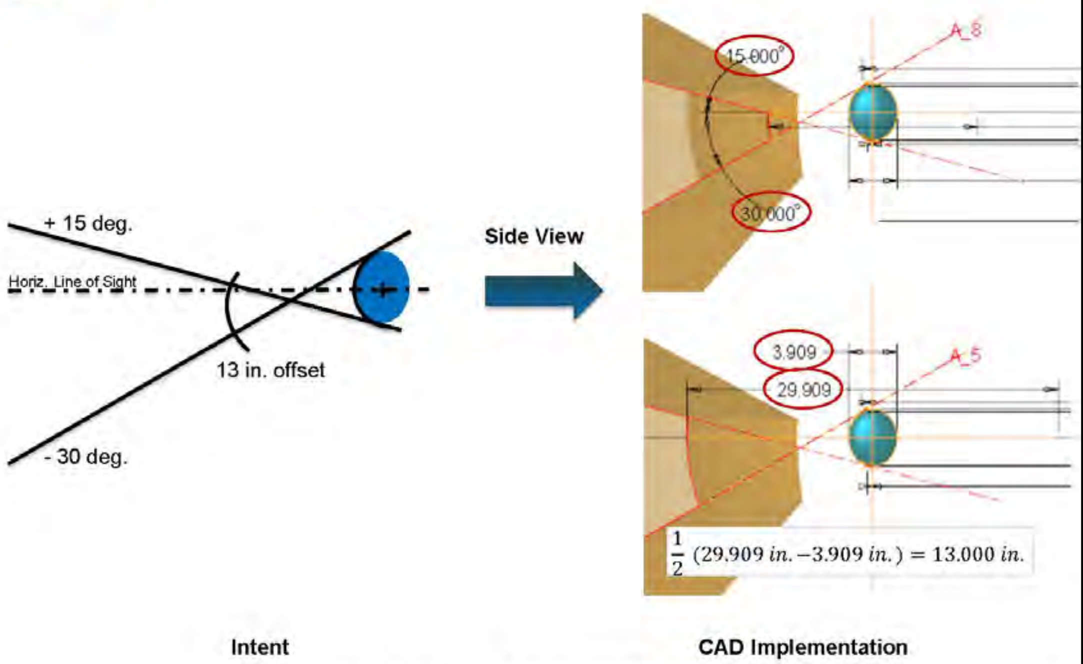
TEST #1: SECONDARY VISION ZONE (CONT.)



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TEST #1: TERTIARY VISION ZONE

The tertiary vision zone indicates a space viewable by all occupants using both maximum eye and maximum head rotation.

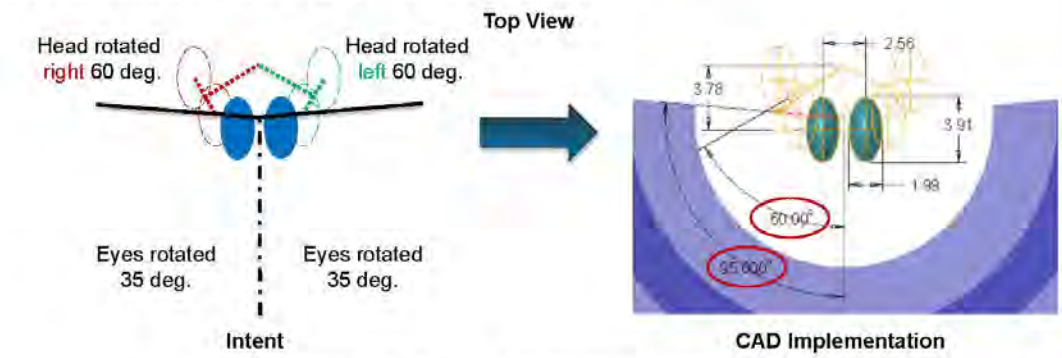
Usage

The tertiary vision zone should only be used to place equipment needed for initial setup but not requiring attention while driving.

Zone Construction

Combining the limits MIL-STD-1472 G and SAE J1050, maximum eye rotation and maximum head turn is defined laterally as 95 degrees side-to-side from the occupant's centerline (35 degrees eye + 60 degrees head) and vertically as +45 degrees/-65 degrees from horizontal (eye rotation only).

The effective viewing distance shall not be less than 13 inches.



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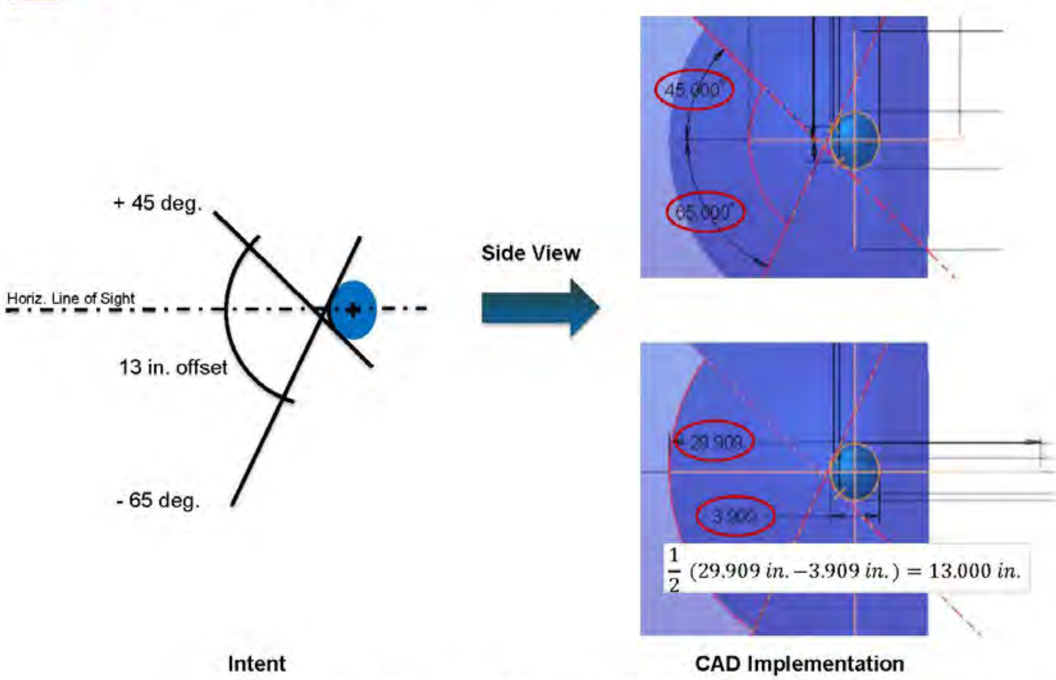
TEST #1: TERTIARY VISION ZONE (CONT.)



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TEST #1: BASELINE FOR TESTS #1-5

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	90%	PPE	13.8	0.0	SAE J826	No

Boundary Manikin Posture and Position

GVSC CAD Model

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 62

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TEST #1: RESULTS, MANIKIN POSITIONING

	UMTRI Value		GVSC Value		Difference	
Small Overall Female						
POSTURE_DHM1_HIP_X	-1.915	in	-1.915	in	0.000	in
POSTURE_DHM1_HIP_Z	13.184	in	13.184	in	0.000	in
POSTURE_DHM1_EYE_X	-4.713	in	-4.713	in	0.000	in
POSTURE_DHM1_EYE_Z	35.545	in	35.545	in	0.000	in
Small Overall Male						
POSTURE_DHM2_HIP_X	-2.177	in	-2.177	in	0.000	in
POSTURE_DHM2_HIP_Z	13.289	in	13.289	in	0.000	in
POSTURE_DHM2_EYE_X	-5.422	in	-5.422	in	0.000	in
POSTURE_DHM2_EYE_Z	37.443	in	37.443	in	0.000	in
Average Size Male						
POSTURE_DHM3_HIP_X	-2.175	in	-2.175	in	0.000	in
POSTURE_DHM3_HIP_Z	13.288	in	13.288	in	0.000	in
POSTURE_DHM3_EYE_X	-6.163	in	-6.163	in	0.000	in
POSTURE_DHM3_EYE_Z	39.792	in	39.792	in	0.000	in
Widest Shoulders Male						
POSTURE_DHM4_HIP_X	-2.148	in	-2.148	in	0.000	in
POSTURE_DHM4_HIP_Z	13.278	in	13.278	in	0.000	in
POSTURE_DHM4_EYE_X	-6.537	in	-6.537	in	0.000	in
POSTURE_DHM4_EYE_Z	41.147	in	41.147	in	0.000	in
Longest Torso Male						
POSTURE_DHM5_HIP_X	-2.134	in	-2.134	in	0.000	in
POSTURE_DHM5_HIP_Z	13.272	in	13.272	in	0.000	in
POSTURE_DHM5_EYE_X	-6.546	in	-6.546	in	0.000	in
POSTURE_DHM5_EYE_Z	42.322	in	42.322	in	0.000	in
Longest Legs Male						
POSTURE_DHM6_HIP_X	-2.309	in	-2.303	in	0.000	in
POSTURE_DHM6_HIP_Z	13.340	in	13.340	in	0.000	in
POSTURE_DHM6_EYE_X	-6.728	in	-6.728	in	0.000	in
POSTURE_DHM6_EYE_Z	40.153	in	40.153	in	0.000	in
Large Overall Male						
POSTURE_DHM7_HIP_X	-2.535	in	-2.535	in	0.000	in
POSTURE_DHM7_HIP_Z	13.433	in	13.433	in	0.000	in
POSTURE_DHM7_EYE_X	-7.004	in	-7.004	in	0.000	in
POSTURE_DHM7_EYE_Z	42.141	in	42.141	in	0.000	in

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

Largest Observed Differences:
0.000 inches

Values in agreement

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 63

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Test #1: Small Overall Female

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-19.6	-48.6	-91.6	→	-1.915	in
Hip re H-point Z	-15.7	-15.7	-15.7	→	13.184	in
Eye re H-point X	-67.7	-119.7	-180.7	→	-4.713	in
Eye re H-point Z	552.3	552.3	552.3	→	35.545	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM1_HIP_X	-1.915	in
POSTURE_DHM1_HIP_Z	13.184	in
POSTURE_DHM1_EYE_X	-4.713	in
POSTURE_DHM1_EYE_Z	35.545	in

GVSC CAD Model Geometry

Side View Front View

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 84

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Test #1: Small Overall Male

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-26.3	-55.3	-98.3	→	-2.177	in
Hip re H-point Z	-13.0	-13.0	-13.0	→	13.289	in
Eye re H-point X	-85.7	-137.7	-198.7	→	-5.422	in
Eye re H-point Z	600.5	600.5	600.5	→	37.443	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM2_HIP_X	-2.177	in
POSTURE_DHM2_HIP_Z	13.289	in
POSTURE_DHM2_EYE_X	-5.422	in
POSTURE_DHM2_EYE_Z	37.443	in

GVSC CAD Model Geometry

Side View Front View

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 85

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TEST #1: AVERAGE SIZE MALE

DEVCOM

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-26.2	-55.2	-98.2	→	-2.175	in
Hip re H-point Z	-13.0	-13.0	-13.0	→	13.288	in
Eye re H-point X	-104.5	-156.5	-217.5	→	-6.163	in
Eye re H-point Z	660.2	660.2	660.2	→	39.792	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM3_HIP_X	-2.175	in
POSTURE_DHM3_HIP_Z	13.288	in
POSTURE_DHM3_EYE_X	-6.163	in
POSTURE_DHM3_EYE_Z	39.792	in

GVSC CAD Model Geometry

Side View

Front View

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 66

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TEST #1: WIDEST SHOULDERS MALE

DEVCOM

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-25.6	-54.6	-97.6	→	-2.148	in
Hip re H-point Z	-13.3	-13.3	-13.3	→	13.278	in
Eye re H-point X	-114.0	-166.0	-227.0	→	-6.537	in
Eye re H-point Z	694.6	694.6	694.6	→	41.147	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM4_HIP_X	-2.148	in
POSTURE_DHM4_HIP_Z	13.278	in
POSTURE_DHM4_EYE_X	-6.537	in
POSTURE_DHM4_EYE_Z	41.147	in

GVSC CAD Model Geometry

Side View

Front View

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 67

TEST #1: LONGEST TORSO MALE

DEVCOM

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-25.2	-54.2	-97.2	→	-2.134	in
Hip re H-point Z	-13.4	-13.4	-13.4	→	13.272	in
Eye re H-point X	-114.3	-166.3	-227.3	→	-6.546	in
Eye re H-point Z	724.5	724.5	724.5	→	42.322	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM5_HIP_X	-2.134	in
POSTURE_DHM5_HIP_Z	13.272	in
POSTURE_DHM5_EYE_X	-6.546	in
POSTURE_DHM5_EYE_Z	42.322	in

GVSC CAD Model Geometry

Side View

Front View

TEST #1: LONGEST LEGS MALE

DEVCOM

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-29.5	-58.5	-101.5	→	-2.303	in
Hip re H-point Z	-11.7	-11.7	-11.7	→	13.340	in
Eye re H-point X	-118.9	-170.9	-231.9	→	-6.728	in
Eye re H-point Z	669.4	669.4	669.4	→	40.153	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM6_HIP_X	-2.303	in
POSTURE_DHM6_HIP_Z	13.340	in
POSTURE_DHM6_EYE_X	-6.728	in
POSTURE_DHM6_EYE_Z	40.153	in

GVSC CAD Model Geometry

Side View

Front View

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Test #1: Large Overall Male

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-35.4	-64.4	-107.4	→	-2.535	in
Hip re H-point Z	-9.3	-9.3	-9.3	→	13.433	in
Eye re H-point X	-125.9	-177.9	-238.9	→	-7.004	in
Eye re H-point Z	719.9	719.9	719.9	→	42.141	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM7_HIP_X	-2.535	in
POSTURE_DHM7_HIP_Z	13.433	in
POSTURE_DHM7_EYE_X	-7.004	in
POSTURE_DHM7_EYE_Z	42.141	in

GVSC CAD Model Geometry

Side View

Front View

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY

10.7.2 TEST #2 – VARY SEATING HEIGHT/ANGLE

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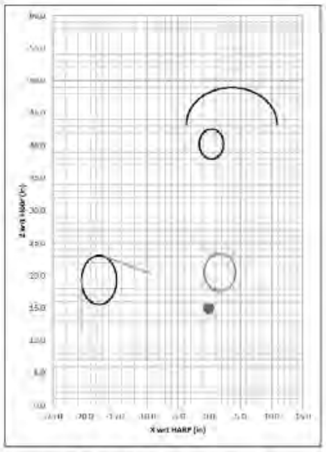
TEST #2: VARY SEATING HEIGHT/ANGLE

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	90%	PPE	15.0	20.0	SAE J826	No

Basic Accommodation



UMTRI Spreadsheet

GVSC CAD Model

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TEST #2: COMPARISON TO BASELINE

Test #	Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
1	90%	90%	PPE	13.8	0.0	SAE J826	No
2	90%	90%	PPE	15.0	20.0	SAE J826	No

Note: Highlighted values differ from comparison test

Side View

— Test #1 (Baseline)
Test #2

Front View

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY

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Test #2: Results, Accommodation

HARP	UMTRI Value		GVSC Value		Difference	
HARP_X	0.000	in	0.000	in	0.000	in
HARP_Z	15.000	in	15.000	in	0.000	in
Eyellipse	**UMTRI Value**		**GVSC Value**		**Difference**	
EYELLIPSE_CENTROID_X	0.372	in	0.372	in	0.000	in
EYELLIPSE_CENTROID_Y (+/-)	1.280	in	1.280	in	0.000	in
EYELLIPSE_CENTROID_Z	40.253	in	40.254	in	0.001	in
EYELLIPSE_X_AXIS_LENGTH	3.907	in	3.909	in	0.003	in
EYELLIPSE_Y_AXIS_LENGTH	1.988	in	1.990	in	0.001	in
EYELLIPSE_Z_AXIS_LENGTH	4.594	in	4.596	in	0.002	in
Helmet Contour	**UMTRI Value**		**GVSC Value**		**Difference**	
HELMET_CONTOUR_CENTROID_X	3.620	in	3.620	in	0.000	in
HELMET_CONTOUR_CENTROID_Y (+/-)	2.185	in	2.185	in	0.000	in
HELMET_CONTOUR_CENTROID_Z	43.238	in	43.238	in	0.001	in
HELMET_CONTOUR_X_AXIS_LENGTH	14.509	in	14.512	in	0.003	in
HELMET_CONTOUR_Y_AXIS_LENGTH	9.657	in	9.659	in	0.001	in
HELMET_CONTOUR_Z_AXIS_LENGTH	11.366	in	11.368	in	0.002	in
Knee Contour	**UMTRI Value**		**GVSC Value**		**Difference**	
KNEE_CONTOUR_WEIGHTED_CENT_X	-17.610	in	-17.610	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Y (+/-)	7.594	in	7.594	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Z	19.311	in	19.311	in	0.000	in
KNEE_CONTOUR_X_AXIS_LENGTH	5.628	in	5.630	in	0.002	in
KNEE_CONTOUR_Y_AXIS_LENGTH	9.035	in	9.037	in	0.002	in
KNEE_CONTOUR_Z_AXIS_LENGTH	7.529	in	7.529	in	0.001	in
KNEE_SHIN_ANGLE	0.000	deg	0.000	deg	0.000	deg
KNEE_THIGH_ANGLE	19.296	deg	19.296	deg	0.000	deg
Elbow Contour	**UMTRI Value**		**GVSC Value**		**Difference**	
ELBOW_WEIGHTED_CENT_X	1.739	in	1.739	in	0.000	in
ELBOW_WEIGHTED_CENT_Y	12.517	in	12.517	in	0.000	in
ELBOW_WEIGHTED_CENT_Z	20.506	in	20.506	in	0.000	in
ELBOW_X_AXIS_LENGTH	4.996	in	5.000	in	0.004	in
ELBOW_Y_AXIS_LENGTH	3.683	in	3.684	in	0.001	in
ELBOW_Z_AXIS_LENGTH	5.779	in	5.782	in	0.003	in

Boot Contour	UMTRI Value		GVSC Value		Difference	
BOOT_TOE_WEIGHTED_CENT_X	-26.002	in	-26.002	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Y	7.594	in	7.594	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Z	0.000	in	0.000	in	0.000	in
BOOT_TOE_X_AXIS_LENGTH	1.089	in	1.090	in	0.001	in
BOOT_TOE_Y_AXIS_LENGTH	8.704	in	8.706	in	0.002	in
BOOT_TOE_Z_AXIS_LENGTH	4.921	in	4.921	in	0.000	in

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

Largest Observed Differences:
0.004 inches
0.000 degrees

Values in agreement

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 73

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Test #2: Seat HARP

UMTRI Spreadsheet Calculations

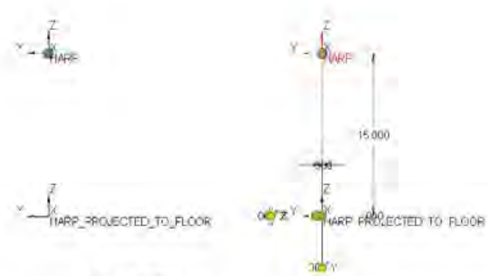
	X (in)	Z (in)
HARP	0.000	15.000

GVSC CAD Model Calculations

HARP_X	0.000	in
HARP_Z	15.000	in

GVSC CAD Model Geometry

Side View



Front View

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TEST #2: EYELLIPSE

UMTRI Spreadsheet Calculations

Eyellipse Centroids	X (in)	Y (in)	Z (in)
Right	0.372	1.280*	40.253
Left	0.372	-1.280*	40.253

Side View of Eyellipses (X, Z)		
Axis Length (X)	3.907	in
Axis Length (Z)	4.594	in

Rear View of Eyellipses (Y, Z)		
Axis Length (Y)	1.988	in
Axis Length (Z)	4.594	in

GVSC CAD Model Calculations

EYELLIPSE_CENTROID_X	0.372	in
EYELLIPSE_CENTROID_Y	1.280*	in
EYELLIPSE_CENTROID_Z	40.254	in
EYELLIPSE_X_AXIS_LENGTH	3.909	in
EYELLIPSE_Y_AXIS_LENGTH	1.990	in
EYELLIPSE_Z_AXIS_LENGTH	4.596	in

*Given value, not calculated

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 75

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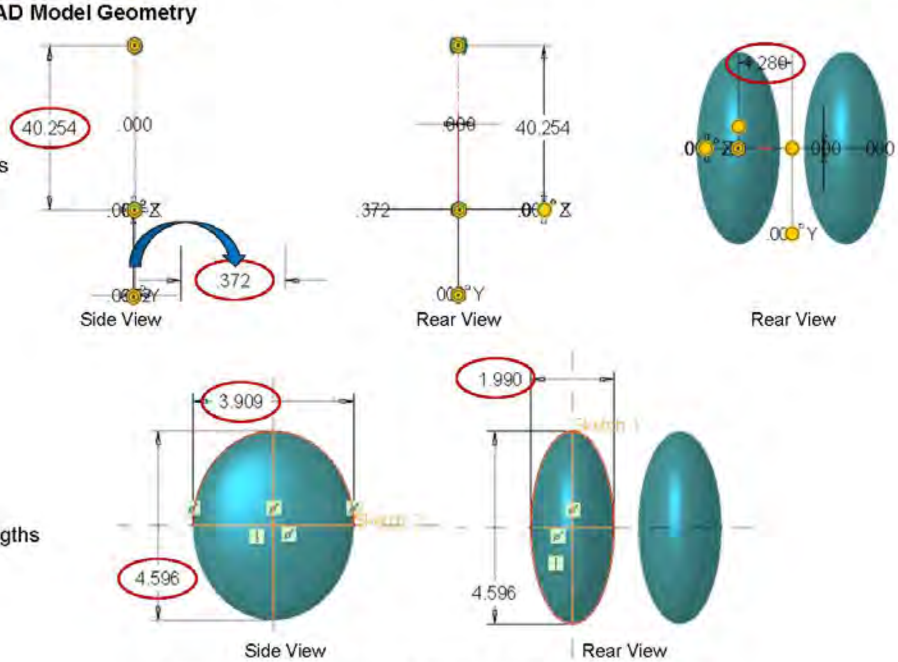
TEST #2: EYELLIPSE (CONT.)

GVSC CAD Model Geometry

Centroids

Axis Lengths



DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 76

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TEST #2: HELMET CONTOUR

UMTRI Spreadsheet Calculations

Construction Centroids	X (in)	Y (in)	Z (in)
Right	3.620	2.185*	43.238
Left	3.620	-2.185*	43.238

Side View of Helmet Contour (X, Z)		
Axis Length (X)	14.509	in
Axis Length (Z)	11.366	in

Rear View of Helmet Contour (Y, Z)		
Axis Length (Y)	9.657	in
Axis Length (Z)	11.366	in

GVSC CAD Model Calculations

HELMET_CONTOUR_CENTROID_X	3.620	in
HELMET_CONTOUR_CENTROID_Y	2.185*	in
HELMET_CONTOUR_CENTROID_Z	43.238	in
HELMET_CONTOUR_X_AXIS_LENGTH	14.512	in
HELMET_CONTOUR_Y_AXIS_LENGTH	9.659	in
HELMET_CONTOUR_Z_AXIS_LENGTH	11.368	in

*Given value, not calculated

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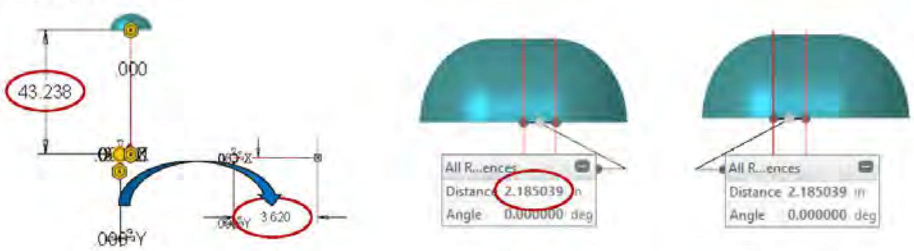
TEST #2: HELMET CONTOUR (CONT.)

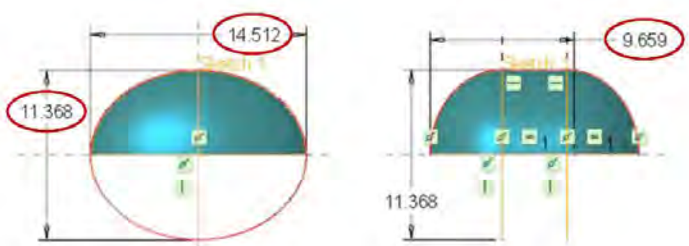
GVSC CAD Model Result

Centroids



Side View Rear View Rear View

Axis Lengths



Side View Rear View

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 78

TEST #2: KNEE CONTOUR

UMTRI Spreadsheet Calculations

Knee Centroids	X (in)	Y (in)	Z (in)
Right	-17.610	7.594	19.311
Left	-17.610	-7.594	19.311

Side View of Knee Contours (X, Z)		
Axis Length (X)	5.628	in
Axis Length (Z)	7.529	in
Rear View of Knee Contours (Y, Z)		
Axis Length (Y)	9.035	in
Axis Length (Z)	7.529	in
Leg Segment Angle wrt Vertical	0.000*	deg
Thigh Segment Angle wrt Horizontal	19.296	deg

GVSC CAD Model Calculations

KNEE_CONTOUR_WEIGHTED_CENT_X	-17.610	in
KNEE_CONTOUR_WEIGHTED_CENT_Y	7.594	in
KNEE_CONTOUR_WEIGHTED_CENT_Z	19.311	in
KNEE_CONTOUR_X_AXIS_LENGTH	5.630	in
KNEE_CONTOUR_Y_AXIS_LENGTH	9.037	in
KNEE_CONTOUR_Z_AXIS_LENGTH	7.529	in
KNEE_SHIN_ANGLE	0.000*	deg
KNEE_THIGH_ANGLE	19.296	deg

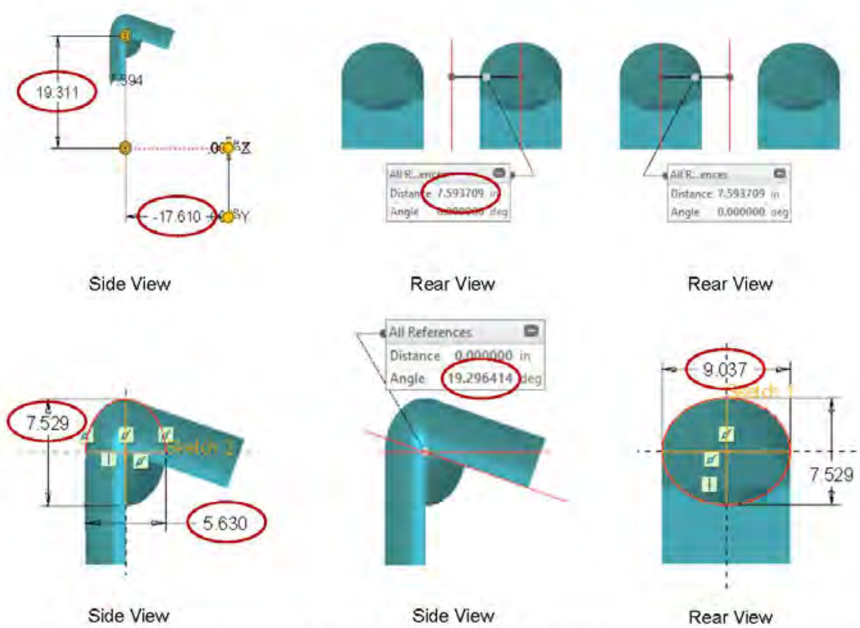
*Given value, not calculated

TEST #2: KNEE CONTOUR (CONT.)

GVSC CAD Model Result

Centroids

Axis Lengths
Shin/Thigh Angles



Test #2: Elbow Contour

UMTRI Spreadsheet Calculations

Elbow Centroids	X (in)	Y (in)	Z (in)
Right	1.739	12.517	20.506
Left	1.739	-12.517	20.506

Side View of Elbow Contours (X, Z)

Axis Length (X)	4.996	in
Axis Length (Z)	5.779	in

Rear View of Elbow Contours (Y, Z)

Axis Length (Y)	3.683	in
Axis Length (Z)	5.779	in

GVSC CAD Model Calculations

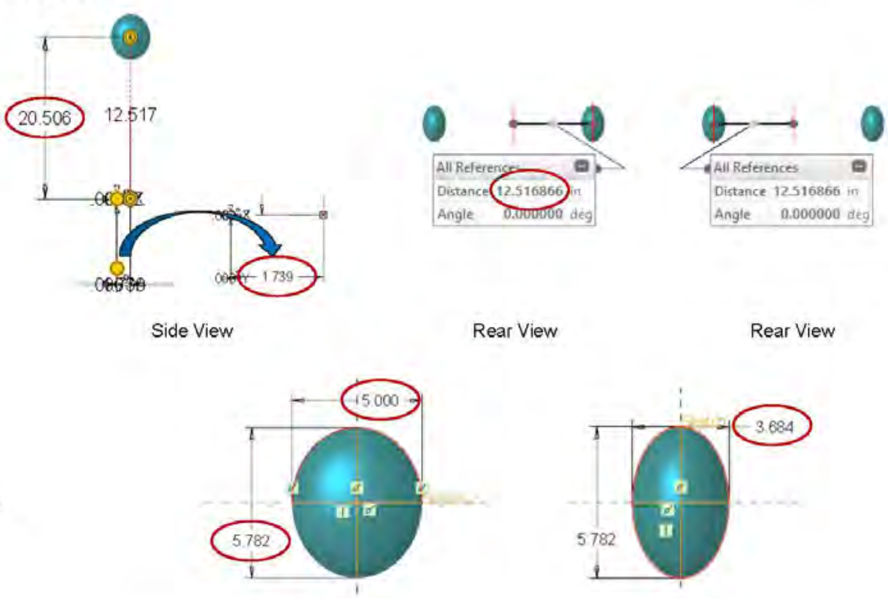
ELBOW_WEIGHTED_CENT_X	1.739	in
ELBOW_WEIGHTED_CENT_Y	12.517	in
ELBOW_WEIGHTED_CENT_Z	20.506	in
ELBOW_X_AXIS_LENGTH	5.000	in
ELBOW_Y_AXIS_LENGTH	3.684	in
ELBOW_Z_AXIS_LENGTH	5.782	in

Test #2: Elbow Contour (cont.)

GVSC CAD Model Result

Centroids

Axis Lengths



Side View — Rear View — Rear View

Side View — Rear View

TEST #2: BOOT CONTOUR

UMTRI Spreadsheet Calculations

Boot Centroids	X (in)	Y (in)	Z (in)
Right	-26.002	7.594	0.000
Left	-26.002	-7.594	0.000

Side View of Boot Contours (X, Z)		
Axis Length (X)	1.889	in
Axis Length (Z)	4.921	in

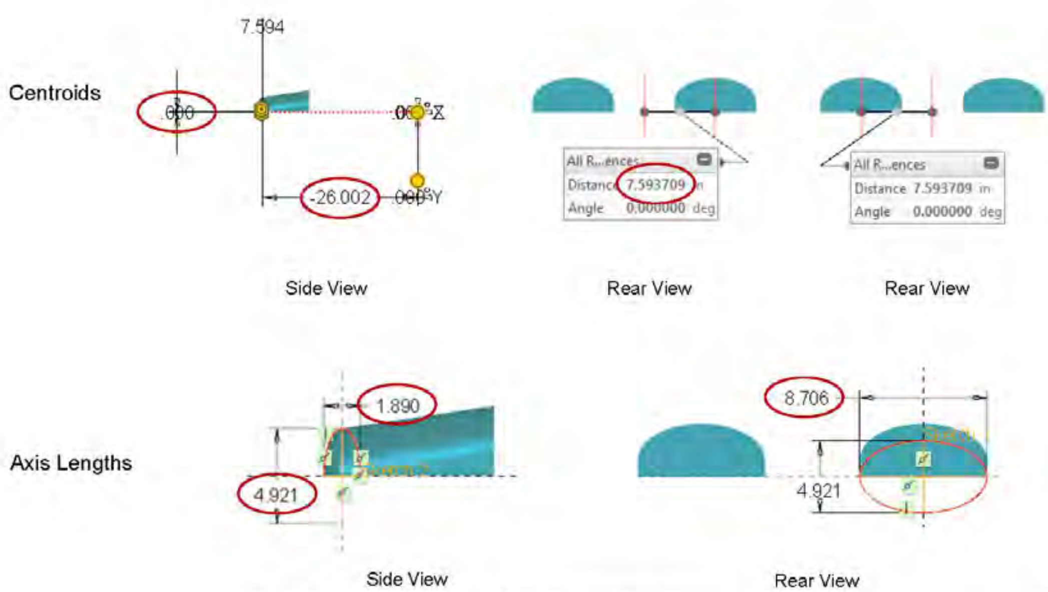
Rear View of Boot Contours (Y, Z)		
Axis Length (Y)	8.704	in
Axis Length (Z)	4.921	in

GVSC CAD Model Calculations

BOOT_TOE_WEIGHTED_CENT_X	-26.002	in
BOOT_TOE_WEIGHTED_CENT_Y	7.594	in
BOOT_TOE_WEIGHTED_CENT_Z	0.000	in
BOOT_TOE_X_AXIS_LENGTH	1.890	in
BOOT_TOE_Y_AXIS_LENGTH	8.706	in
BOOT_TOE_Z_AXIS_LENGTH	4.921	in

TEST #2: BOOT CONTOUR (CONT.)

GVSC CAD Model Result



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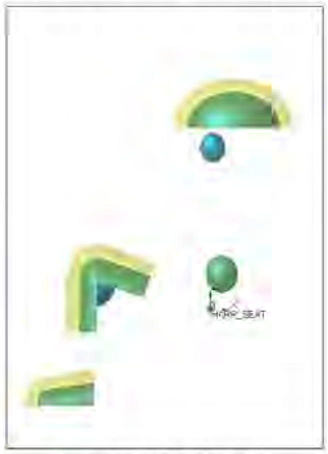
TEST #2: VARY SEATING HEIGHT/ANGLE

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	90%	PPE	15.0	20.0	SAE J826	No

Clearance (2.0 inches), Shown in Yellow



GVSC CAD Model

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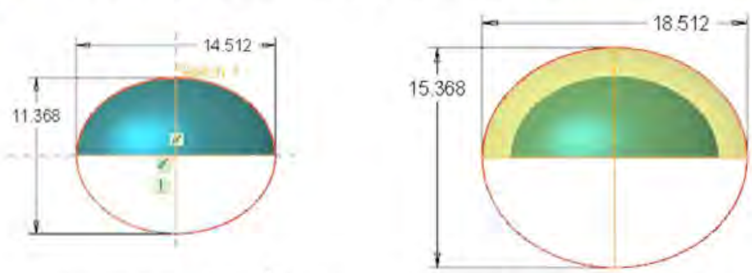
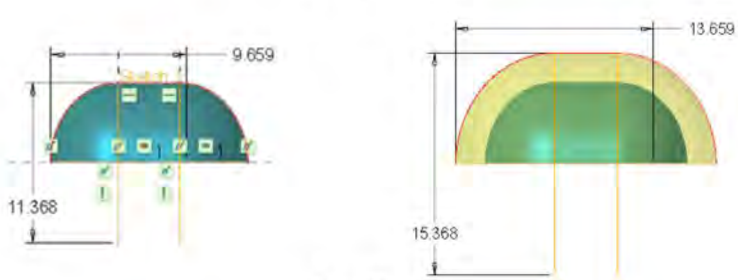
TEST #2: CLEARANCE, HELMET CONTOUR



$$Sample\ Calculation:\ \frac{1}{2}\,(18.512\ in. - 14.512\ in.) = \ 2.000\ in.\, clearance$$

Side View



Rear View

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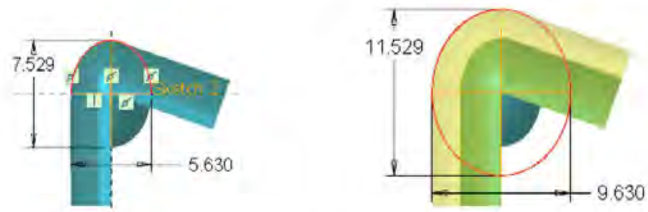
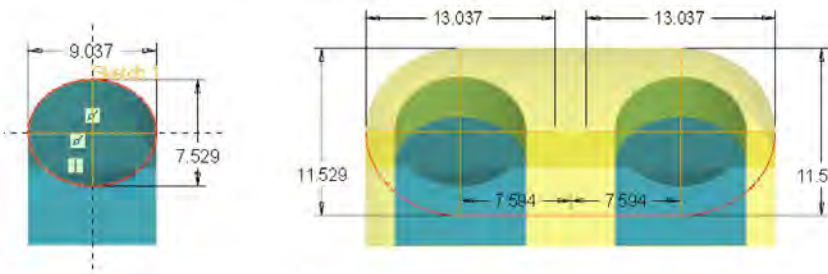
TEST #2: CLEARANCE, KNEE CONTOUR



Sample Calculation: $\frac{1}{2}(11.529\ in. - 7.529\ in.) = 2.000\ in.\ clearance$

Side View



Rear View

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 87

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TEST #2: CLEARANCE, ELBOW CONTOUR

Sample Calculation: $14.517\ in. - 12.517\ in. = 2.000\ in.\ clearance$

Rear View

Side View **Rear View**

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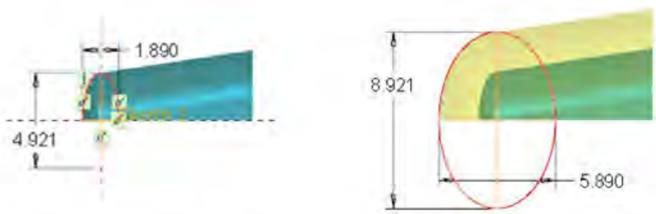
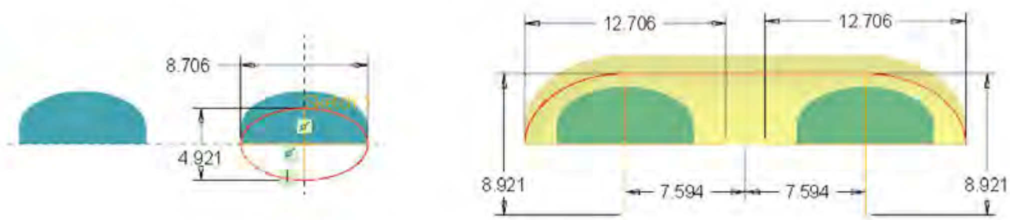
TEST #2: CLEARANCE, BOOT CONTOUR



$$Sample\ Calculation: \frac{1}{2}\,(8.921\ in. - 4.921\ in.) = 2.000\ in.clearance$$

Side View



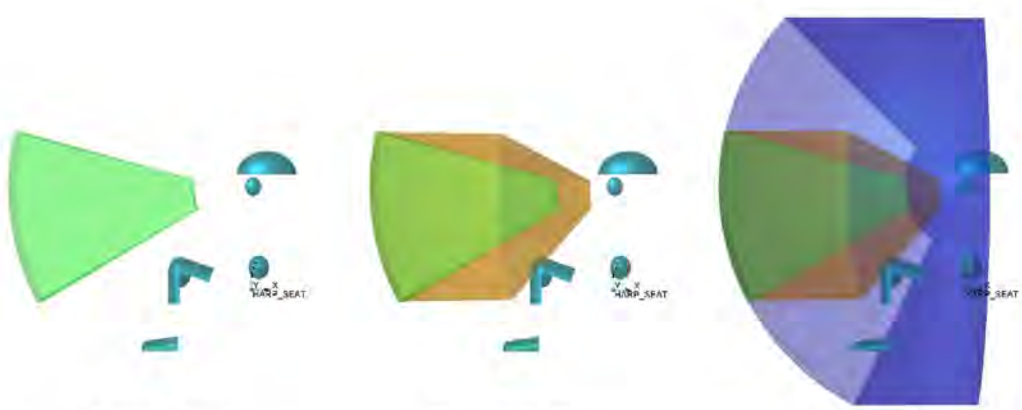
Rear View

TEST #2: VARY SEATING HEIGHT/ANGLE

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	90%	PPE	15.0	20.0	SAE J826	No

Vision Zones

Vison zones are constructed geometrically; no calculations are involved.



Primary Zone Secondary Zone Tertiary Zone

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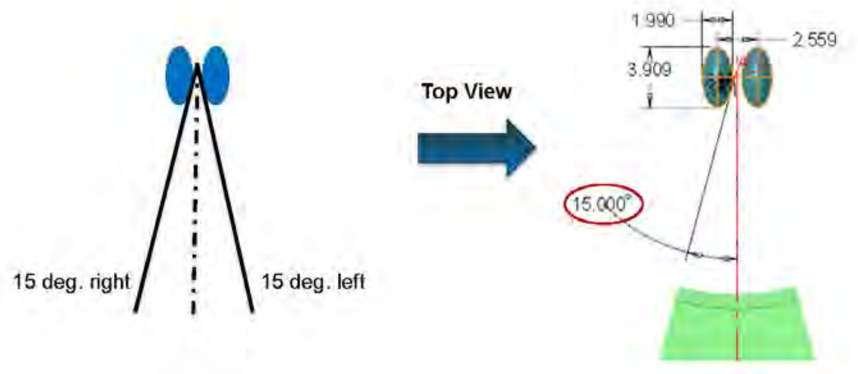
TEST #2: PRIMARY VISION ZONE



Intent

CAD Implementation

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 91

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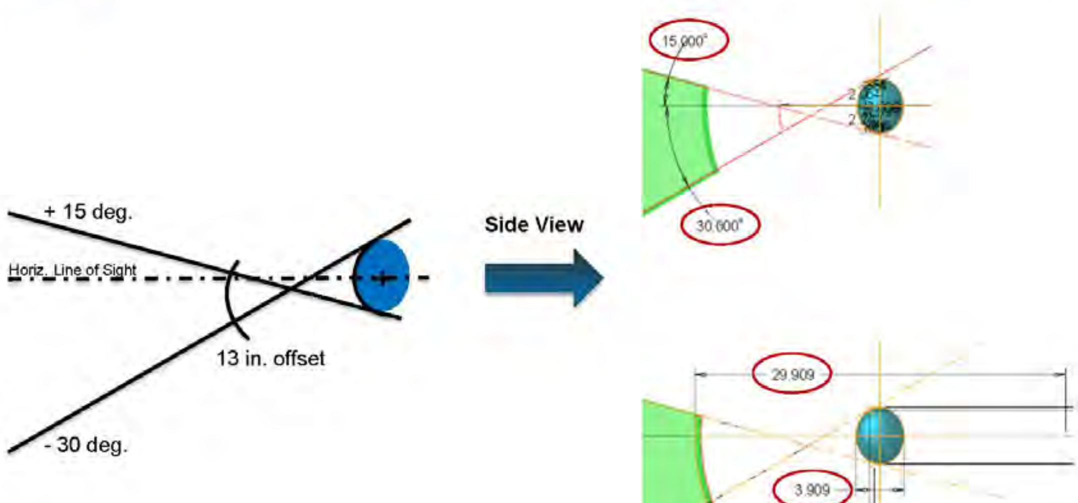
TEST #2: PRIMARY VISION ZONE (CONT.)



$$\frac{1}{2}(29.909\ in. - 3.909\ in.) = 13.000\ in.$$

Intent

CAD Implementation

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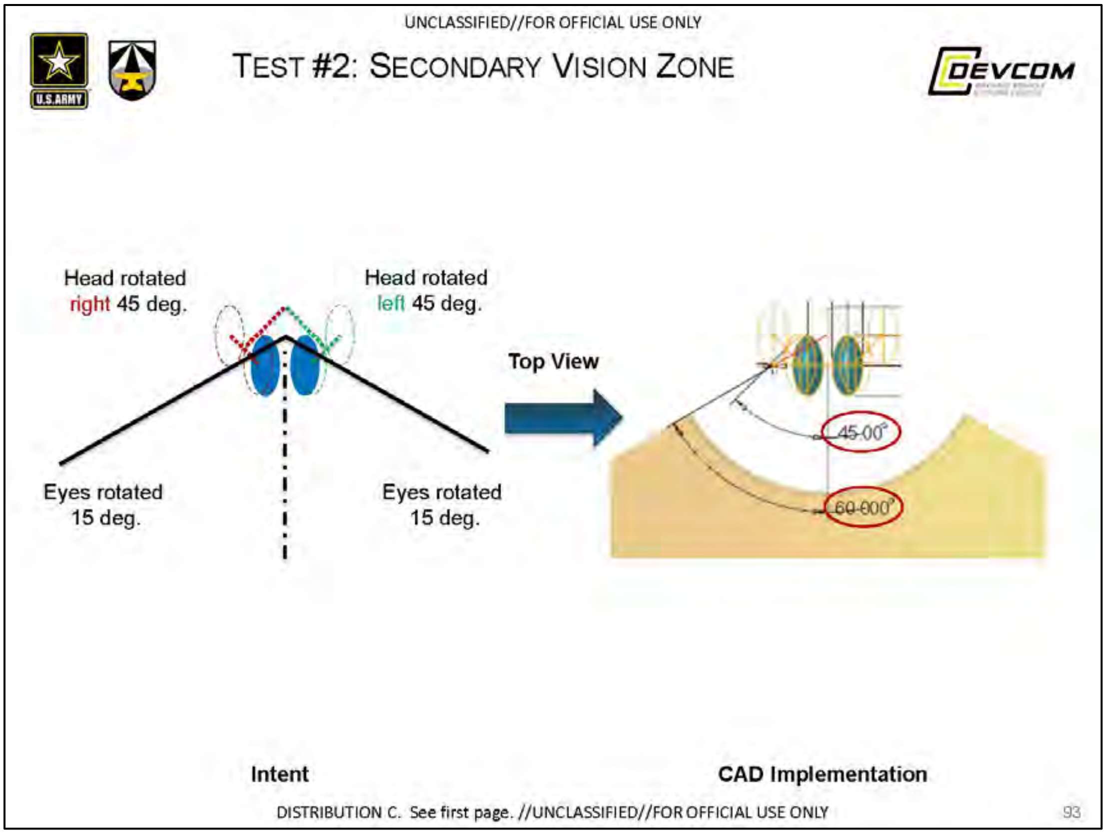
UNCLASSIFIED//FOR OFFICIAL USE ONLY
TEST #2: SECONDARY VISION ZONE
U.S. ARMY
DEVCOM
Head rotated right 45 deg.
Head rotated left 45 deg.
Eyes rotated 15 deg.
Eyes rotated 15 deg.
Top View
45.00°
60.000°
Intent
CAD Implementation
DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY
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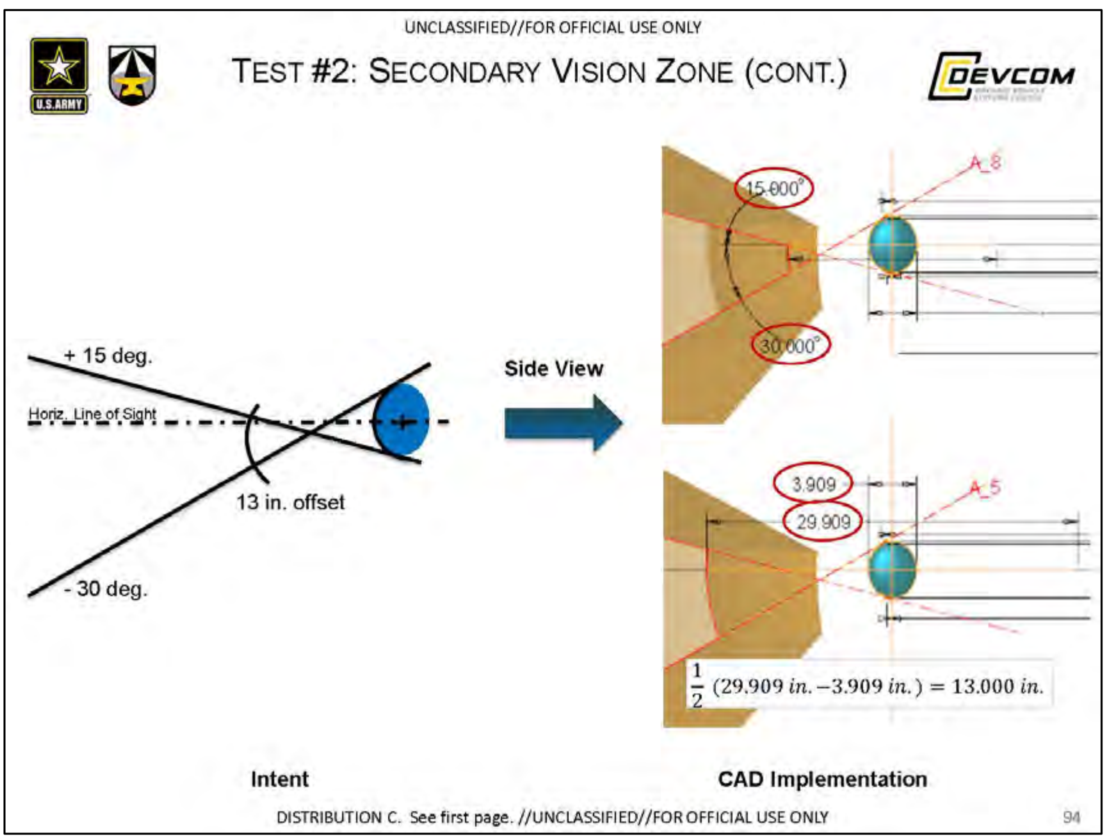
UNCLASSIFIED//FOR OFFICIAL USE ONLY
TEST #2: SECONDARY VISION ZONE (CONT.)
U.S. ARMY
DEVCOM
+ 15 deg.
Horiz. Line of Sight
13 in. offset
- 30 deg.
Side View
15.000°
30.000°
A_8
3.909
29.909
A_5
$\frac{1}{2}(29.909\ in. - 3.909\ in.) = 13.000\ in.$
Intent
CAD Implementation
DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY
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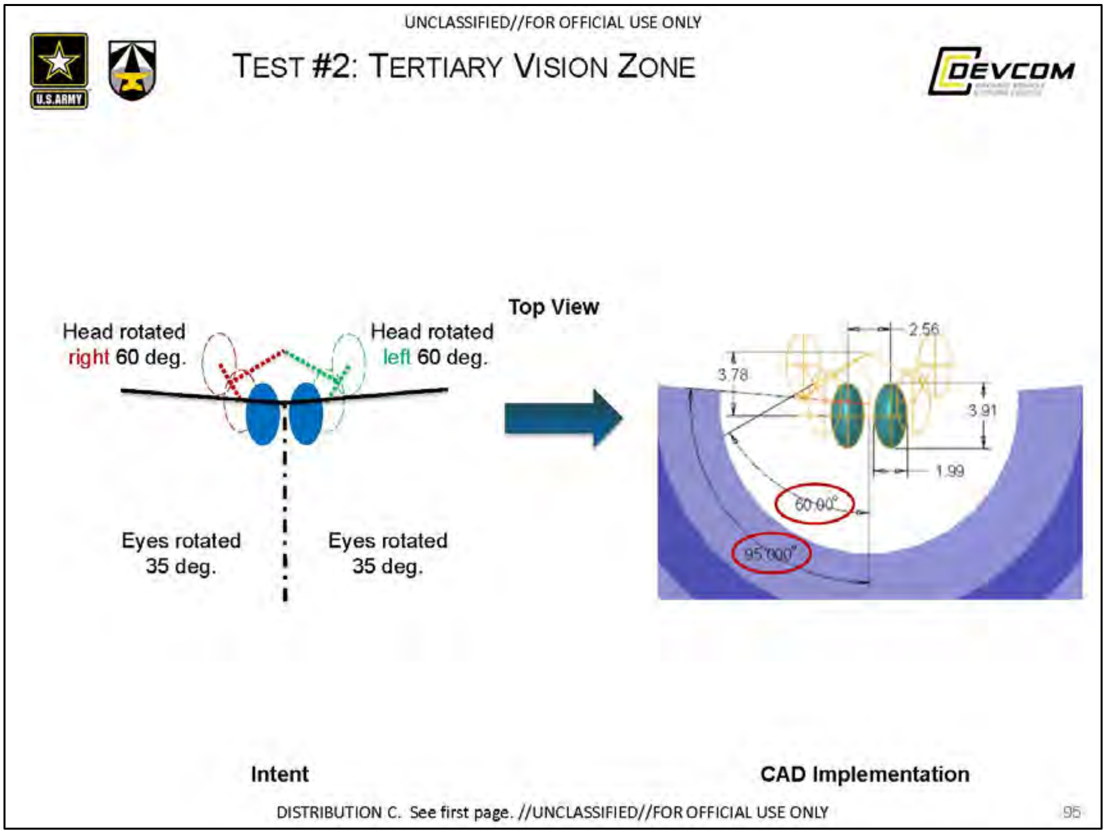

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TEST #2: TERTIARY VISION ZONE
U.S.ARMY
DEVCOM
Top View
Head rotated right 60 deg.
Head rotated left 60 deg.
Eyes rotated 35 deg.
Eyes rotated 35 deg.
2.56
3.78
3.91
1.99
60.00°
95.000°
Intent
CAD Implementation
DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY
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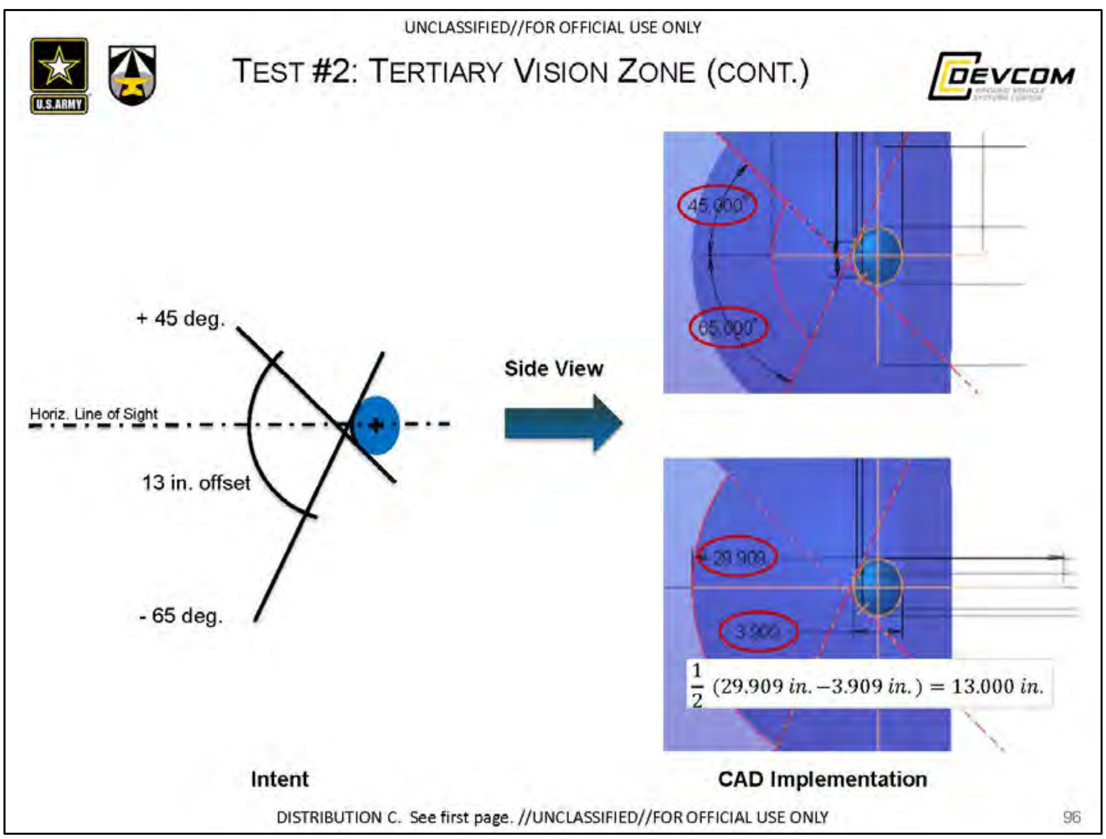

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TEST #2: TERTIARY VISION ZONE (CONT.)
U.S.ARMY
DEVCOM
+ 45 deg.
Horiz. Line of Sight
13 in. offset
- 65 deg.
Side View
45.000°
65.000°
29.909
3.909
$\frac{1}{2}(29.909\ in. - 3.909\ in.) = 13.000\ in.$
Intent
CAD Implementation
DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY
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Test #2: Vary Seating Height/Angle

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	90%	PPE	15.0	20.0	SAE J826	No

Boundary Manikin Posture and Position

GVSC CAD Model

Test #2: Results, Manikin Positioning

Small Overall Female	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM1_HIP_X	-0.552	in	-0.552	in	0.000	in
POSTURE_DHM1_HIP_Z	14.384	in	14.384	in	0.000	in
POSTURE_DHM1_EYE_X	1.626	in	1.626	in	0.000	in
POSTURE_DHM1_EYE_Z	36.312	in	36.312	in	0.000	in

Small Overall Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM2_HIP_X	-0.815	in	-0.815	in	0.000	in
POSTURE_DHM2_HIP_Z	14.489	in	14.489	in	0.000	in
POSTURE_DHM2_EYE_X	0.917	in	0.917	in	0.000	in
POSTURE_DHM2_EYE_Z	38.209	in	38.209	in	0.000	in

Average Size Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM3_HIP_X	-0.813	in	-0.813	in	0.000	in
POSTURE_DHM3_HIP_Z	14.488	in	14.488	in	0.000	in
POSTURE_DHM3_EYE_X	0.176	in	0.176	in	0.000	in
POSTURE_DHM3_EYE_Z	40.558	in	40.558	in	0.000	in

Widest Shoulders Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM4_HIP_X	-0.786	in	-0.786	in	0.000	in
POSTURE_DHM4_HIP_Z	14.478	in	14.478	in	0.000	in
POSTURE_DHM4_EYE_X	-0.198	in	-0.198	in	0.000	in
POSTURE_DHM4_EYE_Z	41.914	in	41.914	in	0.000	in

Longest Torso Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM5_HIP_X	-0.772	in	-0.772	in	0.000	in
POSTURE_DHM5_HIP_Z	14.472	in	14.472	in	0.000	in
POSTURE_DHM5_EYE_X	-0.208	in	-0.208	in	0.000	in
POSTURE_DHM5_EYE_Z	43.088	in	43.088	in	0.000	in

Longest Legs Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM6_HIP_X	-0.941	in	-0.941	in	0.000	in
POSTURE_DHM6_HIP_Z	14.540	in	14.540	in	0.000	in
POSTURE_DHM6_EYE_X	-0.390	in	-0.390	in	0.000	in
POSTURE_DHM6_EYE_Z	40.920	in	40.920	in	0.000	in

Large Overall Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM7_HIP_X	-1.173	in	-1.173	in	0.000	in
POSTURE_DHM7_HIP_Z	14.633	in	14.633	in	0.000	in
POSTURE_DHM7_EYE_X	-0.666	in	-0.666	in	0.000	in
POSTURE_DHM7_EYE_Z	42.908	in	42.908	in	0.000	in

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

Largest Observed Differences:
0.000 inches

Values in agreement

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Test #2: Small Overall Female

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	15.0	-14.0	-57.0	→	-0.552	in
Hip re H-point Z	-15.7	-15.7	-15.7	→	14.384	in
Eye re H-point X	93.3	41.3	-19.7	→	1.626	in
Eye re H-point Z	541.3	541.3	541.3	→	36.312	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM1_HIP_X	-0.552	in
POSTURE_DHM1_HIP_Z	14.384	in
POSTURE_DHM1_EYE_X	1.626	in
POSTURE_DHM1_EYE_Z	36.312	in

GVSC CAD Model Geometry

Side View

Front View

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Test #2: Small Overall Male

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	8.3	-20.7	-63.7	→	-0.815	in
Hip re H-point Z	-13.0	-13.0	-13.0	→	14.489	in
Eye re H-point X	75.3	23.3	-37.7	→	0.917	in
Eye re H-point Z	589.5	589.5	589.5	→	38.209	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM2_HIP_X	-0.815	in
POSTURE_DHM2_HIP_Z	14.489	in
POSTURE_DHM2_EYE_X	0.917	in
POSTURE_DHM2_EYE_Z	38.209	in

GVSC CAD Model Geometry

Side View

Front View

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TEST #2: AVERAGE SIZE MALE

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	8.4	-20.6	-63.6	→	-0.813	in
Hip re H-point Z	-13.0	-13.0	-13.0	→	14.488	in
Eye re H-point X	56.5	4.5	-56.5	→	0.176	in
Eye re H-point Z	649.2	649.2	649.2	→	40.558	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM3_HIP_X	-0.813	in
POSTURE_DHM3_HIP_Z	14.488	in
POSTURE_DHM3_EYE_X	0.176	in
POSTURE_DHM3_EYE_Z	40.558	in

GVSC CAD Model Geometry

Side View

Front View

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TEST #2: WIDEST SHOULDERS MALE

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	9.0	-20.0	-63.0	→	-0.786	in
Hip re H-point Z	-13.3	-13.3	-13.3	→	14.478	in
Eye re H-point X	47.0	-5.0	-66.0	→	-0.198	in
Eye re H-point Z	683.6	683.6	683.6	→	41.914	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM4_HIP_X	-0.786	in
POSTURE_DHM4_HIP_Z	14.478	in
POSTURE_DHM4_EYE_X	-0.198	in
POSTURE_DHM4_EYE_Z	41.914	in

GVSC CAD Model Geometry

Side View

Front View

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TEST #2: LONGEST TORSO MALE

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	9.4	-19.6	-62.6	→	-0.772	in
Hip re H-point Z	-13.4	-13.4	-13.4	→	14.472	in
Eye re H-point X	46.7	-5.3	-66.3	→	-0.208	in
Eye re H-point Z	713.4	713.4	713.4	→	43.088	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM5_HIP_X	-0.772	in
POSTURE_DHM5_HIP_Z	14.472	in
POSTURE_DHM5_EYE_X	-0.208	in
POSTURE_DHM5_EYE_Z	43.088	in

GVSC CAD Model Geometry

Side View   Front View

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 103

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TEST #2: LONGEST LEGS MALE

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	5.1	-23.9	-66.9	→	-0.941	in
Hip re H-point Z	-11.7	-11.7	-11.7	→	14.540	in
Eye re H-point X	42.1	-9.9	-70.9	→	-0.390	in
Eye re H-point Z	658.4	658.4	658.4	→	40.920	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM6_HIP_X	-0.941	in
POSTURE_DHM6_HIP_Z	14.540	in
POSTURE_DHM6_EYE_X	-0.390	in
POSTURE_DHM6_EYE_Z	40.920	in

GVSC CAD Model Geometry

Side View   Front View

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 104

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TEST #2: LARGE OVERALL MALE

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-0.8	-29.8	-72.8	→	-1.173	in
Hip re H-point Z	-9.3	-9.3	-9.3	→	14.633	in
Eye re H-point X	35.1	-16.9	-77.9	→	-0.666	in
Eye re H-point Z	708.9	708.9	708.9	→	42.908	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM7_HIP_X	-1.173	in
POSTURE_DHM7_HIP_Z	14.633	in
POSTURE_DHM7_EYE_X	-0.666	in
POSTURE_DHM7_EYE_Z	42.908	in

GVSC CAD Model Geometry

Side View

Front View

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10.7.3 TEST #3 – VARY SEATING HEIGHT/ANGLE AND HARP TOOL

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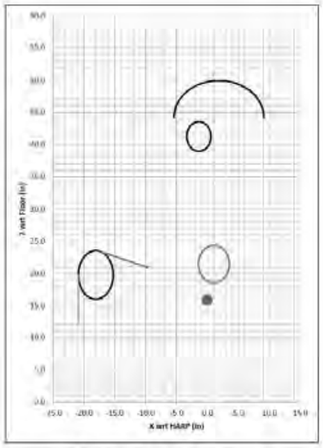
TEST #3: VARY SEATING HEIGHT/ANGLE AND HARP TOOL

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	90%	PPE	15.8	15.0	ISO 5353	No

Basic Accommodation



UMTRI Spreadsheet

GVSC CAD Model

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TEST #3: COMPARISON TO BASELINE

Test #	Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
1	90%	90%	PPE	13.8	0.0	SAE J826	No
3	90%	90%	PPE	15.8	15.0	ISO 5353	No

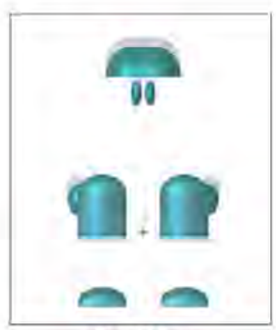
Note: Highlighted values differ from comparison test.

Observations/Notes

- The HARP Measurement Tool does not affect the relationship between the occupant and the seat. However, because composite body boundaries are provided with respect to HARP, care must be taken when inserting results into the vehicle environment.

Side View

— Test #1 (Baseline)
Test #3



Front View

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TEST #3: RESULTS, ACCOMMODATION

HARP	UMTRI Value		GVSC Value		Difference	
HARP_X	0.000	in	0.000	in	0.000	in
HARP_Z	15.800	in	15.800	in	0.000	in

Eyellipse	UMTRI Value		GVSC Value		Difference	
EYELLIPSE_CENTROID_X	-1.409	in	-1.409	in	0.000	in
EYELLIPSE_CENTROID_Y (+/-)	1.280	in	1.280	in	0.000	in
EYELLIPSE_CENTROID_Z	41.251	in	41.252	in	0.001	in
EYELLIPSE_X_AXIS_LENGTH	3.907	in	3.909	in	0.003	in
EYELLIPSE_Y_AXIS_LENGTH	1.988	in	1.990	in	0.001	in
EYELLIPSE_Z_AXIS_LENGTH	4.595	in	4.596	in	0.001	in

Helmet Contour	UMTRI Value		GVSC Value		Difference	
HELMET_CONTOUR_CENTROID_X	1.839	in	1.839	in	0.000	in
HELMET_CONTOUR_CENTROID_Y (+/-)	2.185	in	2.185	in	0.000	in
HELMET_CONTOUR_CENTROID_Z	44.235	in	44.236	in	0.001	in
HELMET_CONTOUR_X_AXIS_LENGTH	14.509	in	14.512	in	0.003	in
HELMET_CONTOUR_Y_AXIS_LENGTH	9.657	in	9.659	in	0.001	in
HELMET_CONTOUR_Z_AXIS_LENGTH	11.366	in	11.368	in	0.001	in

Knee Contour	UMTRI Value		GVSC Value		Difference	
KNEE_CONTOUR_WEIGHTED_CENT_X	18.062	in	18.062	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Y (+/-)	7.594	in	7.594	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Z	19.764	in	19.764	in	0.000	in
KNEE_CONTOUR_X_AXIS_LENGTH	5.628	in	5.630	in	0.002	in
KNEE_CONTOUR_Y_AXIS_LENGTH	9.035	in	9.037	in	0.002	in
KNEE_CONTOUR_Z_AXIS_LENGTH	7.529	in	7.529	in	0.001	in
KNEE_SHIN_ANGLE	0.000	deg	0.000	deg	0.000	deg
KNEE_THIGH_ANGLE	17.855	deg	17.855	deg	0.000	deg

Elbow Contour	UMTRI Value		GVSC Value		Difference	
ELBOW_WEIGHTED_CENT_X	1.032	in	1.032	in	0.000	in
ELBOW_WEIGHTED_CENT_Y	12.407	in	12.407	in	0.000	in
ELBOW_WEIGHTED_CENT_Z	21.450	in	21.450	in	0.000	in
ELBOW_X_AXIS_LENGTH	4.996	in	5.000	in	0.004	in
ELBOW_Y_AXIS_LENGTH	3.683	in	3.684	in	0.001	in
ELBOW_Z_AXIS_LENGTH	5.779	in	5.782	in	0.003	in

Boot Contour	UMTRI Value		GVSC Value		Difference	
BOOT_TOE_WEIGHTED_CENT_X	-26.454	in	-26.454	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Y	7.594	in	7.594	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Z	0.000	in	0.000	in	0.000	in
BOOT_TOE_X_AXIS_LENGTH	1.889	in	1.890	in	0.001	in
BOOT_TOE_Y_AXIS_LENGTH	8.704	in	8.706	in	0.002	in
BOOT_TOE_Z_AXIS_LENGTH	4.921	in	4.921	in	0.000	in

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

Largest Observed Differences:
0.004 inches
0.000 degrees

Values in agreement

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TEST #3: SEAT HARP

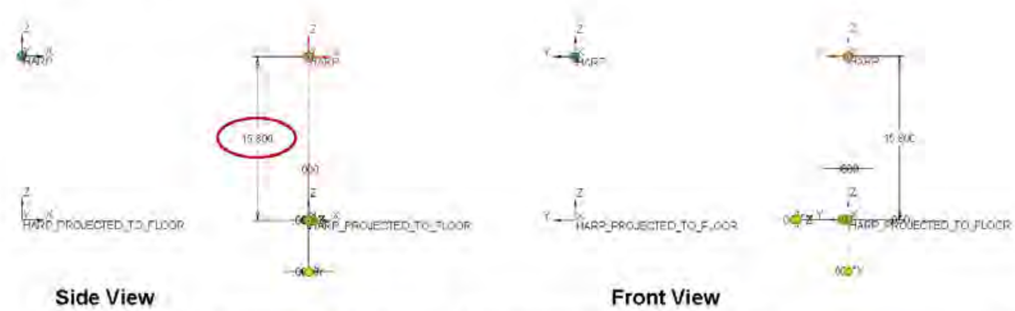
UMTRI Spreadsheet Calculations

	X (in)	Z (in)
HARP	0.000	15.800

GVSC CAD Model Calculations

HARP_X	0.000	in
HARP_Z	15.800	in

GVSC CAD Model Geometry



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TEST #3: EYELLIPSE

UMTRI Spreadsheet Calculations

Eyellipse Centroids	X (in)	Y (in)	Z (in)
Right	-1.409	1.280*	41.251
Left	-1.409	-1.280*	41.251

Side View of Eyellipses (X, Z)		
Axis Length (X)	3.907	in
Axis Length (Z)	4.595	in

Rear View of Eyellipses (Y, Z)		
Axis Length (Y)	1.988	in
Axis Length (Z)	4.595	in

GVSC CAD Model Calculations

EYELLIPSE_CENTROID_X	-1.409	in
EYELLIPSE_CENTROID_Y	1.280*	in
EYELLIPSE_CENTROID_Z	41.252	in
EYELLIPSE_X_AXIS_LENGTH	3.909	in
EYELLIPSE_Y_AXIS_LENGTH	1.990	in
EYELLIPSE_Z_AXIS_LENGTH	4.596	in

*Given value, not calculated

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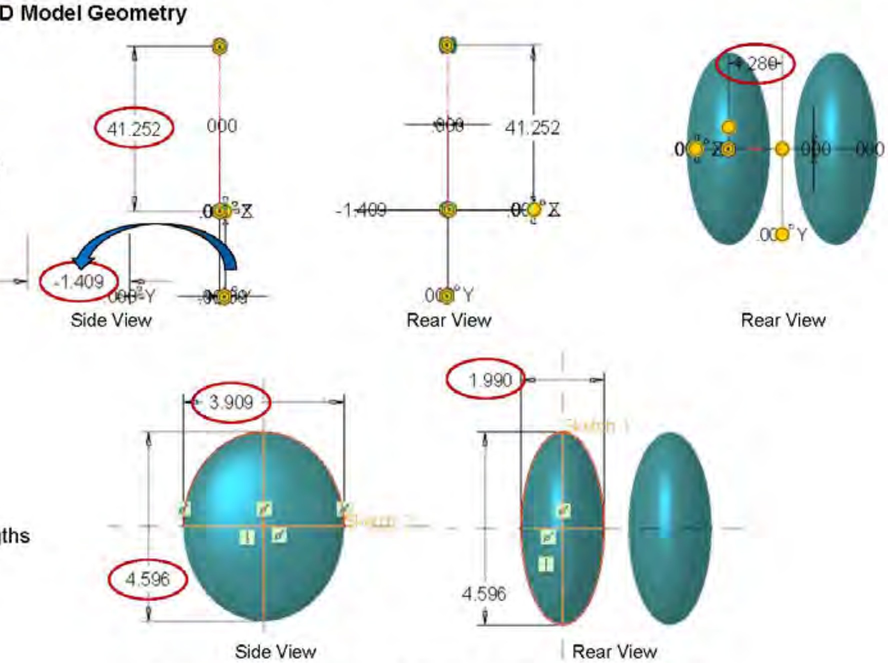
TEST #3: EYELLIPSE (CONT.)

GVSC CAD Model Geometry

Centroids

Axis Lengths



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TEST #3: HELMET CONTOUR

UMTRI Spreadsheet Calculations

Construction Centroids	X (in)	Y (in)	Z (in)
Right	1.839	2.185*	44.235
Left	1.839	-2.185*	44.235

Side View of Helmet Contour (X, Z)		
Axis Length (X)	14.509	in
Axis Length (Z)	11.366	in

Rear View of Helmet Contour (Y, Z)		
Axis Length (Y)	9.657	in
Axis Length (Z)	11.366	in

GVSC CAD Model Calculations

HELMET_CONTOUR_CENTROID_X	1.839	in
HELMET_CONTOUR_CENTROID_Y	2.185*	in
HELMET_CONTOUR_CENTROID_Z	44.236	in
HELMET_CONTOUR_X_AXIS_LENGTH	14.512	in
HELMET_CONTOUR_Y_AXIS_LENGTH	9.659	in
HELMET_CONTOUR_Z_AXIS_LENGTH	11.368	in

*Given value, not calculated

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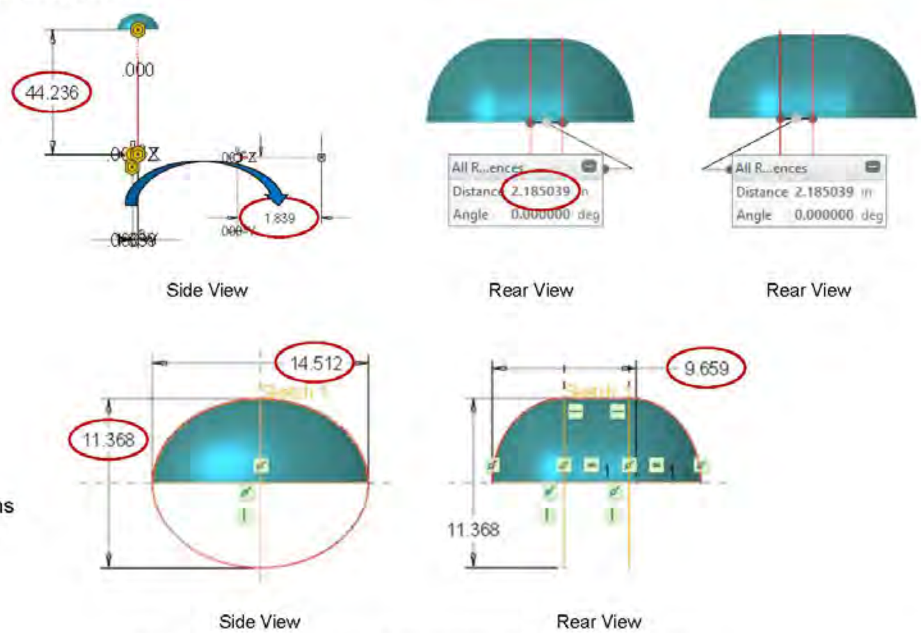
TEST #3: HELMET CONTOUR (CONT.)

GVSC CAD Model Result

Centroids



Axis Lengths

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TEST #3: KNEE CONTOUR

UMTRI Spreadsheet Calculations

Knee Centroids	X (in)	Y (in)	Z (in)
Right	-18.062	7.594	19.764
Left	-18.062	-7.594	19.764

Side View of Knee Contours (X, Z)		
Axis Length (X)	5.628	in
Axis Length (Z)	7.529	in
Rear View of Knee Contours (Y, Z)		
Axis Length (Y)	9.035	in
Axis Length (Z)	7.529	in
Leg Segment Angle wrt Vertical	0.000*	deg
Thigh Segment Angle wrt Horizontal	17.855	deg

GVSC CAD Model Calculations

KNEE_CONTOUR_WEIGHTED_CENT_X	-18.062	in
KNEE_CONTOUR_WEIGHTED_CENT_Y	7.594	in
KNEE_CONTOUR_WEIGHTED_CENT_Z	19.764	in
KNEE_CONTOUR_X_AXIS_LENGTH	5.630	in
KNEE_CONTOUR_Y_AXIS_LENGTH	9.037	in
KNEE_CONTOUR_Z_AXIS_LENGTH	7.529	in
KNEE_SHIN_ANGLE	0.000*	deg
KNEE_THIGH_ANGLE	17.855	deg

*Given value, not calculated

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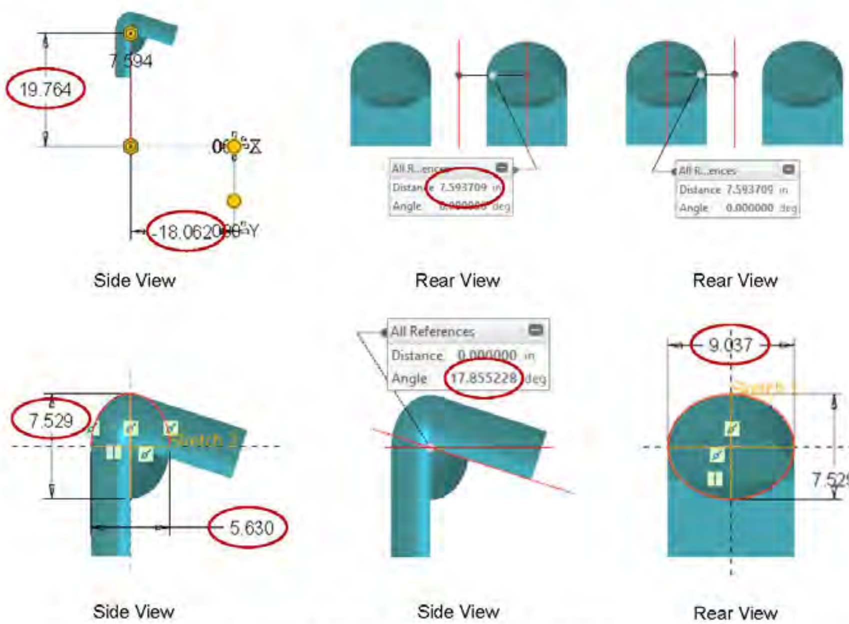
TEST #3: KNEE CONTOUR (CONT.)

GVSC CAD Model Result

Centroids

Axis Lengths
Shin/Thigh Angles



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TEST #3: ELBOW CONTOUR

UMTRI Spreadsheet Calculations

Elbow Centroids	X (in)	Y (in)	Z (in)
Right	1.032	12.407	21.450
Left	1.032	-12.407	21.450

Side View of Elbow Contours (X, Z)

Axis Length (X)	4.996	in
Axis Length (Z)	5.779	in

Rear View of Elbow Contours (Y, Z)

Axis Length (Y)	3.683	in
Axis Length (Z)	5.779	in

GVSC CAD Model Calculations

ELBOW_WEIGHTED_CENT_X	1.032	in
ELBOW_WEIGHTED_CENT_Y	12.407	in
ELBOW_WEIGHTED_CENT_Z	21.450	in
ELBOW_X_AXIS_LENGTH	5.000	in
ELBOW_Y_AXIS_LENGTH	3.684	in
ELBOW_Z_AXIS_LENGTH	5.782	in

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TEST #3: ELBOW CONTOUR (CONT.)

GVSC CAD Model Result

Centroids

Side View Rear View Rear View

Axis Lengths

Side View Rear View

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TEST #3: BOOT CONTOUR

UMTRI Spreadsheet Calculations

Boot Centroids	X (in)	Y (in)	Z (in)
Right	-26.454	7.594	0.000
Left	-26.454	-7.594	0.000

Side View of Boot Contours (X, Z)		
Axis Length (X)	1.889	in
Axis Length (Z)	4.921	in

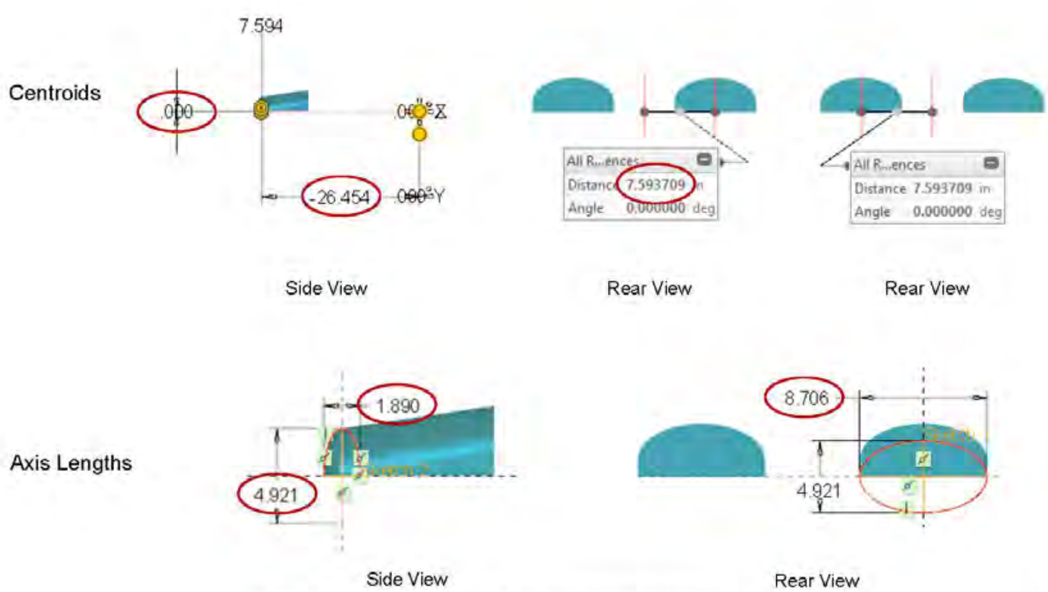
Rear View of Boot Contours (Y, Z)		
Axis Length (Y)	8.704	in
Axis Length (Z)	4.921	in

GVSC CAD Model Calculations

BOOT_TOE_WEIGHTED_CENT_X	-26.454	in
BOOT_TOE_WEIGHTED_CENT_Y	7.594	in
BOOT_TOE_WEIGHTED_CENT_Z	0.000	in
BOOT_TOE_X_AXIS_LENGTH	1.890	in
BOOT_TOE_Y_AXIS_LENGTH	8.706	in
BOOT_TOE_Z_AXIS_LENGTH	4.921	in

TEST #3: BOOT CONTOUR (CONT.)

GVSC CAD Model Result



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Test #3: Vary Seating Height/Angle and HARP Tool

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	90%	PPE	15.8	15.0	ISO 5353	No

Clearance (2.0 inches), Shown in Yellow

GVSC CAD Model

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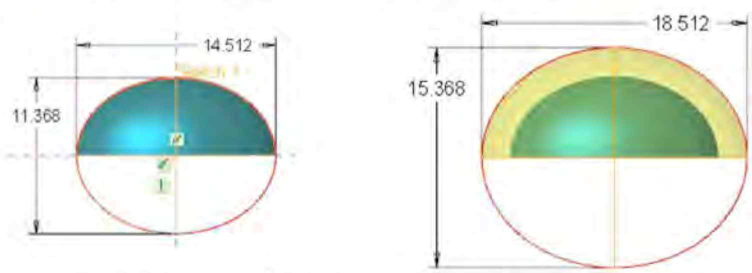
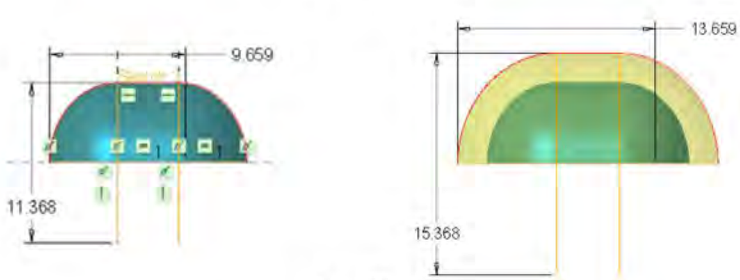
Test #3: Clearance, Helmet Contour



$$\textit{Sample Calculation: } \frac{1}{2}\,(18.512\, in. - 14.512\, in.) = \; 2.000\, in.\, clearance$$

Side View



Rear View

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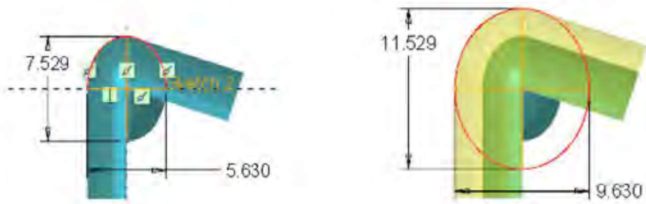
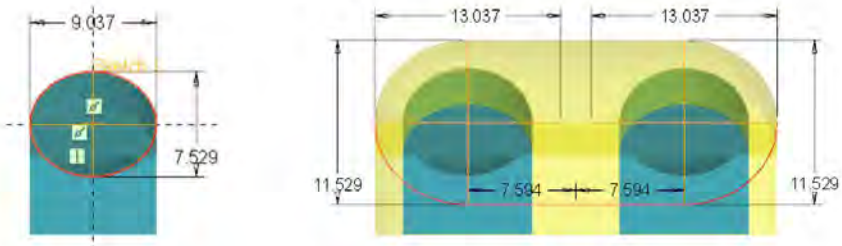
TEST #3: CLEARANCE, KNEE CONTOUR



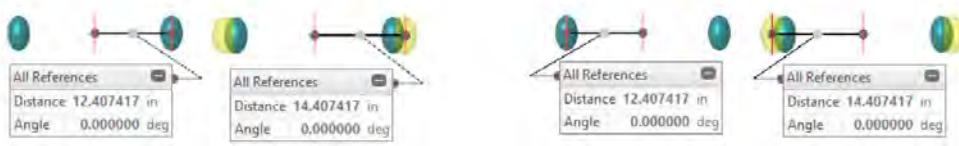
$$Sample\ Calculation: \frac{1}{2}\,(11.529\ in. - 7.529\ in.) = \ 2.000\ in.\ clearance$$

Side View



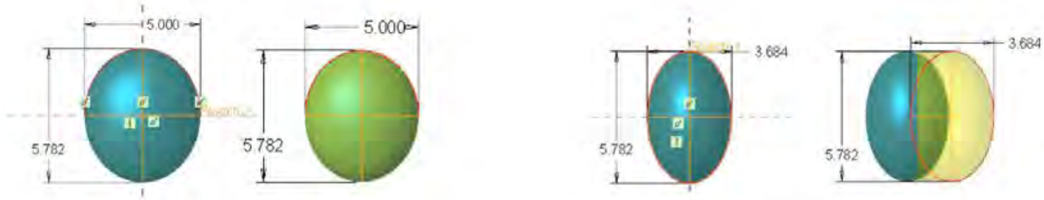
Rear View

TEST #3: CLEARANCE, ELBOW CONTOUR



$$Sample\ Calculation: 14.407\ in. - 12.407\ in. = \ 2.000\ in.\ clearance$$

Rear View



Side View **Rear View**

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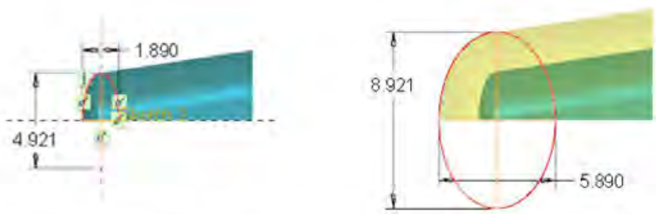
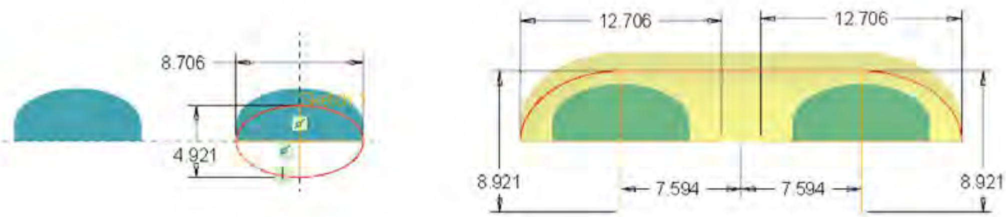
Test #3: Clearance, Boot Contour



$$Sample\ Calculation: \frac{1}{2}(8.921\ in. - 4.921\ in.) = 2.000\ in.\ clearance$$

Side View



Rear View

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 124

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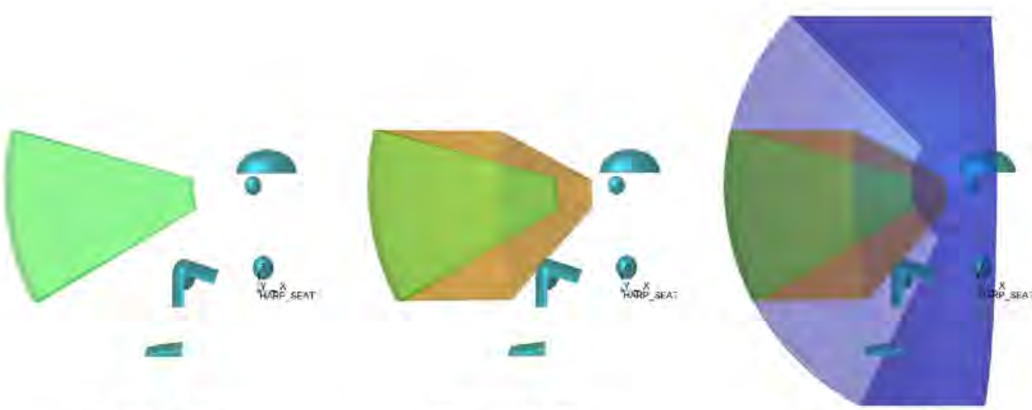
Test #3: Vary Seating Height/Angle and HARP Tool

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	90%	PPE	15.8	15.0	ISO 5353	No

Vision Zones

Vison zones are constructed geometrically; no calculations are involved.



Primary Zone Secondary Zone Tertiary Zone

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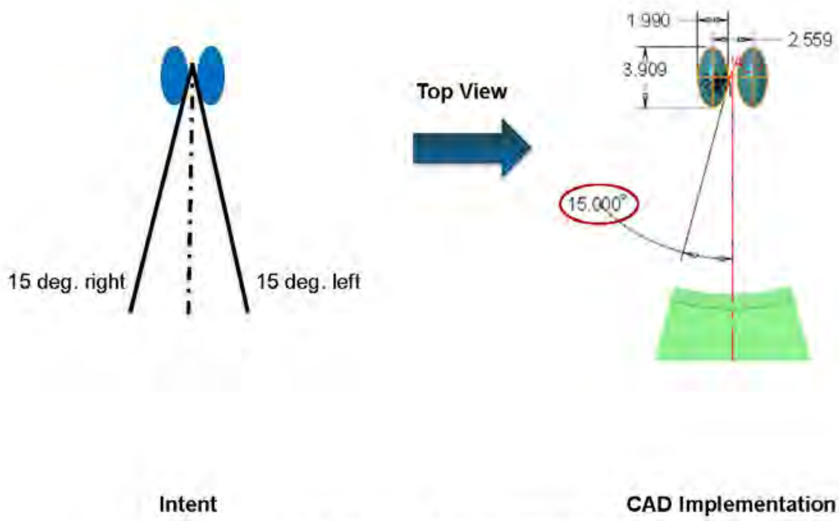
TEST #3: PRIMARY VISION ZONE



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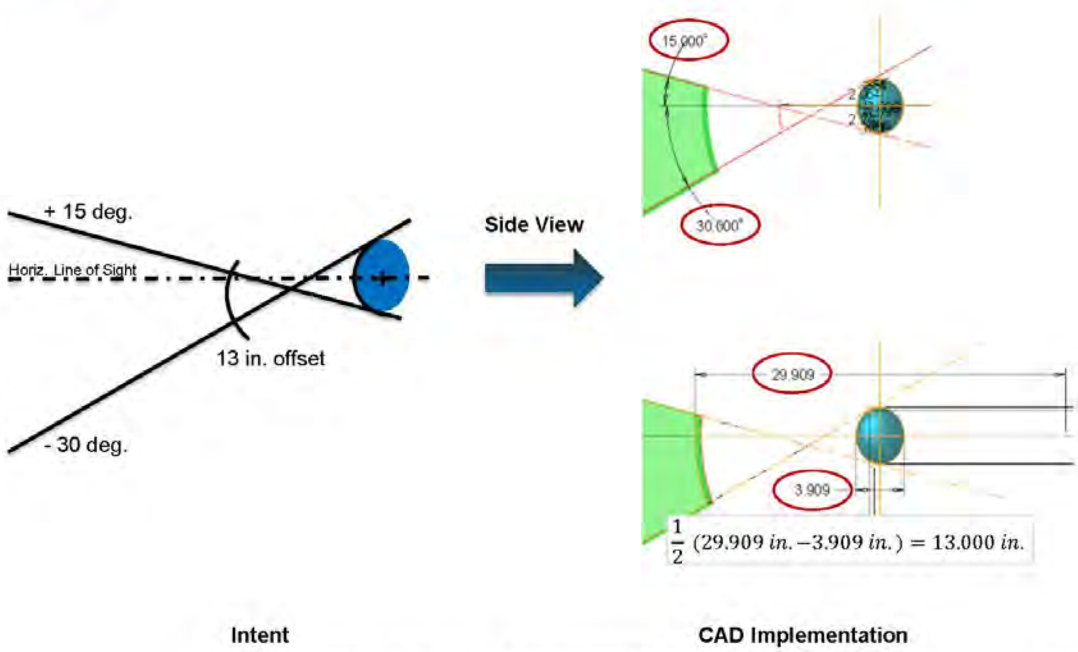
TEST #3: PRIMARY VISION ZONE (CONT.)



DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY

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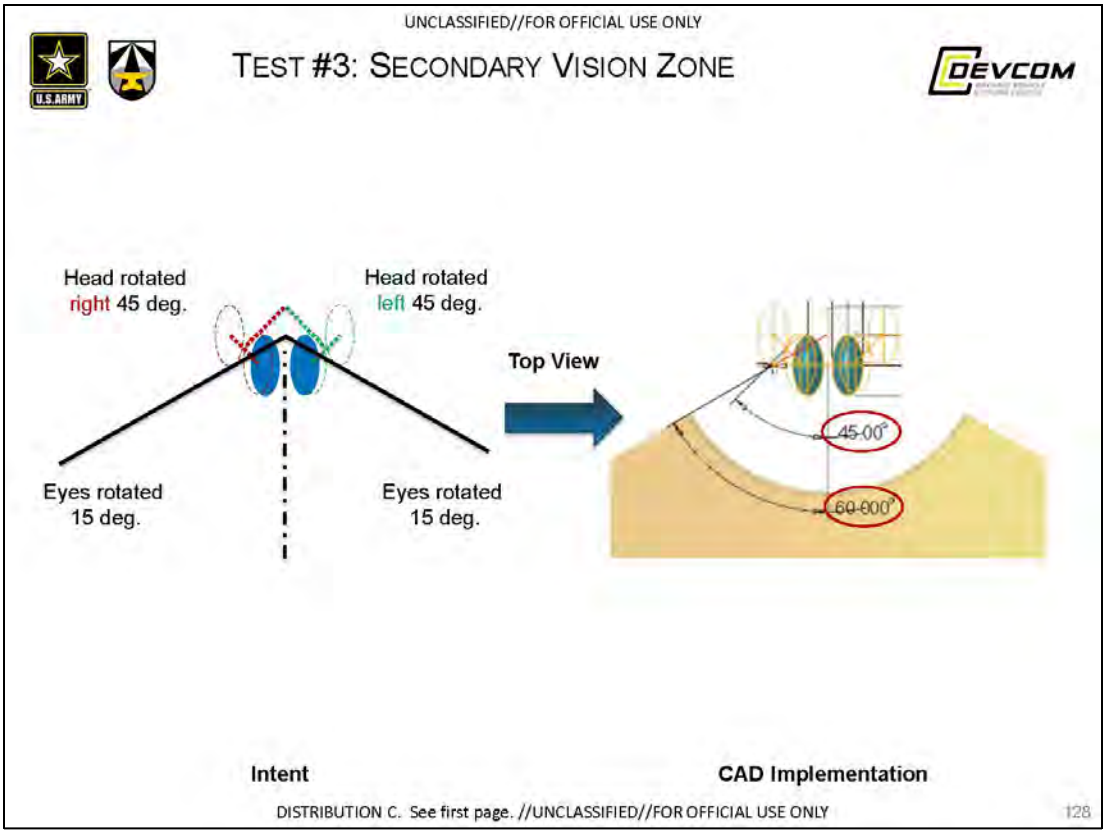
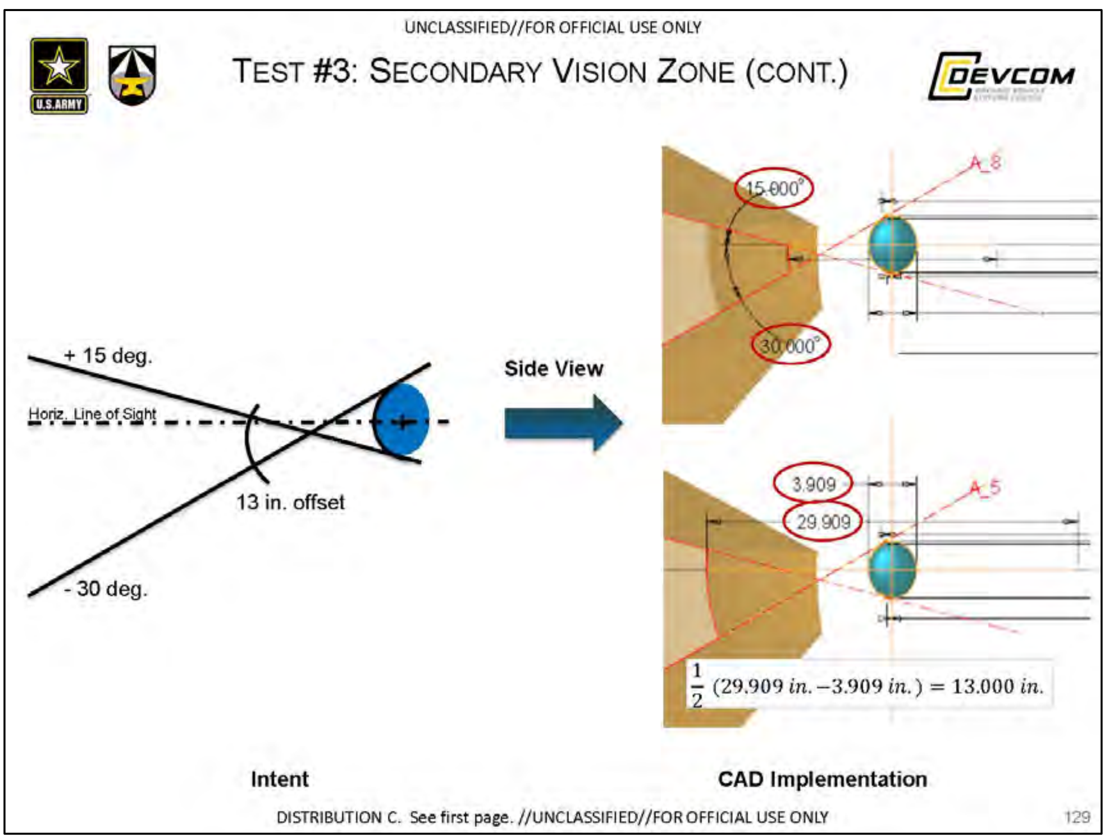

UNCLASSIFIED//FOR OFFICIAL USE ONLY
TEST #3: SECONDARY VISION ZONE
Head rotated right 45 deg.
Head rotated left 45 deg.
Top View
Eyes rotated 15 deg.
Eyes rotated 15 deg.
45.00°
60.000°
Intent
CAD Implementation
DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY
128


UNCLASSIFIED//FOR OFFICIAL USE ONLY
TEST #3: SECONDARY VISION ZONE (CONT.)
+ 15 deg.
Horiz. Line of Sight
13 in. offset
- 30 deg.
Side View
15.000°
30.000°
A_8
3.909
29.909
A_5
$\frac{1}{2}(29.909\ in. - 3.909\ in.) = 13.000\ in.$
Intent
CAD Implementation
DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY
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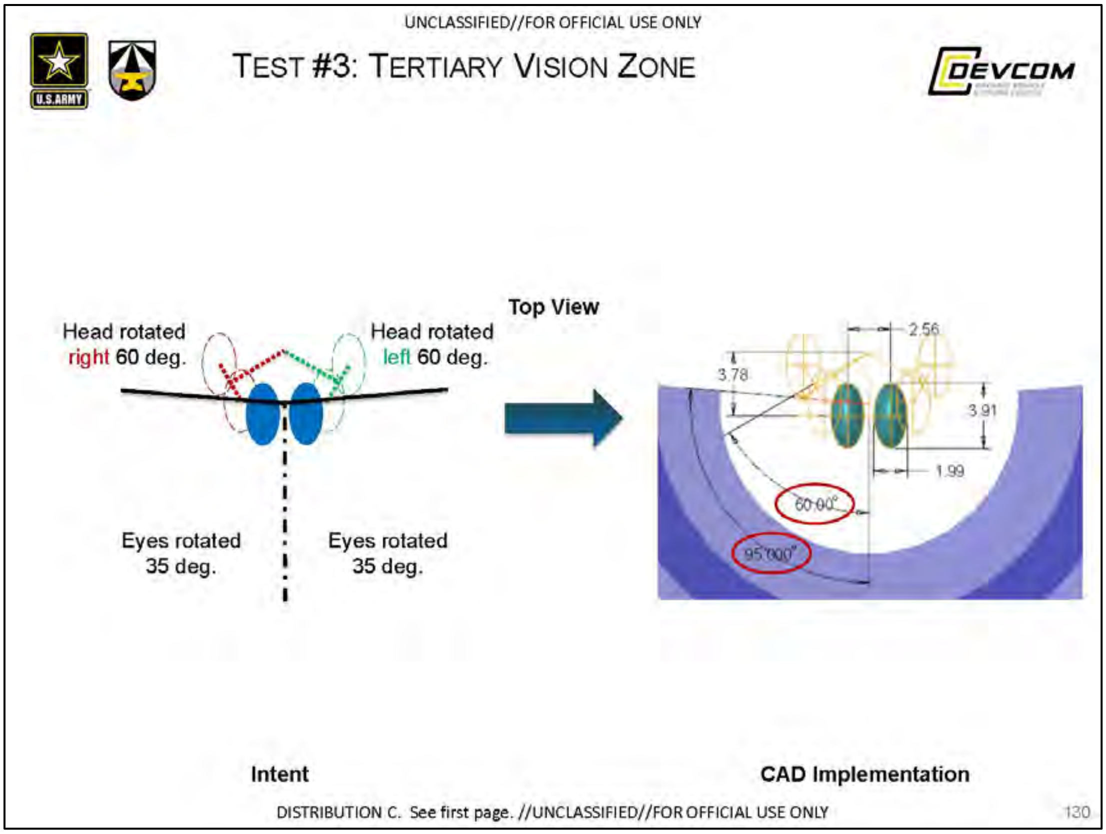
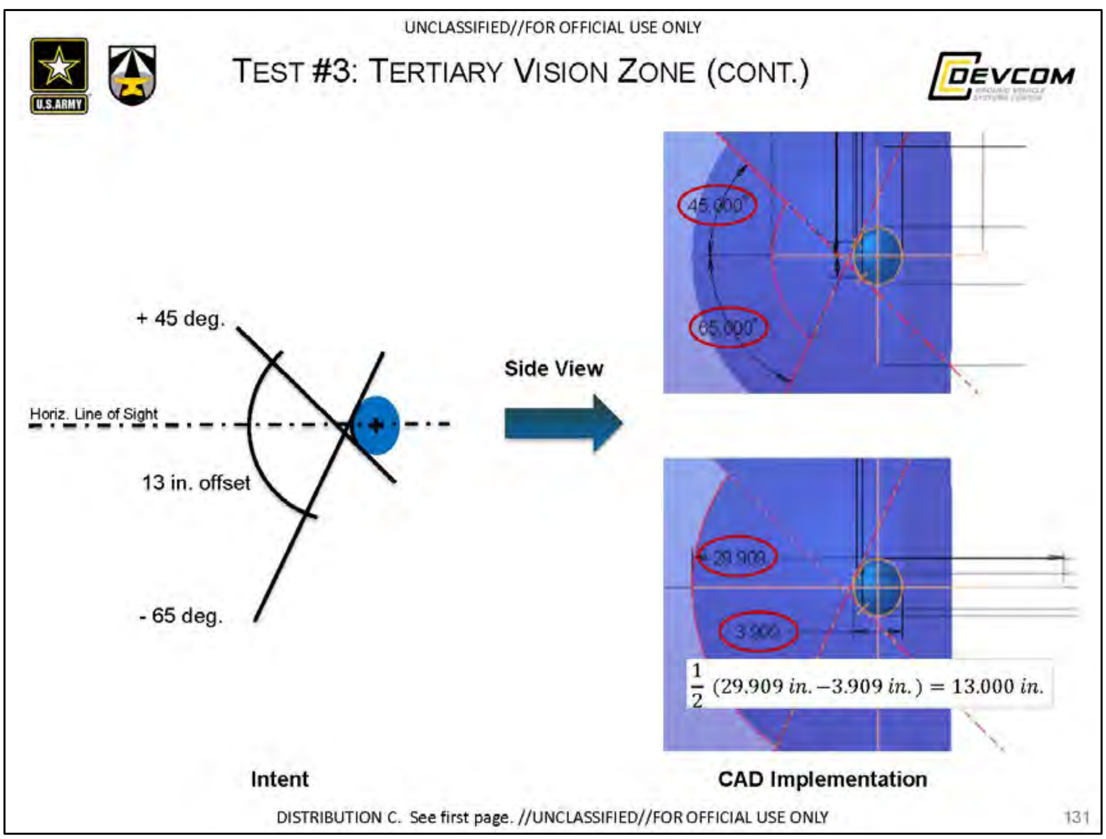

UNCLASSIFIED//FOR OFFICIAL USE ONLY
U.S.ARMY
TEST #3: TERTIARY VISION ZONE
DEVCOM
Top View
Head rotated
right 60 deg.
Head rotated
left 60 deg.
Eyes rotated
35 deg.
Eyes rotated
35 deg.
2.56
3.78
3.91
1.99
60.00°
95.000°
Intent
CAD Implementation
DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY
130


UNCLASSIFIED//FOR OFFICIAL USE ONLY
U.S.ARMY
TEST #3: TERTIARY VISION ZONE (CONT.)
DEVCOM
+ 45 deg.
Horiz. Line of Sight
13 in. offset
- 65 deg.
Side View
45.000°
65.000°
29.909
3.909
$\frac{1}{2}(29.909\ in. - 3.909\ in.) = 13.000\ in.$
Intent
CAD Implementation
DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY
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Test #3: Vary Seating Height/Angle and HARP Tool

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	90%	PPE	15.8	15.0	ISO 5353	No

Boundary Manikin Posture and Position

GVSC CAD Model

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Test #3: Results, Manikin Positioning

Small Overall Female	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM1_HIP_X	-0.893	in	-0.893	in	0.000	in
POSTURE_DHM1_HIP_Z	15.184	in	15.184	in	0.000	in
POSTURE_DHM1_EYE_X	0.041	in	0.041	in	0.000	in
POSTURE_DHM1_EYE_Z	37.309	in	37.309	in	0.000	in

Small Overall Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM2_HIP_X	-1.155	in	-1.155	in	0.000	in
POSTURE_DHM2_HIP_Z	15.289	in	15.289	in	0.000	in
POSTURE_DHM2_EYE_X	-0.668	in	-0.668	in	0.000	in
POSTURE_DHM2_EYE_Z	39.207	in	39.207	in	0.000	in

Average Size Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM3_HIP_X	-1.153	in	-1.153	in	0.000	in
POSTURE_DHM3_HIP_Z	15.288	in	15.288	in	0.000	in
POSTURE_DHM3_EYE_X	-1.409	in	-1.409	in	0.000	in
POSTURE_DHM3_EYE_Z	41.556	in	41.556	in	0.000	in

Widest Shoulders Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM4_HIP_X	-1.127	in	-1.127	in	0.000	in
POSTURE_DHM4_HIP_Z	15.278	in	15.278	in	0.000	in
POSTURE_DHM4_EYE_X	-1.783	in	-1.783	in	0.000	in
POSTURE_DHM4_EYE_Z	42.911	in	42.911	in	0.000	in

Longest Torso Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM5_HIP_X	-1.112	in	-1.112	in	0.000	in
POSTURE_DHM5_HIP_Z	15.272	in	15.272	in	0.000	in
POSTURE_DHM5_EYE_X	-1.792	in	-1.792	in	0.000	in
POSTURE_DHM5_EYE_Z	44.096	in	44.096	in	0.000	in

Longest Legs Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM6_HIP_X	-1.281	in	-1.281	in	0.000	in
POSTURE_DHM6_HIP_Z	15.340	in	15.340	in	0.000	in
POSTURE_DHM6_EYE_X	-1.974	in	-1.974	in	0.000	in
POSTURE_DHM6_EYE_Z	41.917	in	41.917	in	0.000	in

Large Overall Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM7_HIP_X	-1.513	in	-1.513	in	0.000	in
POSTURE_DHM7_HIP_Z	15.433	in	15.433	in	0.000	in
POSTURE_DHM7_EYE_X	-2.250	in	-2.250	in	0.000	in
POSTURE_DHM7_EYE_Z	43.905	in	43.905	in	0.000	in

GVSC CAD values to agree with UMTRI spreadsheet values within
$\pm$ 0.100 inches
$\pm$ 0.100 degrees

Largest Observed Differences:
0.000 inches

Values in agreement

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TEST #3: SMALL OVERALL FEMALE

DEVCOM

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	6.3	-22.7	-65.7	→	-0.893	in
Hip re H-point Z	-15.7	-15.7	-15.7	→	15.184	in
Eye re H-point X	53.0	1.0	-60.0	→	0.041	in
Eye re H-point Z	546.3	546.3	546.3	→	37.309	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM1_HIP_X	-0.893	in
POSTURE_DHM1_HIP_Z	15.184	in
POSTURE_DHM1_EYE_X	0.041	in
POSTURE_DHM1_EYE_Z	37.309	in

GVSC CAD Model Geometry

Side View

Front View

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TEST #3: SMALL OVERALL MALE

DEVCOM

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-0.3	-29.3	-72.3	→	-1.155	in
Hip re H-point Z	-13.0	-13.0	-13.0	→	15.289	in
Eye re H-point X	35.0	-17.0	-78.0	→	-0.668	in
Eye re H-point Z	594.5	594.5	594.5	→	39.207	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM2_HIP_X	-1.155	in
POSTURE_DHM2_HIP_Z	15.289	in
POSTURE_DHM2_EYE_X	-0.668	in
POSTURE_DHM2_EYE_Z	39.207	in

GVSC CAD Model Geometry

Side View

Front View

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TEST #3: AVERAGE SIZE MALE

DEVCOM

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-0.3	-29.3	-72.3	→	-1.153	in
Hip re H-point Z	-13.0	-13.0	-13.0	→	15.288	in
Eye re H-point X	16.2	-35.8	-96.8	→	-1.409	in
Eye re H-point Z	654.2	654.2	654.2	→	41.556	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM3_HIP_X	-1.153	in
POSTURE_DHM3_HIP_Z	15.288	in
POSTURE_DHM3_EYE_X	-1.409	in
POSTURE_DHM3_EYE_Z	41.556	in

GVSC CAD Model Geometry

Side View

Front View

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 136

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TEST #3: WIDEST SHOULDERS MALE

DEVCOM

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	0.4	-28.6	-71.6	→	-1.127	in
Hip re H-point Z	-13.3	-13.3	-13.3	→	15.278	in
Eye re H-point X	6.7	-45.3	-106.3	→	-1.783	in
Eye re H-point Z	688.6	688.6	688.6	→	42.911	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM4_HIP_X	-1.127	in
POSTURE_DHM4_HIP_Z	15.278	in
POSTURE_DHM4_EYE_X	-1.783	in
POSTURE_DHM4_EYE_Z	42.911	in

GVSC CAD Model Geometry

Side View

Front View

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TEST #3: LONGEST TORSO MALE

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	0.8	-28.2	-71.2	→	-1.112	in
Hip re H-point Z	-13.4	-13.4	-13.4	→	15.272	in
Eye re H-point X	6.5	-45.5	-106.5	→	-1.792	in
Eye re H-point Z	718.5	718.5	718.5	→	44.086	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM5_HIP_X	-1.112	in
POSTURE_DHM5_HIP_Z	15.272	in
POSTURE_DHM5_EYE_X	-1.792	in
POSTURE_DHM5_EYE_Z	44.086	in

GVSC CAD Model Geometry

Side View

Front View

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TEST #3: LONGEST LEGS MALE

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-3.5	-32.5	-75.5	→	-1.281	in
Hip re H-point Z	-11.7	-11.7	-11.7	→	15.340	in
Eye re H-point X	1.8	-50.2	-111.2	→	-1.974	in
Eye re H-point Z	663.4	663.4	663.4	→	41.917	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM6_HIP_X	-1.281	in
POSTURE_DHM6_HIP_Z	15.340	in
POSTURE_DHM6_EYE_X	-1.974	in
POSTURE_DHM6_EYE_Z	41.917	in

GVSC CAD Model Geometry

Side View

Front View

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 139

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TEST #3: LARGE OVERALL MALE

DEVCOM

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-9.4	-38.4	-81.4	→	-1.513	in
Hip re H-point Z	-9.3	-9.3	-9.3	→	15.433	in
Eye re H-point X	-5.2	-57.2	-118.2	→	-2.250	in
Eye re H-point Z	713.9	713.9	713.9	→	43.905	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM7_HIP_X	-1.513	in
POSTURE_DHM7_HIP_Z	15.433	in
POSTURE_DHM7_EYE_X	-2.250	in
POSTURE_DHM7_EYE_Z	43.905	in

GVSC CAD Model Geometry

Side View Front View

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 140

10.7.4 TEST #4 – VARY SEATING HEIGHT/ANGLE

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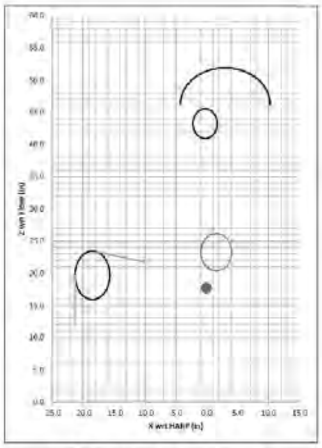
TEST #4: VARY SEATING HEIGHT/ANGLE

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	90%	PPE	17.7	18.0	SAE J826	No

Basic Accommodation



UMTRI Spreadsheet

GVSC CAD Model

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 141

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TEST #4: COMPARISON TO BASELINE

Test #	Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
1	90%	90%	PPE	13.8	0.0	SAE J826	No
4	90%	90%	PPE	17.7	18.0	SAE J826	No

Note: Highlighted values differ from comparison test

Side View

— Test #1 (Baseline)
Test #4

Front View

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Test #4: Results, Accommodation

HARP	UMTRI Value		GVSC Value		Difference	
HARP_X	0.000	in	0.000	in	0.000	in
HARP_Z	17.700	in	17.700	in	0.000	in

Eyellipse	UMTRI Value		GVSC Value		Difference	
EYELLIPSE_CENTROID_X	-0.262	in	-0.262	in	0.000	in
EYELLIPSE_CENTROID_Y (+/-)	1.280	in	1.280	in	0.000	in
EYELLIPSE_CENTROID_Z	43.225	in	43.226	in	0.001	in
EYELLIPSE_X_AXIS_LENGTH	3.907	in	3.909	in	0.003	in
EYELLIPSE_Y_AXIS_LENGTH	1.988	in	1.990	in	0.001	in
EYELLIPSE_Z_AXIS_LENGTH	4.595	in	4.596	in	0.001	in

Helmet Contour	UMTRI Value		GVSC Value		Difference	
HELMET_CONTOUR_CENTROID_X	2.986	in	2.986	in	0.000	in
HELMET_CONTOUR_CENTROID_Y (+/-)	2.185	in	2.185	in	0.000	in
HELMET_CONTOUR_CENTROID_Z	46.209	in	46.210	in	0.001	in
HELMET_CONTOUR_X_AXIS_LENGTH	14.509	in	14.512	in	0.003	in
HELMET_CONTOUR_Y_AXIS_LENGTH	9.657	in	9.659	in	0.001	in
HELMET_CONTOUR_Z_AXIS_LENGTH	11.366	in	11.368	in	0.001	in

Knee Contour	UMTRI Value		GVSC Value		Difference	
KNEE_CONTOUR_WEIGHTED_CENT_X	18.472	in	18.472	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Y (+/-)	7.594	in	7.594	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Z	19.685	in	19.685	in	0.000	in
KNEE_CONTOUR_X_AXIS_LENGTH	5.628	in	5.630	in	0.002	in
KNEE_CONTOUR_Y_AXIS_LENGTH	9.035	in	9.037	in	0.002	in
KNEE_CONTOUR_Z_AXIS_LENGTH	7.529	in	7.529	in	0.001	in
KNEE_SHIN_ANGLE	0.000	deg	0.000	deg	0.000	deg
KNEE_THIGH_ANGLE	11.743	deg	11.743	deg	0.000	deg

Elbow Contour	UMTRI Value		GVSC Value		Difference	
ELBOW_WEIGHTED_CENT_X	1.535	in	1.535	in	0.000	in
ELBOW_WEIGHTED_CENT_Y	12.472	in	12.473	in	0.000	in
ELBOW_WEIGHTED_CENT_Z	23.264	in	23.264	in	0.000	in
ELBOW_X_AXIS_LENGTH	4.996	in	5.000	in	0.004	in
ELBOW_Y_AXIS_LENGTH	3.683	in	3.684	in	0.001	in
ELBOW_Z_AXIS_LENGTH	5.779	in	5.782	in	0.003	in

Boot Contour	UMTRI Value		GVSC Value		Difference	
BOOT_TOE_WEIGHTED_CENT_X	-26.863	in	-26.863	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Y	7.594	in	7.594	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Z	0.000	in	0.000	in	0.000	in
BOOT_TOE_X_AXIS_LENGTH	1.889	in	1.890	in	0.001	in
BOOT_TOE_Y_AXIS_LENGTH	8.704	in	8.706	in	0.002	in
BOOT_TOE_Z_AXIS_LENGTH	4.921	in	4.921	in	0.000	in

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

Largest Observed Differences:
0.004 inches
0.000 degrees

Values in agreement

Test #4: Seat HARP

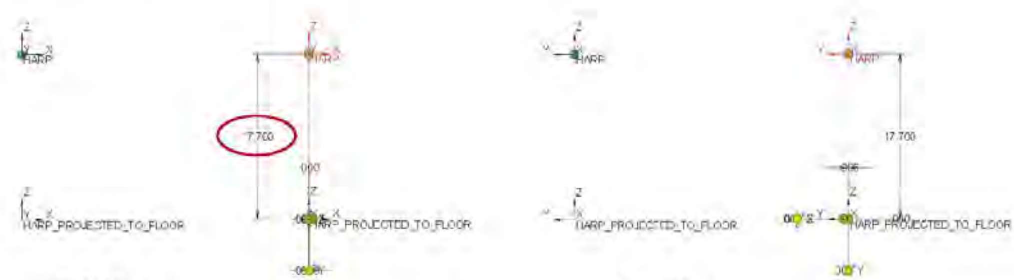
UMTRI Spreadsheet Calculations

	X (in)	Z (in)
HARP	0.000	17.700

GVSC CAD Model Calculations

HARP_X	0.000	in
HARP_Z	17.700	in

GVSC CAD Model Geometry



Side View Front View

TEST #4: EYELLIPSE

UMTRI Spreadsheet Calculations

Eyellipse Centroids	X (in)	Y (in)	Z (in)
Right	-0.262	1.280*	43.225
Left	-0.262	-1.280*	43.225

Side View of Eyellipses (X, Z)

Axis Length (X)	3.907	in
Axis Length (Z)	4.595	in

Rear View of Eyellipses (Y, Z)

Axis Length (Y)	1.988	in
Axis Length (Z)	4.595	in

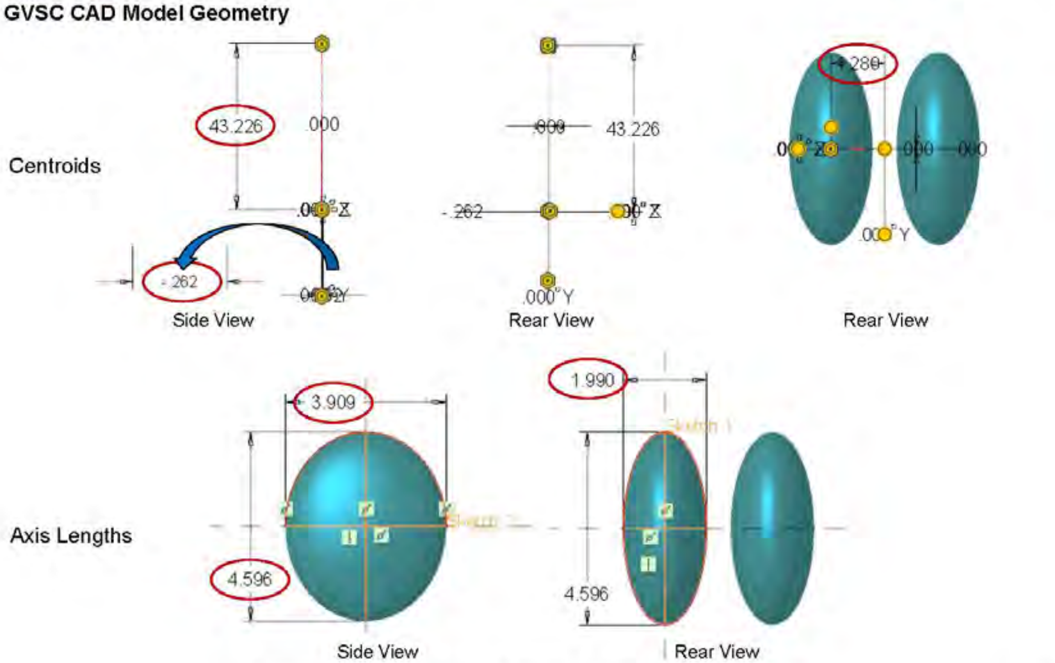
GVSC CAD Model Calculations

EYELLIPSE_CENTROID_X	-0.262	in
EYELLIPSE_CENTROID_Y	1.280*	in
EYELLIPSE_CENTROID_Z	43.226	in
EYELLIPSE_X_AXIS_LENGTH	3.909	in
EYELLIPSE_Y_AXIS_LENGTH	1.990	in
EYELLIPSE_Z_AXIS_LENGTH	4.596	in

*Given value, not calculated

TEST #4: EYELLIPSE (CONT.)

GVSC CAD Model Geometry



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TEST #4: HELMET CONTOUR

UMTRI Spreadsheet Calculations

Construction Centroids	X (in)	Y (in)	Z (in)
Right	2.986	2.185*	46.209
Left	2.986	-2.185*	46.209

Side View of Helmet Contour (X, Z)		
Axis Length (X)	14.509	in
Axis Length (Z)	11.366	in

Rear View of Helmet Contour (Y, Z)		
Axis Length (Y)	9.657	in
Axis Length (Z)	11.366	in

GVSC CAD Model Calculations

HELMET_CONTOUR_CENTROID_X	2.986	in
HELMET_CONTOUR_CENTROID_Y	2.185*	in
HELMET_CONTOUR_CENTROID_Z	46.210	in
HELMET_CONTOUR_X_AXIS_LENGTH	14.512	in
HELMET_CONTOUR_Y_AXIS_LENGTH	9.659	in
HELMET_CONTOUR_Z_AXIS_LENGTH	11.368	in

*Given value, not calculated

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 147

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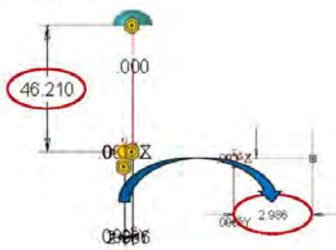
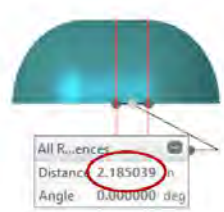
TEST #4: HELMET CONTOUR (CONT.)

GVSC CAD Model Result

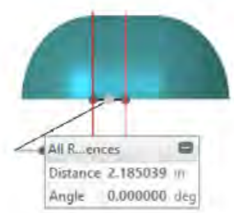
Centroids



Side View



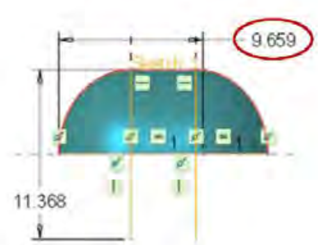
Rear View



Rear View

Axis Lengths

Side View



Rear View

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 148

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TEST #4: KNEE CONTOUR

UMTRI Spreadsheet Calculations

Knee Centroids	X (in)	Y (in)	Z (in)
Right	-18.472	7.594	19.685
Left	-18.472	-7.594	19.685

Side View of Knee Contours (X, Z)		
Axis Length (X)	5.628	in
Axis Length (Z)	7.529	in
Rear View of Knee Contours (Y, Z)		
Axis Length (Y)	9.035	in
Axis Length (Z)	7.529	in
Leg Segment Angle wrt Vertical	0.000*	deg
Thigh Segment Angle wrt Horizontal	11.743	deg

GVSC CAD Model Calculations

KNEE_CONTOUR_WEIGHTED_CENT_X	-18.472	in
KNEE_CONTOUR_WEIGHTED_CENT_Y	7.594	in
KNEE_CONTOUR_WEIGHTED_CENT_Z	19.685	in
KNEE_CONTOUR_X_AXIS_LENGTH	5.630	in
KNEE_CONTOUR_Y_AXIS_LENGTH	9.037	in
KNEE_CONTOUR_Z_AXIS_LENGTH	7.529	in
KNEE_SHIN_ANGLE	0.000*	deg
KNEE_THIGH_ANGLE	11.743	deg

*Given value, not calculated

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 149

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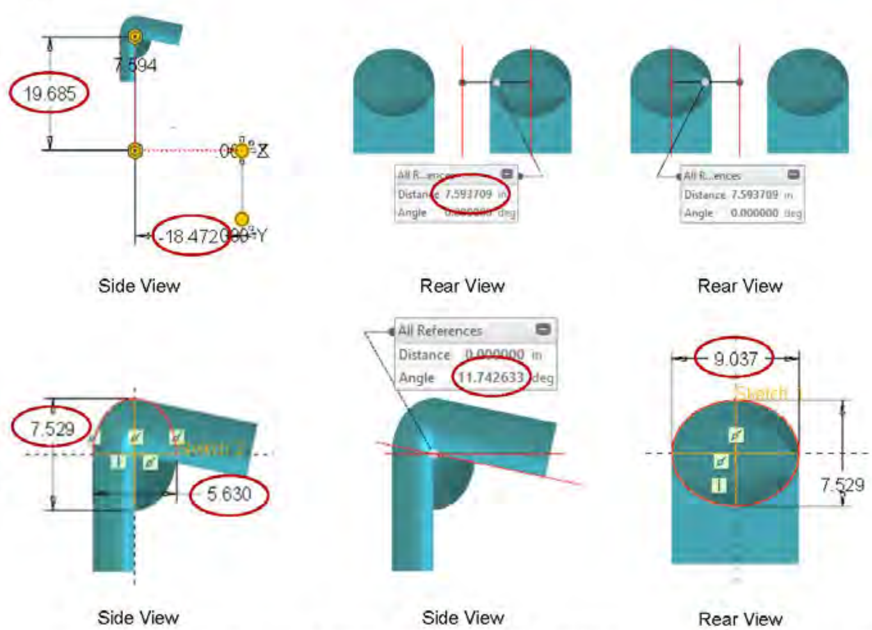
TEST #4: KNEE CONTOUR (CONT.)

GVSC CAD Model Result

Centroids

Axis Lengths
Shin/Thigh Angles



DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 150

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TEST #4: ELBOW CONTOUR

UMTRI Spreadsheet Calculations

Elbow Centroids	X (in)	Y (in)	Z (in)
Right	1.535	12.473	23.264
Left	1.535	-12.473	23.264

Side View of Elbow Contours (X, Z)		
Axis Length (X)	4.996	in
Axis Length (Z)	5.779	in

Rear View of Elbow Contours (Y, Z)		
Axis Length (Y)	3.683	in
Axis Length (Z)	5.779	in

GVSC CAD Model Calculations

ELBOW_WEIGHTED_CENT_X	1.535	in
ELBOW_WEIGHTED_CENT_Y	12.473	in
ELBOW_WEIGHTED_CENT_Z	23.264	in
ELBOW_X_AXIS_LENGTH	5.000	in
ELBOW_Y_AXIS_LENGTH	3.684	in
ELBOW_Z_AXIS_LENGTH	5.782	in

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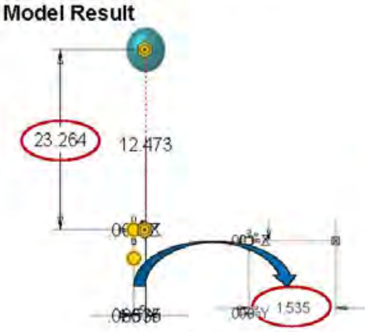
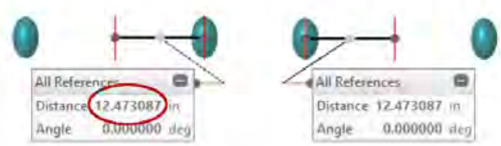
TEST #4: ELBOW CONTOUR (CONT.)

GVSC CAD Model Result

Centroids



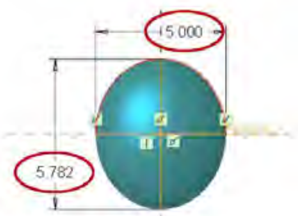
Side View



Rear View

Rear View

Axis Lengths



Side View

Rear View

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 152

TEST #4: BOOT CONTOUR

UMTRI Spreadsheet Calculations

Boot Centroids	X (in)	Y (in)	Z (in)
Right	-26.863	7.594	0.000
Left	-26.863	-7.594	0.000

Side View of Boot Contours (X, Z)		
Axis Length (X)	1.889	in
Axis Length (Z)	4.921	in

Rear View of Boot Contours (Y, Z)		
Axis Length (Y)	8.704	in
Axis Length (Z)	4.921	in

GVSC CAD Model Calculations

BOOT_TOE_WEIGHTED_CENT_X	-26.863	in
BOOT_TOE_WEIGHTED_CENT_Y	7.594	in
BOOT_TOE_WEIGHTED_CENT_Z	0.000	in
BOOT_TOE_X_AXIS_LENGTH	1.890	in
BOOT_TOE_Y_AXIS_LENGTH	8.706	in
BOOT_TOE_Z_AXIS_LENGTH	4.921	in

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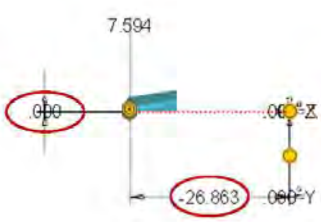
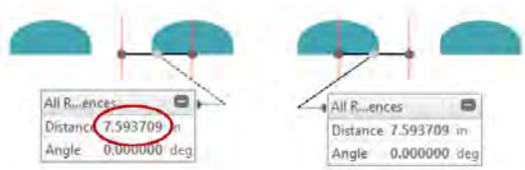
TEST #4: BOOT CONTOUR (CONT.)

GVSC CAD Model Result

Centroids



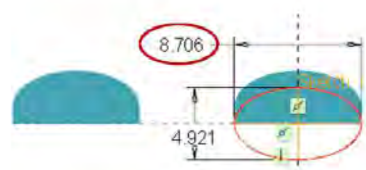
Side View



Rear View Rear View

Axis Lengths

Side View



Rear View

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TEST #4: VARY SEATING HEIGHT/ANGLE

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	90%	PPE	17.7	18.0	SAE J826	No

Clearance (2.0 inches), Shown in Yellow

GVSC CAD Model

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 155

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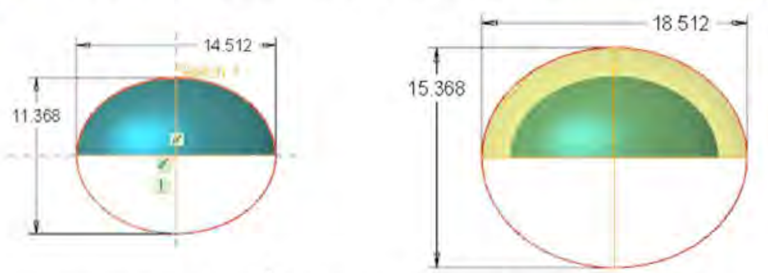
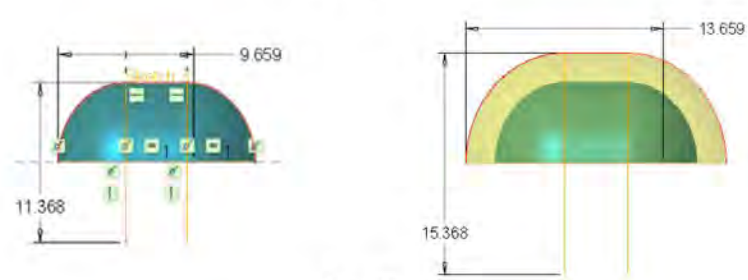
TEST #4: CLEARANCE, HELMET CONTOUR



$$Sample\ Calculation: \frac{1}{2}(18.512\ in. - 14.512\ in.) = 2.000\ in.\ clearance$$

Side View



Rear View

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 156

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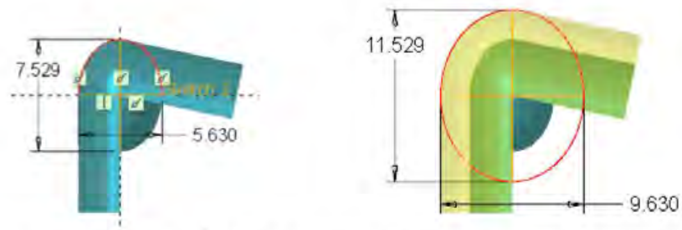
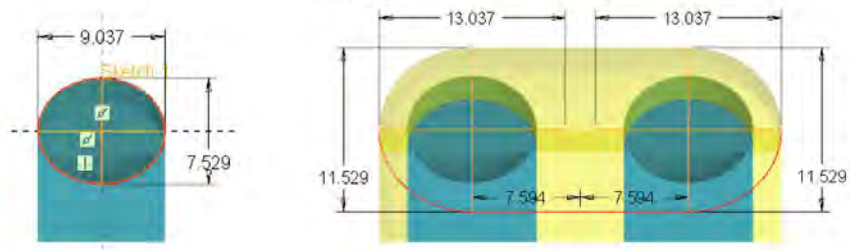
TEST #4: CLEARANCE, KNEE CONTOUR



$$\textit{Sample Calculation: } \frac{1}{2}\,(11.529\ in. - 7.529\ in.) = \ 2.000\ in.\ clearance$$

Side View



Rear View

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 157

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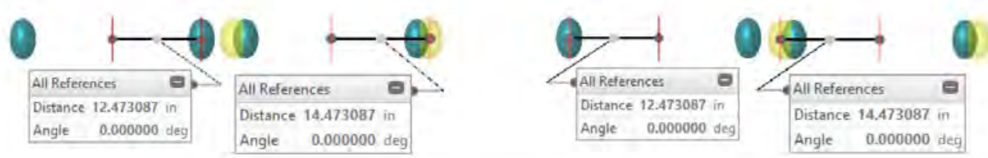
TEST #4: CLEARANCE, ELBOW CONTOUR



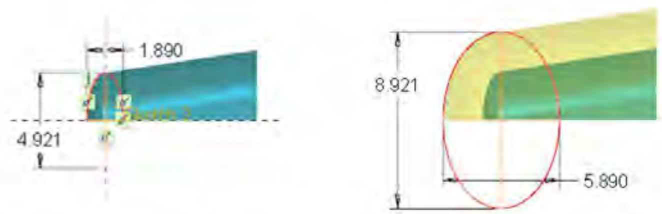
$$\textit{Sample Calculation: } 14.473\ in. - 12.473\ in. = \ 2.000\ in.\ clearance$$

Rear View

Side View **Rear View**

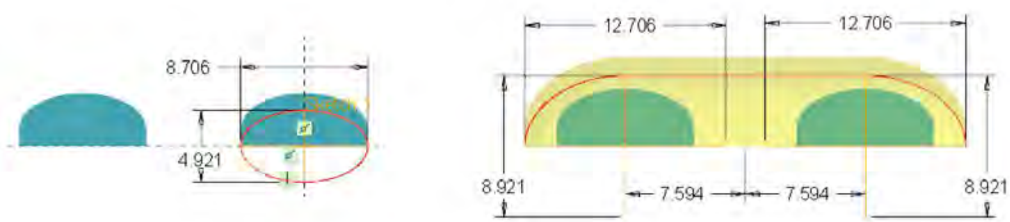
DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 158

TEST #4: CLEARANCE, BOOT CONTOUR



$$Sample\ Calculation: \frac{1}{2}(8.921\ in. - 4.921\ in.) = 2.000\ in.\ clearance$$

Side View



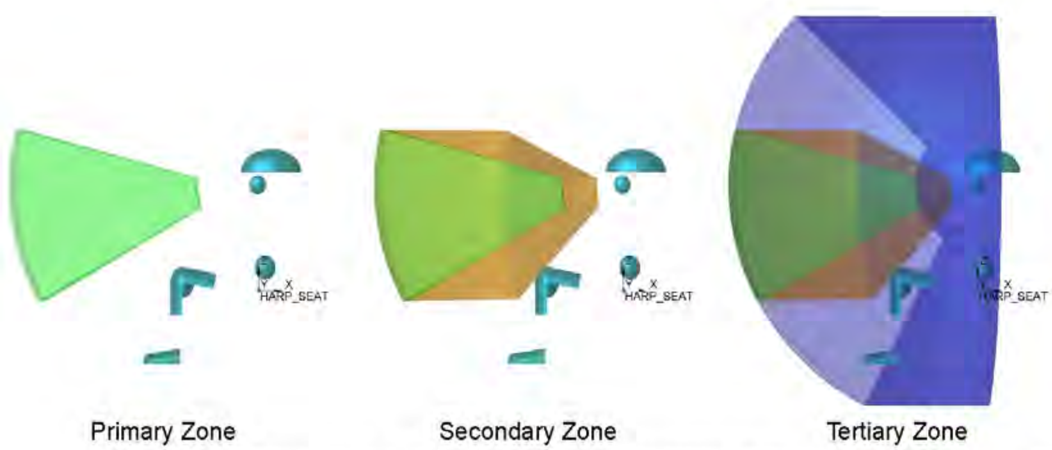
Rear View

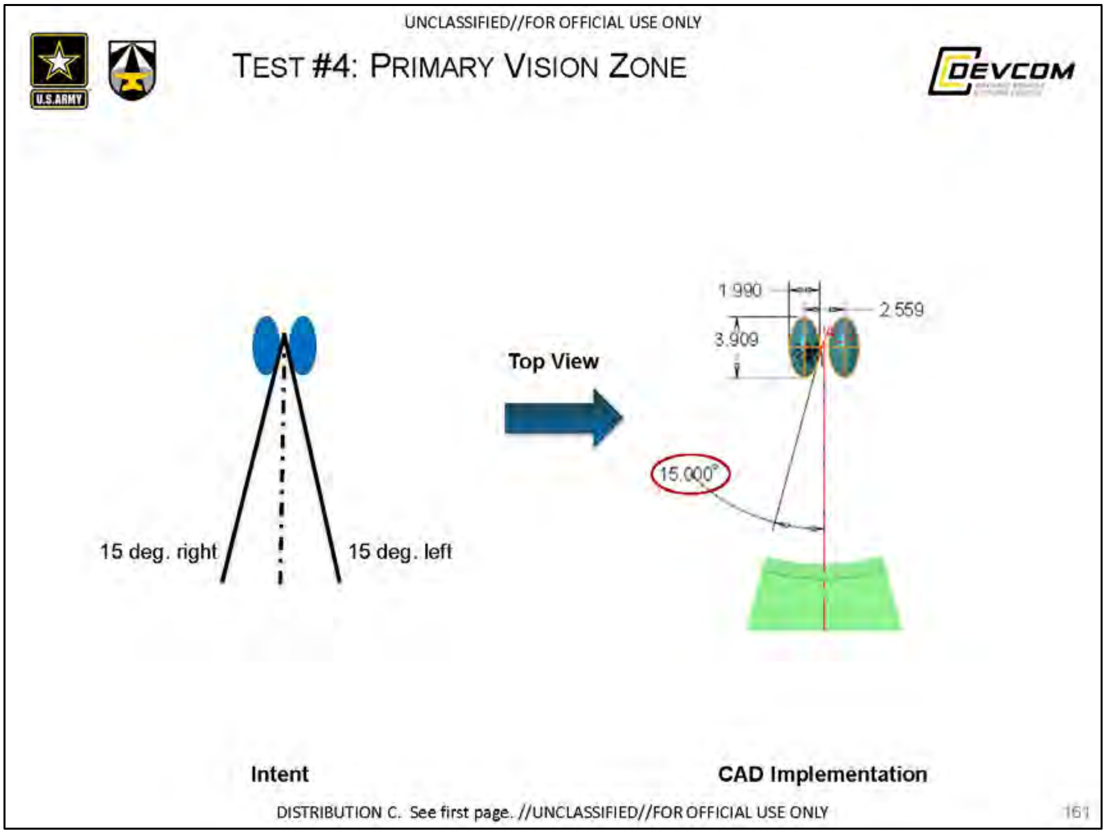
TEST #4: VARY SEATING HEIGHT/ANGLE

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	90%	PPE	17.7	18.0	SAE J826	No

Vision Zones

Vison zones are constructed geometrically; no calculations are involved.




UNCLASSIFIED//FOR OFFICIAL USE ONLY
TEST #4: PRIMARY VISION ZONE
15 deg. right
15 deg. left
Top View
1.990
2.559
3.909
15.000°
Intent
CAD Implementation
DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY
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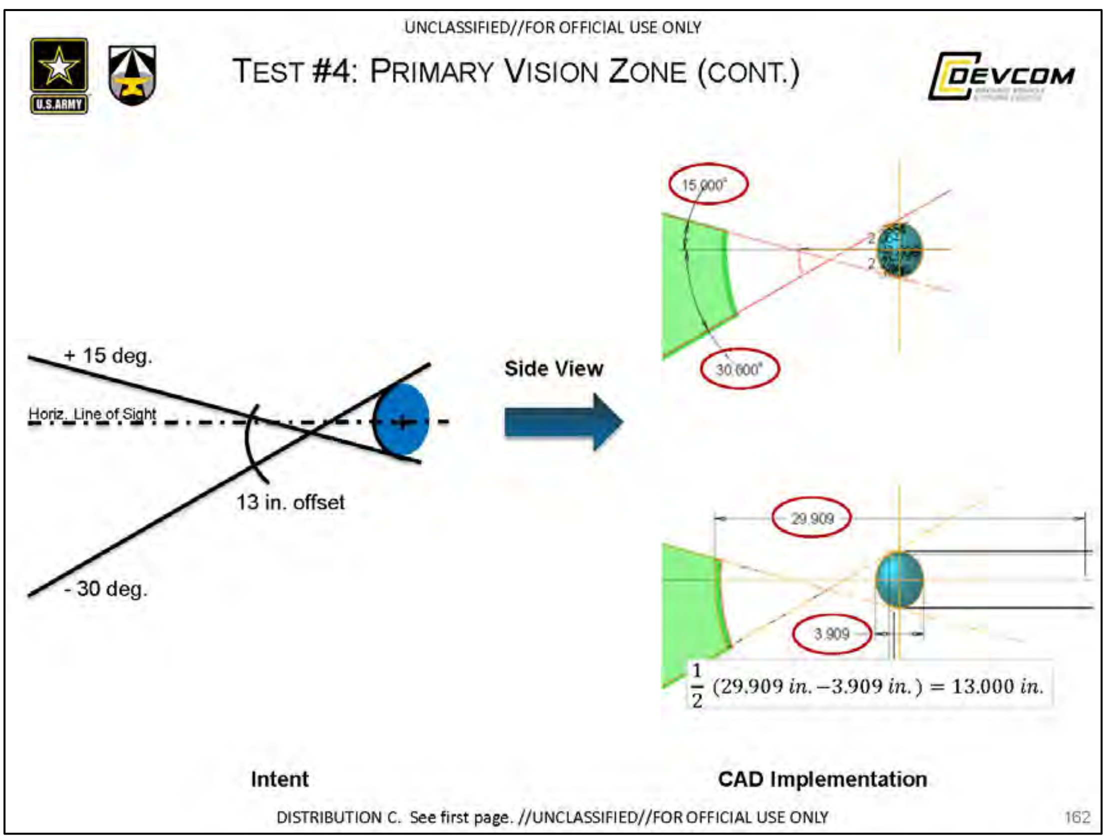
UNCLASSIFIED//FOR OFFICIAL USE ONLY
TEST #4: PRIMARY VISION ZONE (CONT.)
+ 15 deg.
Horiz. Line of Sight
13 in. offset
- 30 deg.
Side View
15.000°
30.000°
29.909
3.909
$\frac{1}{2}(29.909\ in. - 3.909\ in.) = 13.000\ in.$
Intent
CAD Implementation
DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY
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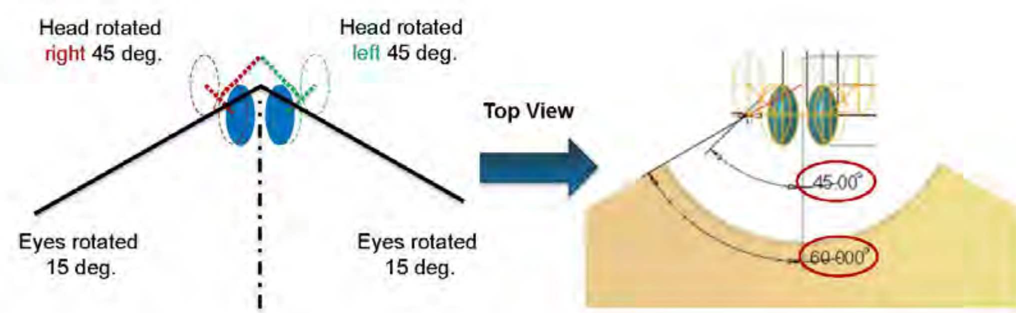
TEST #4: SECONDARY VISION ZONE



Intent

CAD Implementation

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 163

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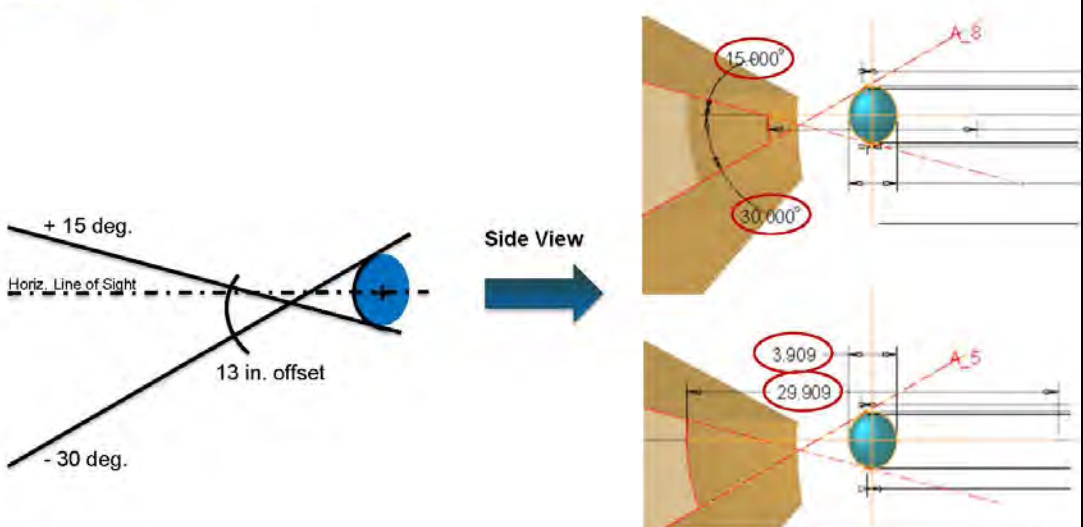
TEST #4: SECONDARY VISION ZONE (CONT.)

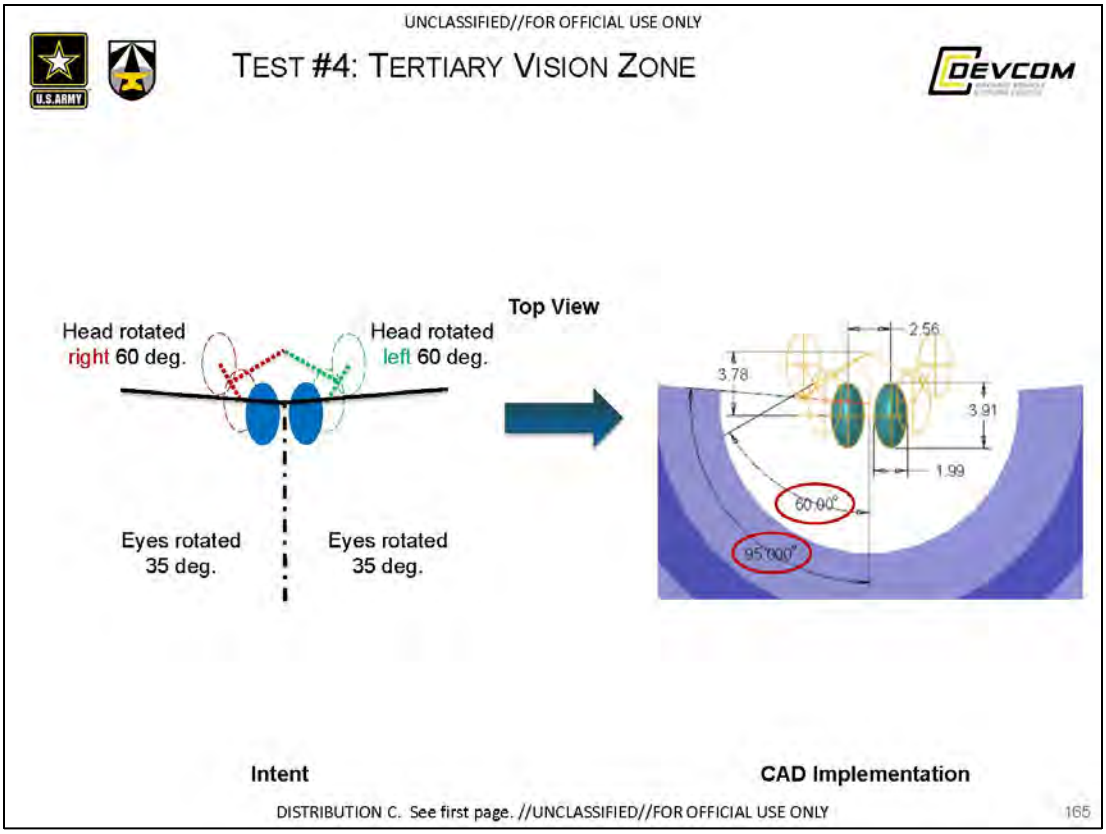


$$\frac{1}{2}(29.909\ in. - 3.909\ in.) = 13.000\ in.$$

Intent

CAD Implementation

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 164


UNCLASSIFIED//FOR OFFICIAL USE ONLY
U.S. ARMY
TEST #4: TERTIARY VISION ZONE
DEVCOM
Top View
Head rotated right 60 deg.
Head rotated left 60 deg.
Eyes rotated 35 deg.
Eyes rotated 35 deg.
2.56
3.78
3.91
1.99
60.00°
95.000°
Intent
CAD Implementation
DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY
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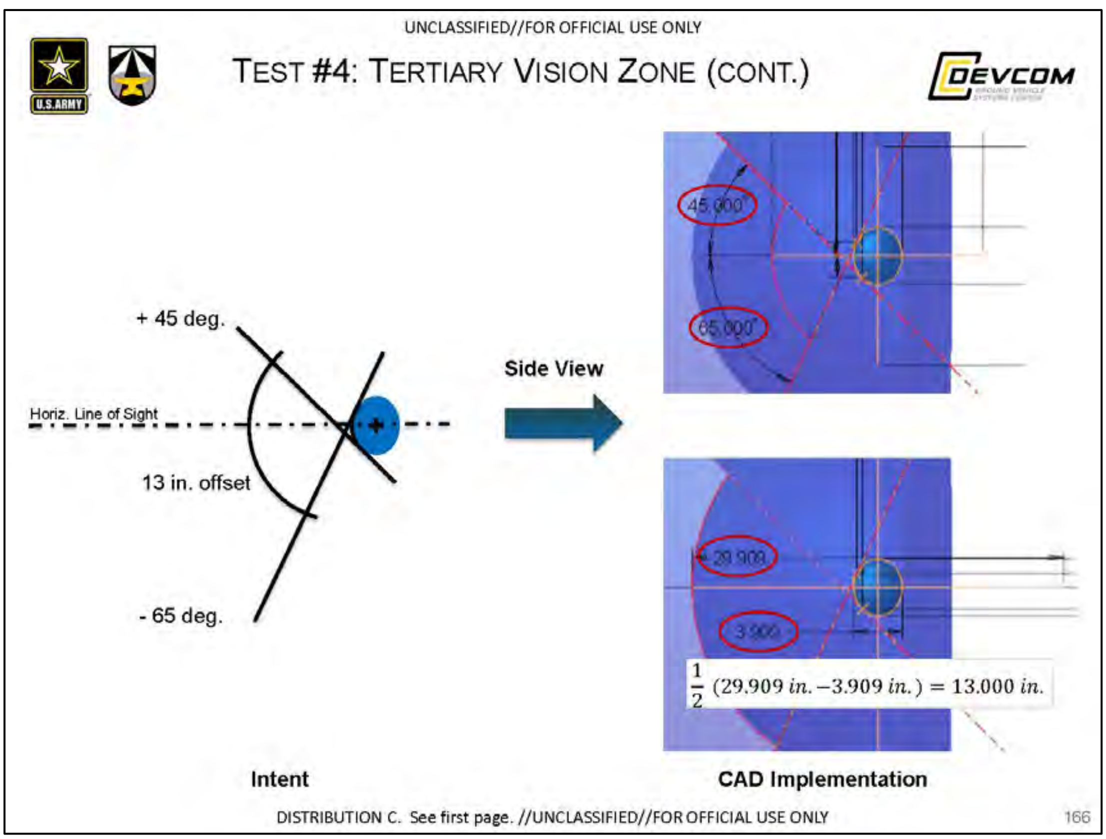
UNCLASSIFIED//FOR OFFICIAL USE ONLY
U.S. ARMY
TEST #4: TERTIARY VISION ZONE (CONT.)
DEVCOM
+ 45 deg.
Horiz. Line of Sight
13 in. offset
- 65 deg.
Side View
45.000°
65.000°
29.909
3.909
$\frac{1}{2}(29.909\ in. - 3.909\ in.) = 13.000\ in.$
Intent
CAD Implementation
DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY
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TEST #4: VARY SEATING HEIGHT/ANGLE

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	90%	PPE	17.7	18.0	SAE J826	No

Boundary Manikin Posture and Position

GVSC CAD Model

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 167

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TEST #4: RESULTS, MANIKIN POSITIONING

Small Overall Female						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM1_HIP_X	-0.689	in	-0.689	in	0.000	in
POSTURE_DHM1_HIP_Z	17.084	in	17.084	in	0.000	in
POSTURE_DHM1_EYE_X	0.992	in	0.992	in	0.000	in
POSTURE_DHM1_EYE_Z	39.283	in	39.283	in	0.000	in

Small Overall Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM2_HIP_X	-0.951	in	-0.951	in	0.000	in
POSTURE_DHM2_HIP_Z	17.189	in	17.189	in	0.000	in
POSTURE_DHM2_EYE_X	0.283	in	0.283	in	0.000	in
POSTURE_DHM2_EYE_Z	41.181	in	41.181	in	0.000	in

Average Size Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM3_HIP_X	-0.949	in	-0.949	in	0.000	in
POSTURE_DHM3_HIP_Z	17.188	in	17.188	in	0.000	in
POSTURE_DHM3_EYE_X	-0.458	in	-0.458	in	0.000	in
POSTURE_DHM3_EYE_Z	43.530	in	43.530	in	0.000	in

Widest Shoulders Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM4_HIP_X	-0.922	in	-0.922	in	0.000	in
POSTURE_DHM4_HIP_Z	17.178	in	17.178	in	0.000	in
POSTURE_DHM4_EYE_X	-0.832	in	-0.832	in	0.000	in
POSTURE_DHM4_EYE_Z	44.885	in	44.885	in	0.000	in

Longest Torso Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM5_HIP_X	-0.908	in	-0.908	in	0.000	in
POSTURE_DHM5_HIP_Z	17.172	in	17.172	in	0.000	in
POSTURE_DHM5_EYE_X	-0.842	in	-0.842	in	0.000	in
POSTURE_DHM5_EYE_Z	46.060	in	46.060	in	0.000	in

Longest Legs Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM6_HIP_X	-1.077	in	-1.077	in	0.000	in
POSTURE_DHM6_HIP_Z	17.240	in	17.240	in	0.000	in
POSTURE_DHM6_EYE_X	-1.024	in	-1.024	in	0.000	in
POSTURE_DHM6_EYE_Z	43.891	in	43.891	in	0.000	in

Large Overall Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM7_HIP_X	-1.309	in	-1.309	in	0.000	in
POSTURE_DHM7_HIP_Z	17.333	in	17.333	in	0.000	in
POSTURE_DHM7_EYE_X	-1.299	in	-1.299	in	0.000	in
POSTURE_DHM7_EYE_Z	45.879	in	45.879	in	0.000	in

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

Largest Observed Differences:
0.000 inches

Values in agreement

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TEST #4: SMALL OVERALL FEMALE

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	11.5	-17.5	-60.5	→	-0.689	in
Hip re H-point Z	-15.7	-15.7	-15.7	→	17.084	in
Eye re H-point X	77.2	25.2	-35.8	→	0.992	in
Eye re H-point Z	548.2	548.2	548.2	→	39.283	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM1_HIP_X	-0.689	in
POSTURE_DHM1_HIP_Z	17.084	in
POSTURE_DHM1_EYE_X	0.992	in
POSTURE_DHM1_EYE_Z	39.283	in

GVSC CAD Model Geometry

Side View

Front View

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TEST #4: SMALL OVERALL MALE

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	4.8	-24.2	-67.2	→	-0.951	in
Hip re H-point Z	-13.0	-13.0	-13.0	→	17.189	in
Eye re H-point X	59.2	7.2	-53.8	→	0.283	in
Eye re H-point Z	596.4	596.4	596.4	→	41.181	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM2_HIP_X	-0.951	in
POSTURE_DHM2_HIP_Z	17.189	in
POSTURE_DHM2_EYE_X	0.283	in
POSTURE_DHM2_EYE_Z	41.181	in

GVSC CAD Model Geometry

Side View

Front View

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TEST #4: AVERAGE SIZE MALE

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	4.9	-24.1	-67.1	→	-0.949	in
Hip re H-point Z	-13.0	-13.0	-13.0	→	17.188	in
Eye re H-point X	40.4	-11.6	-72.6	→	-0.458	in
Eye re H-point Z	656.1	656.1	656.1	→	43.530	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM3_HIP_X	-0.949	in
POSTURE_DHM3_HIP_Z	17.188	in
POSTURE_DHM3_EYE_X	-0.458	in
POSTURE_DHM3_EYE_Z	43.530	in

GVSC CAD Model Geometry

Side View

Front View

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TEST #4: WIDEST SHOULDERS MALE

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	5.6	-23.4	-66.4	→	-0.922	in
Hip re H-point Z	-13.3	-13.3	-13.3	→	17.178	in
Eye re H-point X	30.9	-21.1	-82.1	→	-0.832	in
Eye re H-point Z	690.5	690.5	690.5	→	44.885	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM4_HIP_X	-0.922	in
POSTURE_DHM4_HIP_Z	17.178	in
POSTURE_DHM4_EYE_X	-0.832	in
POSTURE_DHM4_EYE_Z	44.885	in

GVSC CAD Model Geometry

Side View

Front View

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TEST #4: LONGEST TORSO MALE

DEVCOM

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	5.9	-23.1	-66.1	→	-0.908	in
Hip re H-point Z	-13.4	-13.4	-13.4	→	17.172	in
Eye re H-point X	30.6	-21.4	-82.4	→	-0.842	in
Eye re H-point Z	720.3	720.3	720.3	→	46.060	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM5_HIP_X	-0.908	in
POSTURE_DHM5_HIP_Z	17.172	in
POSTURE_DHM5_EYE_X	-0.842	in
POSTURE_DHM5_EYE_Z	46.060	in

GVSC CAD Model Geometry

Side View

Front View

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TEST #4: LONGEST LEGS MALE

DEVCOM

UMTRI Spreadsheet Calculations*

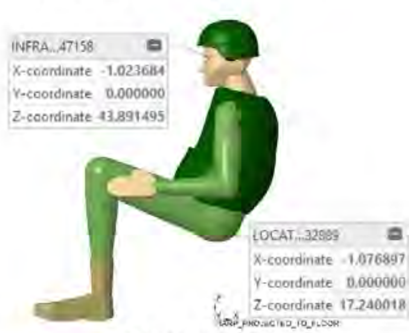
	ACU	PPE	ENC			
Hip re H-point X	1.6	-27.4	-70.4	→	-1.077	in
Hip re H-point Z	-11.7	-11.7	-11.7	→	17.240	in
Eye re H-point X	26.0	-26.0	-87.0	→	-1.024	in
Eye re H-point Z	665.3	665.3	665.3	→	43.891	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM6_HIP_X	-1.077	in
POSTURE_DHM6_HIP_Z	17.240	in
POSTURE_DHM6_EYE_X	-1.024	in
POSTURE_DHM6_EYE_Z	43.891	in

GVSC CAD Model Geometry



Side View

Front View

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TEST #4: LARGE OVERALL MALE

UMTRI Spreadsheet Calculations*

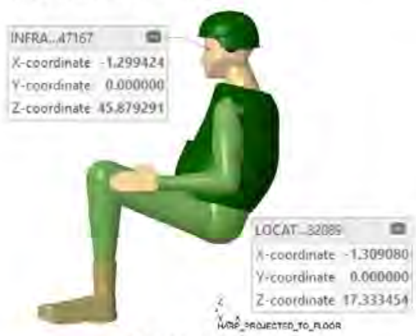
	ACU	PPE	ENC			
Hip re H-point X	-4.3	-33.3	-76.3	→	-1.309	in
Hip re H-point Z	-9.3	-9.3	-9.3	→	17.333	in
Eye re H-point X	19.0	-33.0	-94.0	→	-1.299	in
Eye re H-point Z	715.8	715.8	715.8	→	45.879	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM7_HIP_X	-1.309	in
POSTURE_DHM7_HIP_Z	17.333	in
POSTURE_DHM7_EYE_X	-1.299	in
POSTURE_DHM7_EYE_Z	45.879	in

GVSC CAD Model Geometry



Side View

Front View

10.7.5 TEST #5 – VARY SEATING HEIGHT/ANGLE

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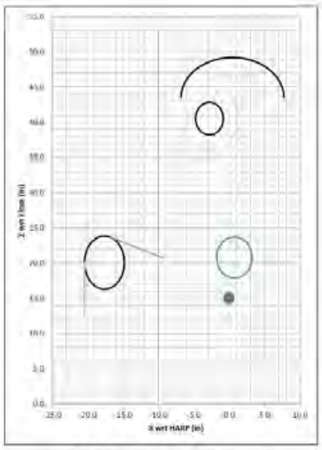
TEST #5: VARY SEATING HEIGHT/ANGLE

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	90%	PPE	15.0	10.0	SAE J826	No

Basic Accommodation



UMTRI Spreadsheet

GVSC CAD Model

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TEST #5: COMPARISON TO BASELINE

Test #	Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
1	90%	90%	PPE	13.8	0.0	SAE J826	No
5	90%	90%	PPE	15.0	10.0	SAE J826	No

Note: Highlighted values differ from comparison test

Side View Front View

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TEST #5: RESULTS, ACCOMMODATION

HARP	UMTRI Value		GVSC Value		Difference	
HARP_X	0.000	in	0.000	in	0.000	in
HARP_Z	15.000	in	15.000	in	0.000	in

Eyellipse	UMTRI Value		GVSC Value		Difference	
EYELLIPSE_CENTROID_X	-2.797	in	-2.797	in	0.000	in
EYELLIPSE_CENTROID_Y (+/-)	1.280	in	1.280	in	0.000	in
EYELLIPSE_CENTROID_Z	40.519	in	40.519	in	0.001	in
EYELLIPSE_X_AXIS_LENGTH	3.907	in	3.909	in	0.002	in
EYELLIPSE_Y_AXIS_LENGTH	1.988	in	1.990	in	0.001	in
EYELLIPSE_Z_AXIS_LENGTH	4.594	in	4.596	in	0.002	in

Helmet Contour	UMTRI Value		GVSC Value		Difference	
HELMET_CONTOUR_CENTROID_X	0.451	in	0.451	in	0.000	in
HELMET_CONTOUR_CENTROID_Y (+/-)	2.185	in	2.185	in	0.000	in
HELMET_CONTOUR_CENTROID_Z	43.503	in	43.504	in	0.001	in
HELMET_CONTOUR_X_AXIS_LENGTH	14.909	in	14.512	in	0.002	in
HELMET_CONTOUR_Y_AXIS_LENGTH	9.657	in	9.659	in	0.001	in
HELMET_CONTOUR_Z_AXIS_LENGTH	11.366	in	11.368	in	0.002	in

Knee Contour	UMTRI Value		GVSC Value		Difference	
KNEE_CONTOUR_WEIGHTED_CENT_X	-17.610	in	-17.610	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Y (+/-)	7.594	in	7.594	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Z	20.087	in	20.087	in	0.000	in
KNEE_CONTOUR_X_AXIS_LENGTH	5.628	in	5.630	in	0.002	in
KNEE_CONTOUR_Y_AXIS_LENGTH	9.035	in	9.037	in	0.002	in
KNEE_CONTOUR_Z_AXIS_LENGTH	7.529	in	7.529	in	0.001	in
KNEE_SHIN_ANGLE	0.000	deg	0.000	deg	0.000	deg
KNEE_THIGH_ANGLE	21.513	deg	21.513	deg	0.000	deg

Elbow Contour	UMTRI Value		GVSC Value		Difference	
ELBOW_WEIGHTED_CENT_X	0.719	in	0.719	in	0.000	in
ELBOW_WEIGHTED_CENT_Y	12.298	in	12.298	in	0.000	in
ELBOW_WEIGHTED_CENT_Z	20.794	in	20.794	in	0.000	in
ELBOW_X_AXIS_LENGTH	4.996	in	5.000	in	0.004	in
ELBOW_Y_AXIS_LENGTH	3.683	in	3.684	in	0.001	in
ELBOW_Z_AXIS_LENGTH	5.779	in	5.782	in	0.003	in

Boot Contour	UMTRI Value		GVSC Value		Difference	
BOOT_TOE_WEIGHTED_CENT_X	-26.002	in	-26.002	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Y	7.594	in	7.594	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Z	0.000	in	0.000	in	0.000	in
BOOT_TOE_X_AXIS_LENGTH	1.889	in	1.890	in	0.001	in
BOOT_TOE_Y_AXIS_LENGTH	8.704	in	8.706	in	0.002	in
BOOT_TOE_Z_AXIS_LENGTH	4.921	in	4.921	in	0.000	in

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

Largest Observed Differences:
0.004 inches
0.000 degrees

Values in agreement

TEST #5: SEAT HARP

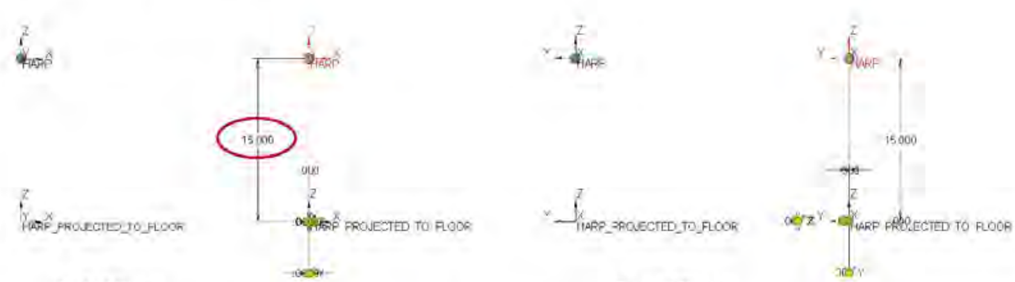
UMTRI Spreadsheet Calculations

	X (in)	Z (in)
HARP	0.000	15.000

GVSC CAD Model Calculations

HARP_X	0.000	in
HARP_Z	15.000	in

GVSC CAD Model Geometry



Side View **Front View**

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TEST #5: EYELLIPSE

UMTRI Spreadsheet Calculations

Eyellipse Centroids	X (in)	Y (in)	Z (in)
Right	-2.797	1.280*	40.519
Left	-2.797	-1.280*	40.519

Side View of Eyellipses (X, Z)		
Axis Length (X)	3.907	in
Axis Length (Z)	4.594	in

Rear View of Eyellipses (Y, Z)		
Axis Length (Y)	1.988	in
Axis Length (Z)	4.594	in

GVSC CAD Model Calculations

EYELLIPSE_CENTROID_X	-2.797	in
EYELLIPSE_CENTROID_Y	1.280*	in
EYELLIPSE_CENTROID_Z	40.519	in
EYELLIPSE_X_AXIS_LENGTH	3.909	in
EYELLIPSE_Y_AXIS_LENGTH	1.990	in
EYELLIPSE_Z_AXIS_LENGTH	4.596	in

*Given value, not calculated

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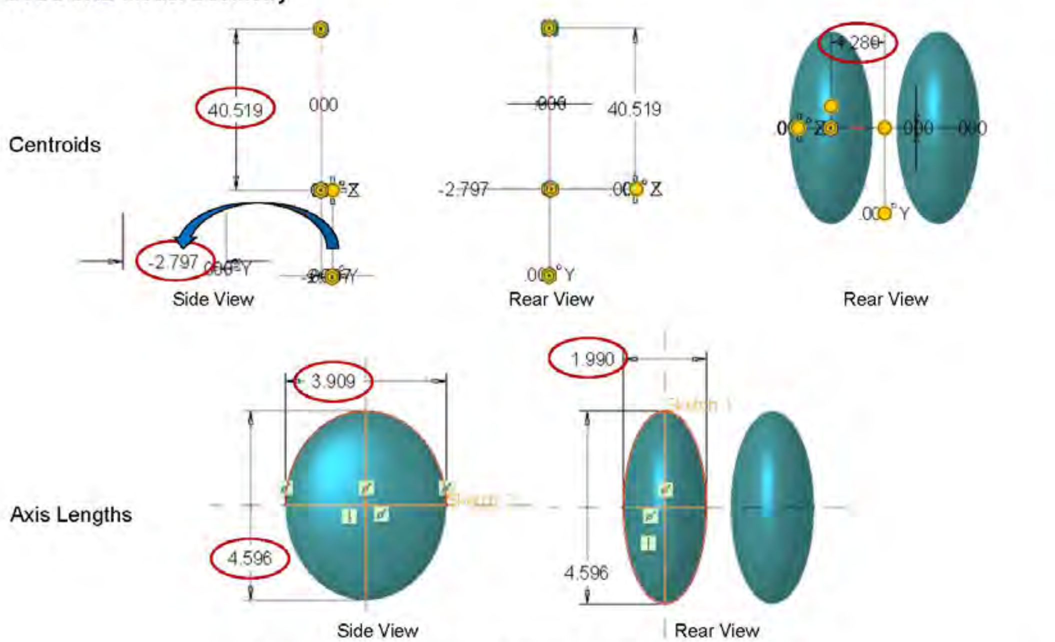
TEST #5: EYELLIPSE (CONT.)

GVSC CAD Model Geometry



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TEST #5: HELMET CONTOUR

UMTRI Spreadsheet Calculations

Construction Centroids	X (in)	Y (in)	Z (in)
Right	0.451	2.185*	43.503
Left	0.451	-2.185*	43.503

Side View of Helmet Contour (X, Z)		
Axis Length (X)	14.509	in
Axis Length (Z)	11.366	in

Rear View of Helmet Contour (Y, Z)		
Axis Length (Y)	9.657	in
Axis Length (Z)	11.366	in

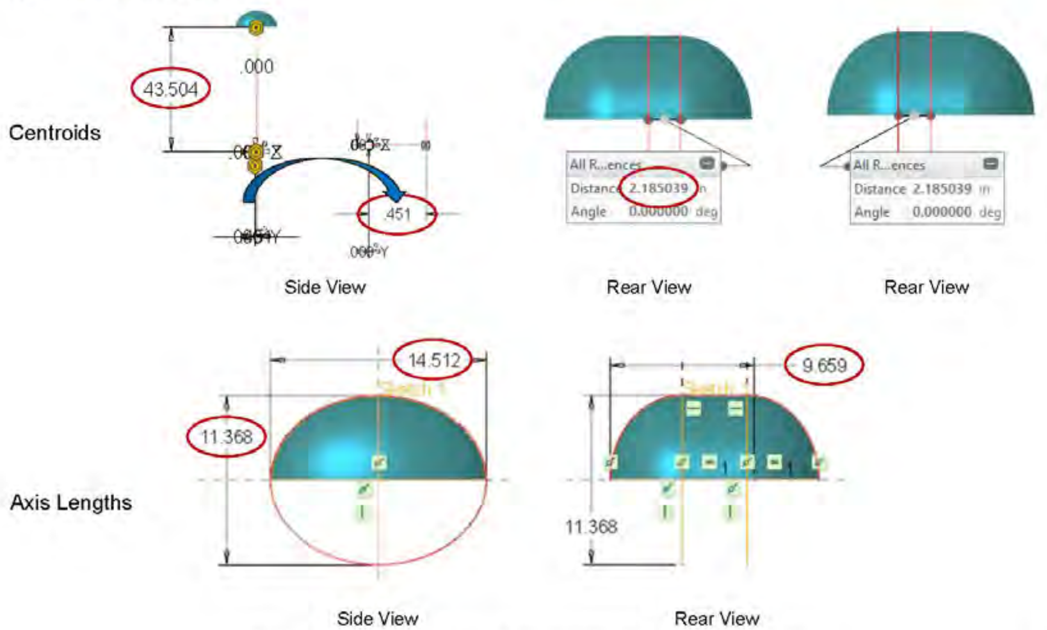
GVSC CAD Model Calculations

HELMET_CONTOUR_CENTROID_X	0.451	in
HELMET_CONTOUR_CENTROID_Y	2.185*	in
HELMET_CONTOUR_CENTROID_Z	43.504	in
HELMET_CONTOUR_X_AXIS_LENGTH	14.512	in
HELMET_CONTOUR_Y_AXIS_LENGTH	9.659	in
HELMET_CONTOUR_Z_AXIS_LENGTH	11.368	in

*Given value, not calculated

TEST #5: HELMET CONTOUR (CONT.)

GVSC CAD Model Result



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Test #5: Knee Contour

UMTRI Spreadsheet Calculations

Knee Centroids	X (in)	Y (in)	Z (in)
Right	-17.610	7.594	20.087
Left	-17.610	-7.594	20.087

Side View of Knee Contours (X, Z)		
Axis Length (X)	5.628	in
Axis Length (Z)	7.529	in

Rear View of Knee Contours (Y, Z)		
Axis Length (Y)	9.035	in
Axis Length (Z)	7.529	in

Leg Segment Angle wrt Vertical	0.000*	deg
Thigh Segment Angle wrt Horizontal	21.513	deg

GVSC CAD Model Calculations

KNEE_CONTOUR_WEIGHTED_CENT_X	-17.610	in
KNEE_CONTOUR_WEIGHTED_CENT_Y	7.594	in
KNEE_CONTOUR_WEIGHTED_CENT_Z	20.087	in
KNEE_CONTOUR_X_AXIS_LENGTH	5.630	in
KNEE_CONTOUR_Y_AXIS_LENGTH	9.037	in
KNEE_CONTOUR_Z_AXIS_LENGTH	7.529	in
KNEE_SHIN_ANGLE	0.000*	deg
KNEE_THIGH_ANGLE	21.513	deg

*Given value, not calculated

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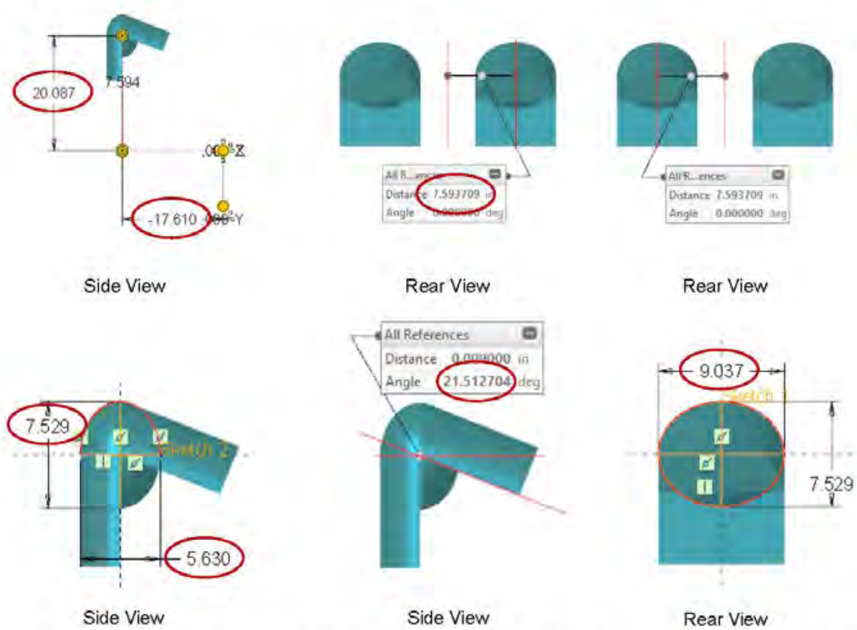
Test #5: Knee Contour (cont.)

GVSC CAD Model Result

Centroids

Axis Lengths
Shin/Thigh Angles



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TEST #5: ELBOW CONTOUR

UMTRI Spreadsheet Calculations

Elbow Centroids	X (in)	Y (in)	Z (in)
Right	0.719	12.298	20.794
Left	0.719	-12.298	20.794

Side View of Elbow Contours (X, Z)		
Axis Length (X)	4.996	in
Axis Length (Z)	5.779	in

Rear View of Elbow Contours (Y, Z)		
Axis Length (Y)	3.683	in
Axis Length (Z)	5.779	in

GVSC CAD Model Calculations

ELBOW_WEIGHTED_CENT_X	0.719	in
ELBOW_WEIGHTED_CENT_Y	12.298	in
ELBOW_WEIGHTED_CENT_Z	20.794	in
ELBOW_X_AXIS_LENGTH	5.000	in
ELBOW_Y_AXIS_LENGTH	3.684	in
ELBOW_Z_AXIS_LENGTH	5.782	in

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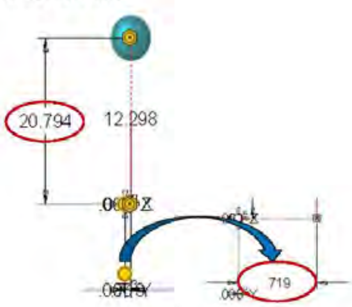
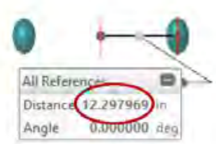
TEST #5: ELBOW CONTOUR (CONT.)

GVSC CAD Model Result

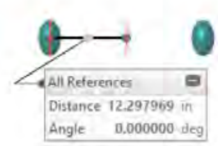
Centroids



Side View

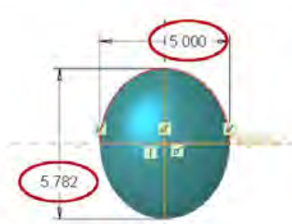


Rear View



Rear View

Axis Lengths



Side View

Rear View

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TEST #5: BOOT CONTOUR

UMTRI Spreadsheet Calculations

Boot Centroids	X (in)	Y (in)	Z (in)
Right	-26.002	7.594	0.000
Left	-26.002	-7.594	0.000

Side View of Boot Contours (X, Z)
Axis Length (X) → 1.889 in
Axis Length (Z) → 4.921 in

Rear View of Boot Contours (Y, Z)
Axis Length (Y) → 8.704 in
Axis Length (Z) → 4.921 in

GVSC CAD Model Calculations

BOOT_TOE_WEIGHTED_CENT_X	-26.002	in
BOOT_TOE_WEIGHTED_CENT_Y	7.594	in
BOOT_TOE_WEIGHTED_CENT_Z	0.000	in
BOOT_TOE_X_AXIS_LENGTH →	1.890	in
BOOT_TOE_Y_AXIS_LENGTH →	8.706	in
BOOT_TOE_Z_AXIS_LENGTH →	4.921	in

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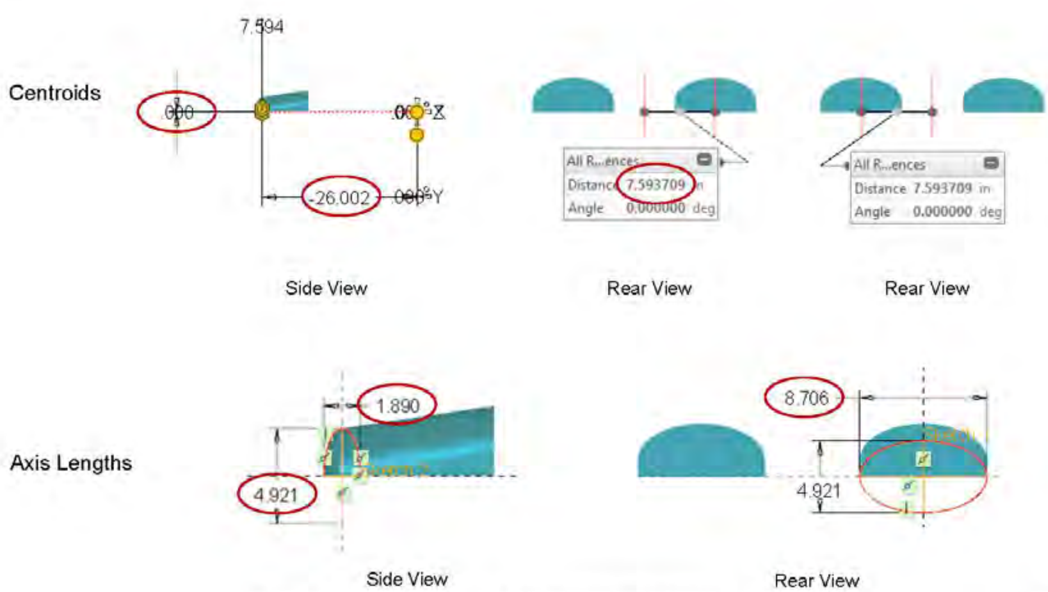
TEST #5: BOOT CONTOUR (CONT.)

GVSC CAD Model Result



DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY

UNCLASSIFIED//FOR OFFICIAL USE ONLY

TEST #5: VARY SEATING HEIGHT/ANGLE

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	90%	PPE	15.0	10.0	SAE J826	No

Clearance (2.0 inches), Shown in Yellow

GVSC CAD Model

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 190

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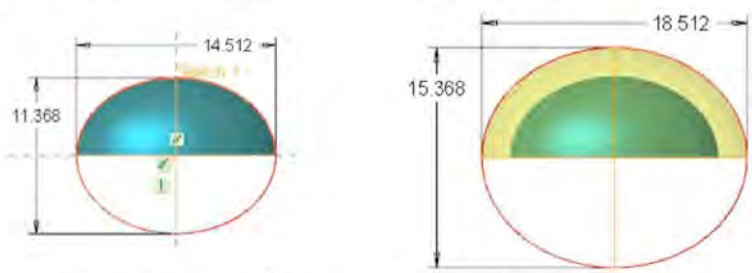
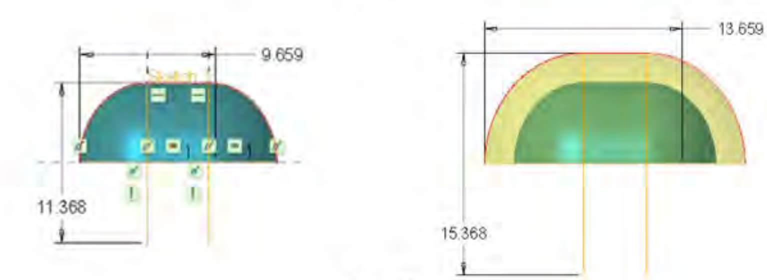
TEST #5: CLEARANCE, HELMET CONTOUR



$$\text{Sample Calculation: } \frac{1}{2}(18.512\ in. - 14.512\ in.) = 2.000\ in.\ clearance$$

Side View



Rear View

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 191

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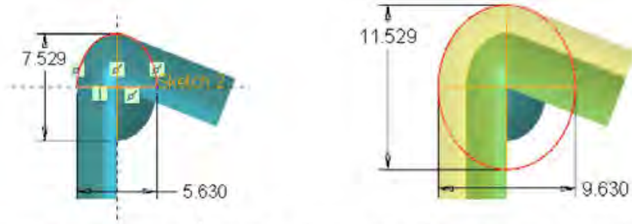
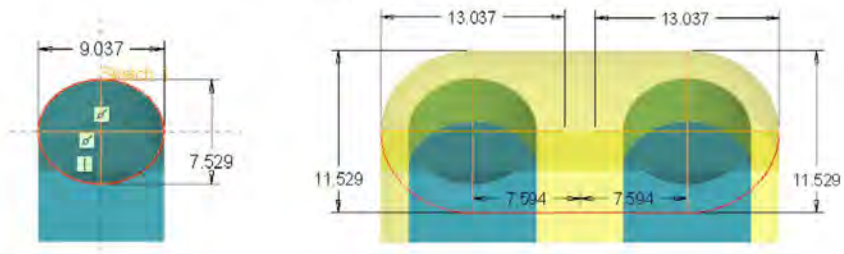
TEST #5: CLEARANCE, KNEE CONTOUR



$$Sample\ Calculation: \frac{1}{2}\ (11.529\ in. - 7.529\ in.) = \ 2.000\ in.\ clearance$$

Side View



Rear View

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 192

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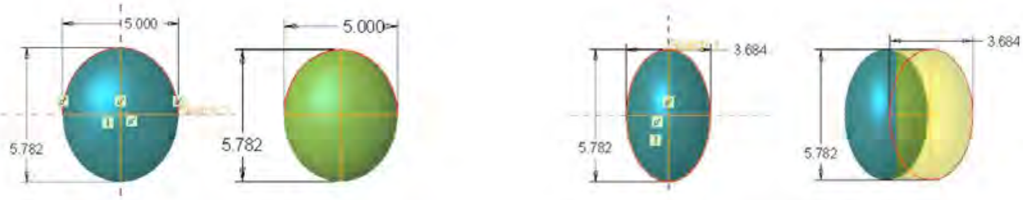
TEST #5: CLEARANCE, ELBOW CONTOUR

$$Sample\ Calculation: 14.298\ in. - 12.298\ in. = \ 2.000\ in.\ clearance$$

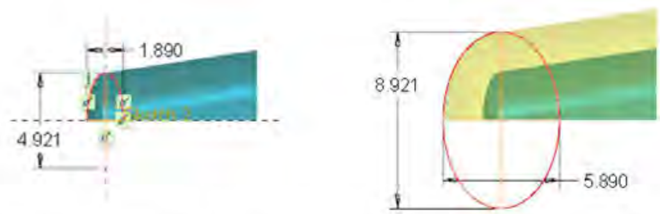
Rear View



Side View **Rear View**

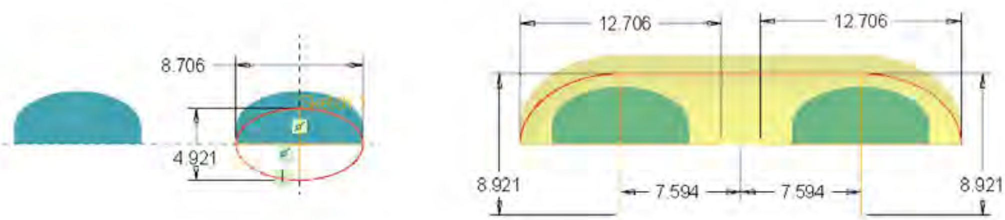
DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 193

TEST #5: CLEARANCE, BOOT CONTOUR



$$Sample\ Calculation: \frac{1}{2}(8.921\ in. - 4.921\ in.) = 2.000\ in.clearance$$

Side View



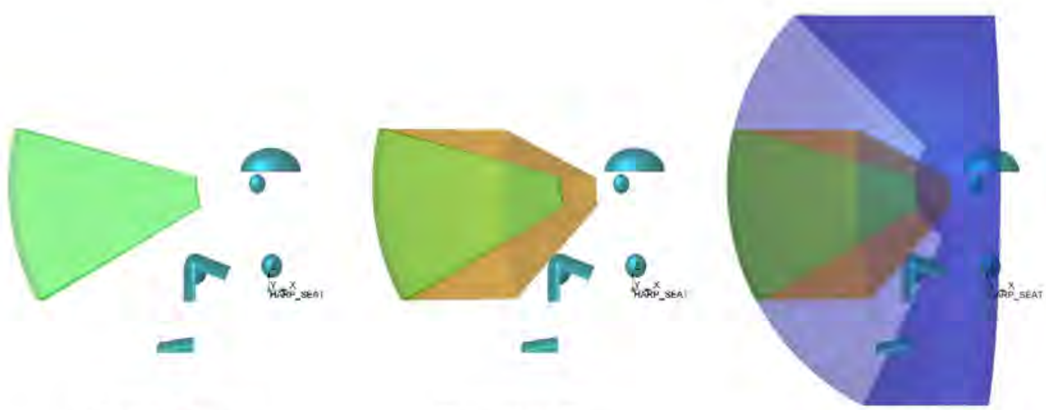
Rear View

TEST #5: VARY SEATING HEIGHT/ANGLE

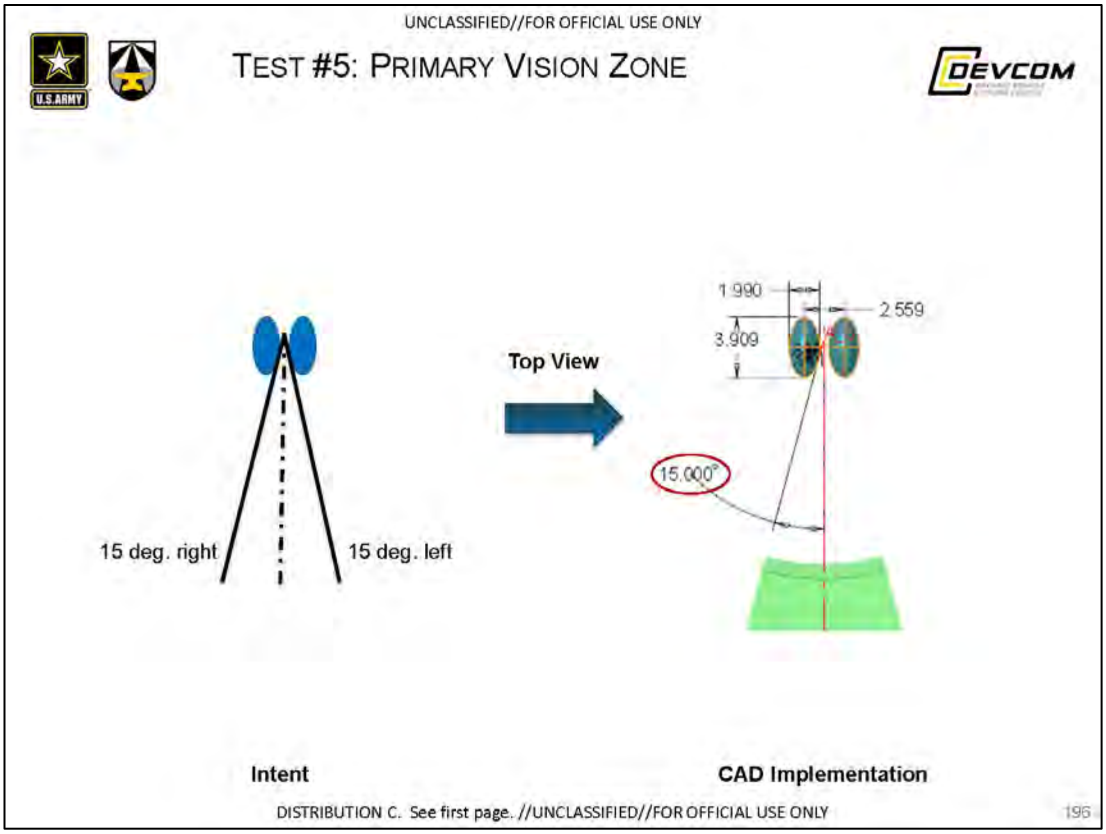
Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	90%	PPE	15.0	10.0	SAE J826	No

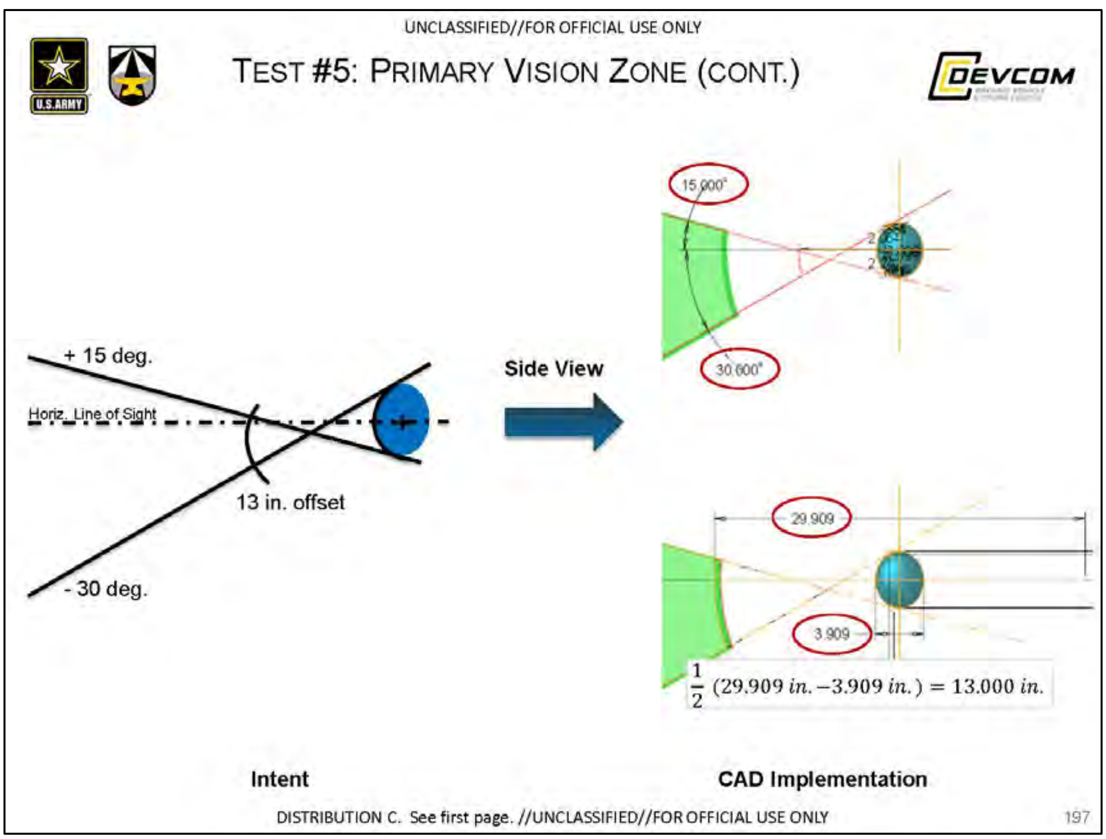
Vision Zones

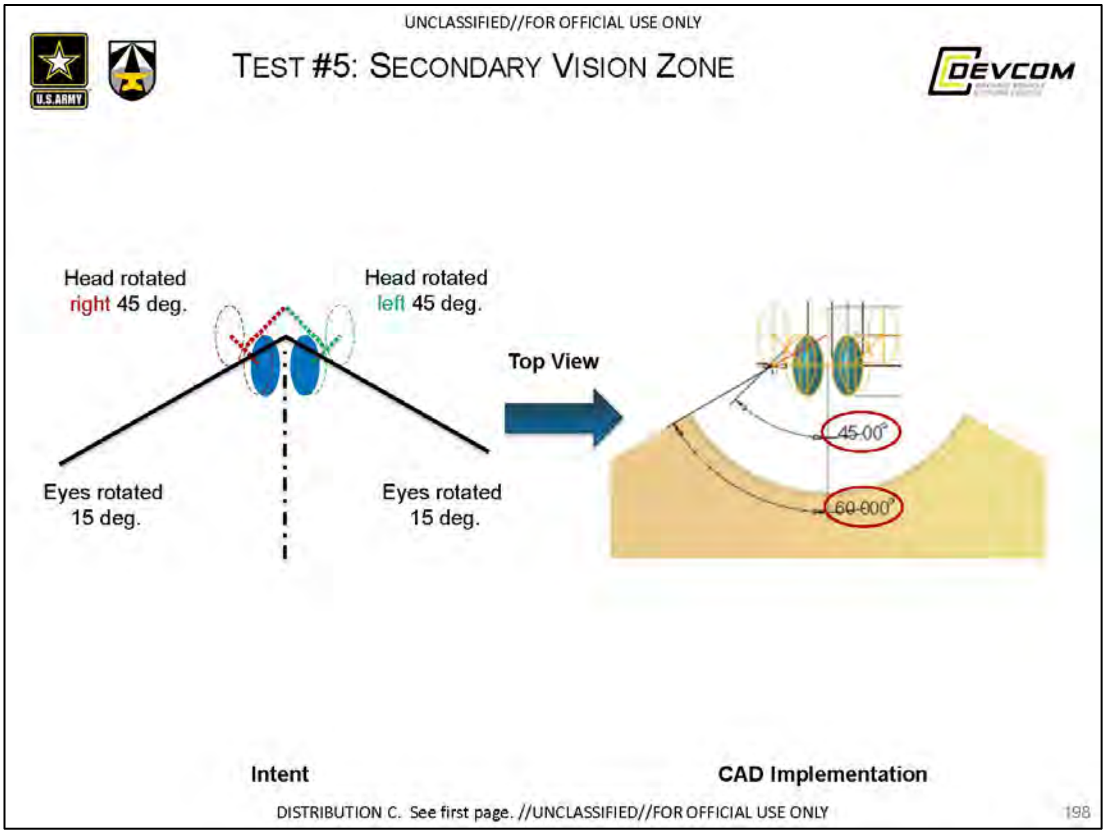
Vison zones are constructed geometrically; no calculations are involved.

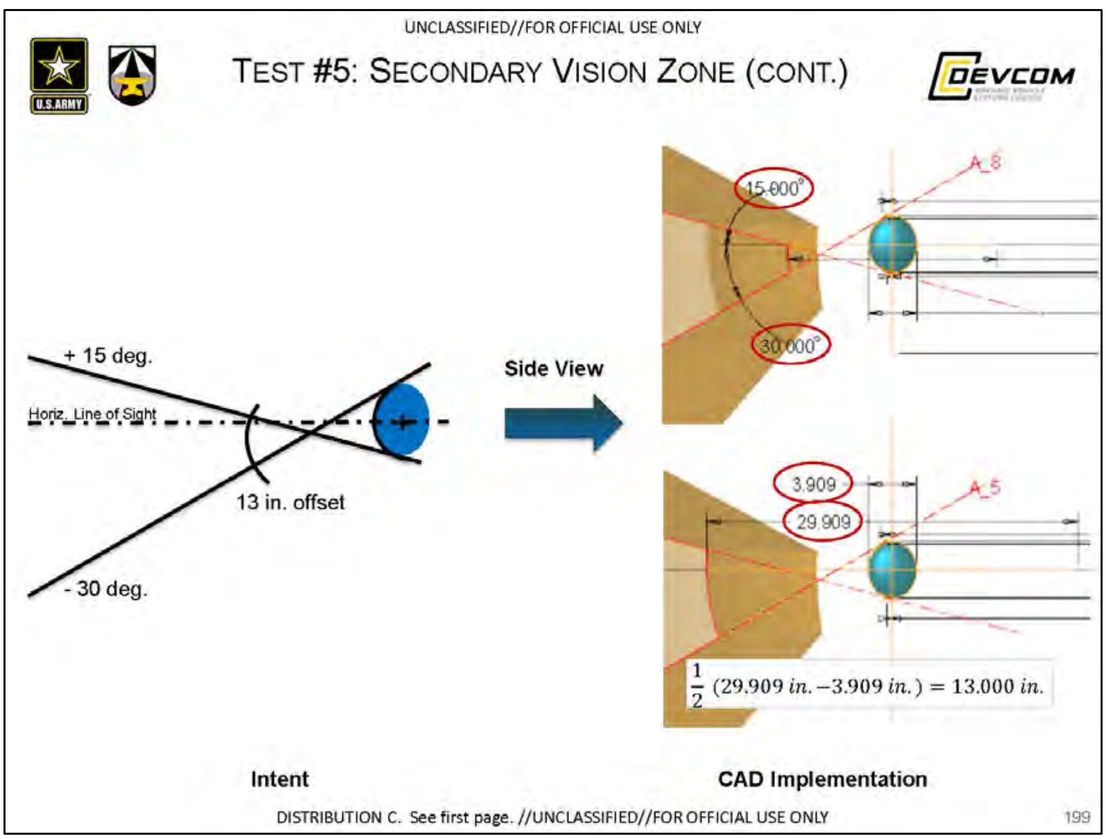


Primary Zone Secondary Zone Tertiary Zone

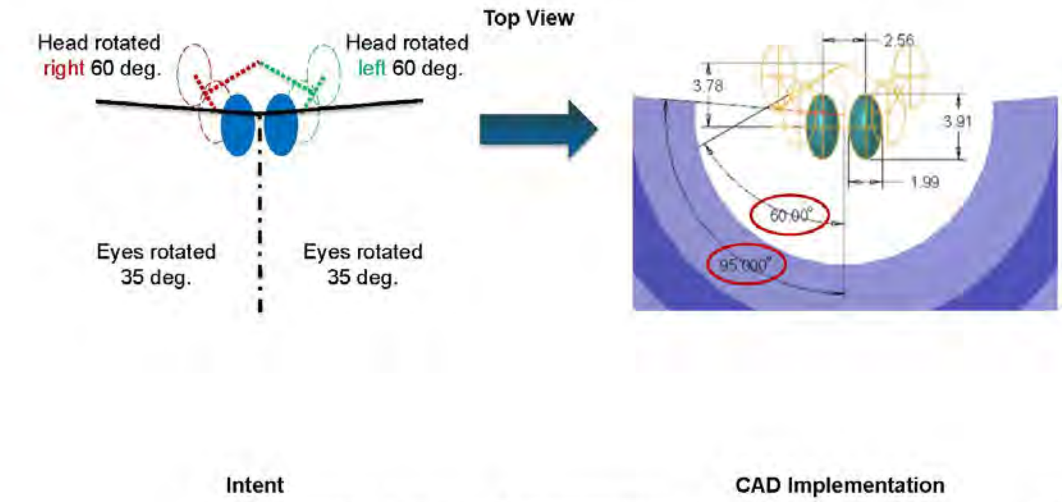

UNCLASSIFIED//FOR OFFICIAL USE ONLY
TEST #5: PRIMARY VISION ZONE
U.S.ARMY
DEVCOM
1.990
2.559
3.909
Top View
15.000°
15 deg. right
15 deg. left
Intent
CAD Implementation
DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY
196


UNCLASSIFIED//FOR OFFICIAL USE ONLY
TEST #5: PRIMARY VISION ZONE (CONT.)
U.S.ARMY
DEVCOM
15.000°
30.000°
+ 15 deg.
Horiz. Line of Sight
Side View
13 in. offset
- 30 deg.
29.909
3.909
$\frac{1}{2}(29.909\ in. - 3.909\ in.) = 13.000\ in.$
Intent
CAD Implementation
DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY
197

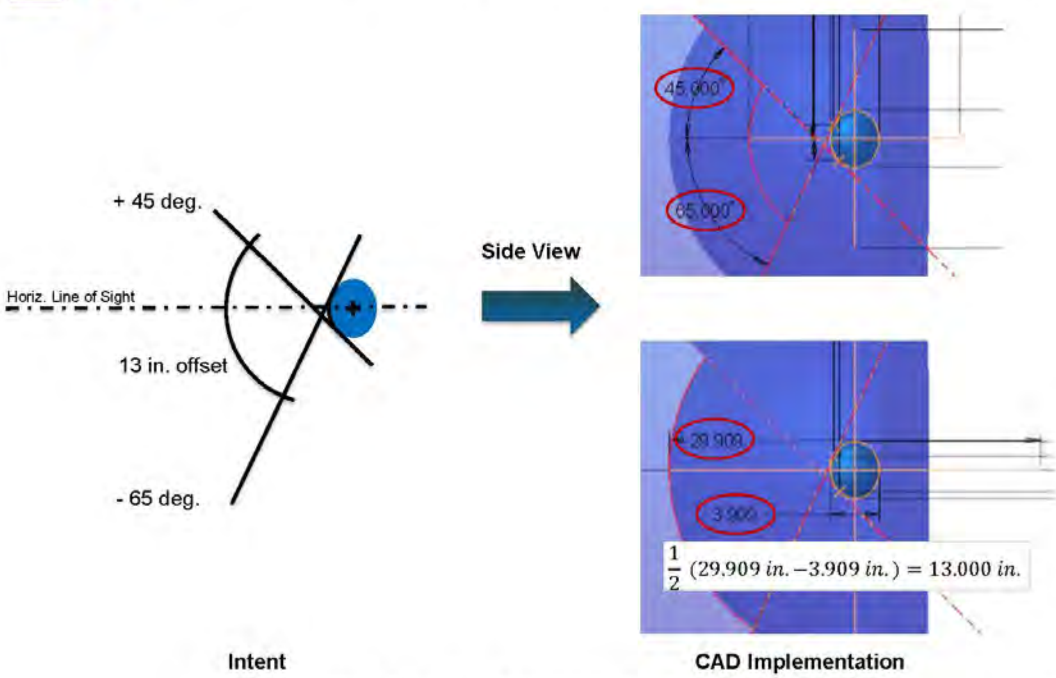

UNCLASSIFIED//FOR OFFICIAL USE ONLY
U.S. ARMY
TEST #5: SECONDARY VISION ZONE
DEVCOM
Head rotated right 45 deg.
Head rotated left 45 deg.
Top View
Eyes rotated 15 deg.
Eyes rotated 15 deg.
45.00°
60.000°
Intent
CAD Implementation
DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY
198


UNCLASSIFIED//FOR OFFICIAL USE ONLY
U.S. ARMY
TEST #5: SECONDARY VISION ZONE (CONT.)
DEVCOM
+ 15 deg.
Horiz. Line of Sight
13 in. offset
- 30 deg.
Side View
A_8
15.000°
30.000°
3.909
29.909
A_5
$\frac{1}{2}(29.909\ in. - 3.909\ in.) = 13.000\ in.$
Intent
CAD Implementation
DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY
199

TEST #5: TERTIARY VISION ZONE



TEST #5: TERTIARY VISION ZONE (CONT.)



TEST #5: VARY SEATING HEIGHT/ANGLE

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	90%	PPE	15.0	10.0	SAE J826	No

Boundary Manikin Posture and Position

GVSC CAD Model

TEST #5: RESULTS, MANIKIN POSITIONING

	UMTRI Value		GVSC Value		Difference	
Small Overall Female						
POSTURE_DHM1_HIP_X	-1.253	in	-1.253	in	0.000	in
POSTURE_DHM1_HIP_Z	14.384	in	14.384	in	0.000	in
POSTURE_DHM1_EYE_X	-1.544	in	-1.544	in	0.000	in
POSTURE_DHM1_EYE_Z	36.577	in	36.577	in	0.000	in
Small Overall Male						
POSTURE_DHM2_HIP_X	-1.496	in	-1.496	in	0.000	in
POSTURE_DHM2_HIP_Z	14.489	in	14.489	in	0.000	in
POSTURE_DHM2_EYE_X	-2.253	in	-2.253	in	0.000	in
POSTURE_DHM2_EYE_Z	38.474	in	38.474	in	0.000	in
Average Size Male						
POSTURE_DHM3_HIP_X	-1.494	in	-1.494	in	0.000	in
POSTURE_DHM3_HIP_Z	14.488	in	14.488	in	0.000	in
POSTURE_DHM3_EYE_X	-2.994	in	-2.994	in	0.000	in
POSTURE_DHM3_EYE_Z	40.824	in	40.824	in	0.000	in
Widest Shoulders Male						
POSTURE_DHM4_HIP_X	-1.467	in	-1.467	in	0.000	in
POSTURE_DHM4_HIP_Z	14.478	in	14.478	in	0.000	in
POSTURE_DHM4_EYE_X	-3.368	in	-3.368	in	0.000	in
POSTURE_DHM4_EYE_Z	42.179	in	42.179	in	0.000	in
Longest Torso Male						
POSTURE_DHM5_HIP_X	-1.453	in	-1.453	in	0.000	in
POSTURE_DHM5_HIP_Z	14.472	in	14.472	in	0.000	in
POSTURE_DHM5_EYE_X	-3.377	in	-3.377	in	0.000	in
POSTURE_DHM5_EYE_Z	43.354	in	43.354	in	0.000	in
Longest Legs Male						
POSTURE_DHM6_HIP_X	-1.622	in	-1.622	in	0.000	in
POSTURE_DHM6_HIP_Z	14.540	in	14.540	in	0.000	in
POSTURE_DHM6_EYE_X	-3.559	in	-3.559	in	0.000	in
POSTURE_DHM6_EYE_Z	41.185	in	41.185	in	0.000	in
Large Overall Male						
POSTURE_DHM7_HIP_X	-1.654	in	-1.654	in	0.000	in
POSTURE_DHM7_HIP_Z	14.633	in	14.633	in	0.000	in
POSTURE_DHM7_EYE_X	-3.835	in	-3.835	in	0.000	in
POSTURE_DHM7_EYE_Z	43.173	in	43.173	in	0.000	in

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

Largest Observed Differences:
0.000 inches

Values in agreement

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TEST #5: SMALL OVERALL FEMALE

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-2.3	-31.3	-74.3	→	-1.233	in
Hip re H-point Z	-15.7	-15.7	-15.7	→	14.384	in
Eye re H-point X	12.8	-39.2	-100.2	→	-1.544	in
Eye re H-point Z	548.1	548.1	548.1	→	36.577	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM1_HIP_X	-1.233	in
POSTURE_DHM1_HIP_Z	14.384	in
POSTURE_DHM1_EYE_X	-1.544	in
POSTURE_DHM1_EYE_Z	36.577	in

GVSC CAD Model Geometry

Side View

Front View

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 204

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TEST #5: SMALL OVERALL MALE

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-9.0	-38.0	-81.0	→	-1.496	in
Hip re H-point Z	-13.0	-13.0	-13.0	→	14.489	in
Eye re H-point X	-5.2	-57.2	-118.2	→	-2.253	in
Eye re H-point Z	596.3	596.3	596.3	→	38.474	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM2_HIP_X	-1.496	in
POSTURE_DHM2_HIP_Z	14.489	in
POSTURE_DHM2_EYE_X	-2.253	in
POSTURE_DHM2_EYE_Z	38.474	in

GVSC CAD Model Geometry

Side View

Front View

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 205

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Test #5: Average Size Male

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-8.9	-37.9	-80.9	→	-1.494	in
Hip re H-point Z	-13.0	-13.0	-13.0	→	14.488	in
Eye re H-point X	-24.0	-76.0	-137.0	→	-2.994	in
Eye re H-point Z	655.9	655.9	655.9	→	40.824	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM3_HIP_X	-1.494	in
POSTURE_DHM3_HIP_Z	14.488	in
POSTURE_DHM3_EYE_X	-2.994	in
POSTURE_DHM3_EYE_Z	40.824	in

GVSC CAD Model Geometry

Side View

Front View

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 206

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Test #5: Widest Shoulders Male

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-8.3	-37.3	-80.3	→	-1.467	in
Hip re H-point Z	-13.3	-13.3	-13.3	→	14.478	in
Eye re H-point X	-33.5	-85.5	-146.5	→	-3.368	in
Eye re H-point Z	690.3	690.3	690.3	→	42.179	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM4_HIP_X	-1.467	in
POSTURE_DHM4_HIP_Z	14.478	in
POSTURE_DHM4_EYE_X	-3.368	in
POSTURE_DHM4_EYE_Z	42.179	in

GVSC CAD Model Geometry

Side View

Front View

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 207

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Test #5: Longest Torso Male

UMTRI Spreadsheet Calculations*

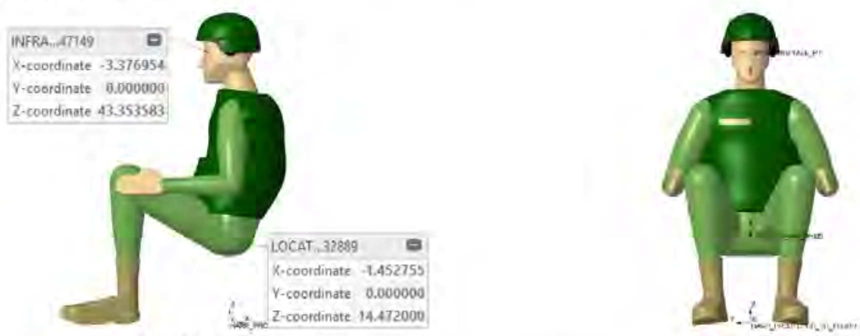
	ACU	PPE	ENC			
Hip re H-point X	-7.9	-36.9	-79.9	→	-1.453	in
Hip re H-point Z	-13.4	-13.4	-13.4	→	14.472	in
Eye re H-point X	-33.8	-85.8	-146.8	→	-3.377	in
Eye re H-point Z	720.2	720.2	720.2	→	43.354	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM5_HIP_X	-1.453	in
POSTURE_DHM5_HIP_Z	14.472	in
POSTURE_DHM5_EYE_X	-3.377	in
POSTURE_DHM5_EYE_Z	43.354	in

GVSC CAD Model Geometry



Side View **Front View**

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 208

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Test #5: Longest Legs Male

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-12.2	-41.2	-84.2	→	-1.622	in
Hip re H-point Z	-11.7	-11.7	-11.7	→	14.540	in
Eye re H-point X	-38.4	-90.4	-151.4	→	-3.559	in
Eye re H-point Z	665.1	665.1	665.1	→	41.185	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM6_HIP_X	-1.622	in
POSTURE_DHM6_HIP_Z	14.540	in
POSTURE_DHM6_EYE_X	-3.559	in
POSTURE_DHM6_EYE_Z	41.185	in

GVSC CAD Model Geometry

Side View **Front View**

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TEST #5: LARGE OVERALL MALE

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-18.1	-47.1	-90.1	→	-1.854	in
Hip re H-point Z	-9.3	-9.3	-9.3	→	14.633	in
Eye re H-point X	-45.4	-97.4	-158.4	→	-3.835	in
Eye re H-point Z	715.6	715.6	715.6	→	43.173	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM7_HIP_X	-1.854	in
POSTURE_DHM7_HIP_Z	14.633	in
POSTURE_DHM7_EYE_X	-3.835	in
POSTURE_DHM7_EYE_Z	43.173	in

GVSC CAD Model Geometry

Side View

Front View

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 210

10.7.6 TEST #6 – VARY ENSEMBLE

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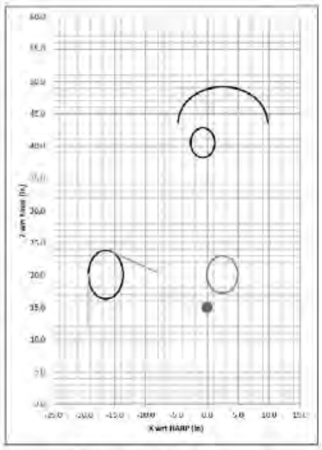
TEST #6: VARY ENSEMBLE

DEVCOM

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	90%	ACU	15.0	10.0	SAE J826	No

Basic Accommodation



UMTRI Spreadsheet

GVSC CAD Model

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TEST #6: ENSEMBLE EFFECTS

DEVCOM

Test #	Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
5	90%	90%	PPE	15.0	10.0	SAE J826	No
6	90%	90%	ACU	15.0	10.0	SAE J826	No

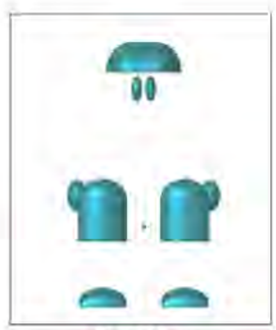
Note: Highlighted values differ from comparison test.

Observations/Notes

- For a given seat, Soldiers wearing ACU are able to sit further rearward and are able to rest their elbows closer to the body than those wearing PPE.

Side View

— Test #5
Test #6



Front View

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Test #6: Results, Accommodation

HARP

	UMTRI Value		GVSC Value		Difference	
HARP_X	0.000	in	0.000	in	0.000	in
HARP_Z	15.000	in	15.000	in	0.000	in

Eyellipse

	UMTRI Value		GVSC Value		Difference	
EYELLIPSE_CENTROID_X	-0.750	in	-0.750	in	0.000	in
EYELLIPSE_CENTROID_Y (+/-)	1.280	in	1.280	in	0.000	in
EYELLIPSE_CENTROID_Z	40.519	in	40.519	in	0.001	in
EYELLIPSE_X_AXIS_LENGTH	3.907	in	3.909	in	0.003	in
EYELLIPSE_Y_AXIS_LENGTH	1.988	in	1.990	in	0.001	in
EYELLIPSE_Z_AXIS_LENGTH	4.594	in	4.596	in	0.002	in

Helmet Contour

The ACU ensemble does not include a helmet

Knee Contour

	UMTRI Value		GVSC Value		Difference	
KNEE_CONTOUR_WEIGHTED_CENT_X	16.469	in	16.469	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Y (+/-)	7.594	in	7.594	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Z	20.087	in	20.087	in	0.000	in
KNEE_CONTOUR_X_AXIS_LENGTH	5.628	in	5.630	in	0.002	in
KNEE_CONTOUR_Y_AXIS_LENGTH	9.035	in	9.037	in	0.002	in
KNEE_CONTOUR_Z_AXIS_LENGTH	7.529	in	7.529	in	0.001	in
KNEE_SHIN_ANGLE	0.000	deg	0.000	deg	0.000	deg
KNEE_THIGH_ANGLE	22.855	deg	22.855	deg	0.000	deg

Elbow Contour

	UMTRI Value		GVSC Value		Difference	
ELBOW_WEIGHTED_CENT_X	2.412	in	2.412	in	0.000	in
ELBOW_WEIGHTED_CENT_Y	11.595	in	11.595	in	0.000	in
ELBOW_WEIGHTED_CENT_Z	20.097	in	20.097	in	0.000	in
ELBOW_X_AXIS_LENGTH	4.996	in	5.000	in	0.004	in
ELBOW_Y_AXIS_LENGTH	3.683	in	3.684	in	0.001	in
ELBOW_Z_AXIS_LENGTH	5.779	in	5.782	in	0.003	in

Boot Contour

	UMTRI Value		GVSC Value		Difference	
BOOT_TOE_WEIGHTED_CENT_X	-24.860	in	-24.860	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Y	7.594	in	7.594	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Z	0.000	in	0.000	in	0.000	in
BOOT_TOE_X_AXIS_LENGTH	1.889	in	1.890	in	0.001	in
BOOT_TOE_Y_AXIS_LENGTH	8.704	in	8.706	in	0.002	in
BOOT_TOE_Z_AXIS_LENGTH	4.921	in	4.921	in	0.000	in

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

Largest Observed Differences:
0.004 inches
0.000 degrees

Values in agreement

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Test #6: Seat HARP

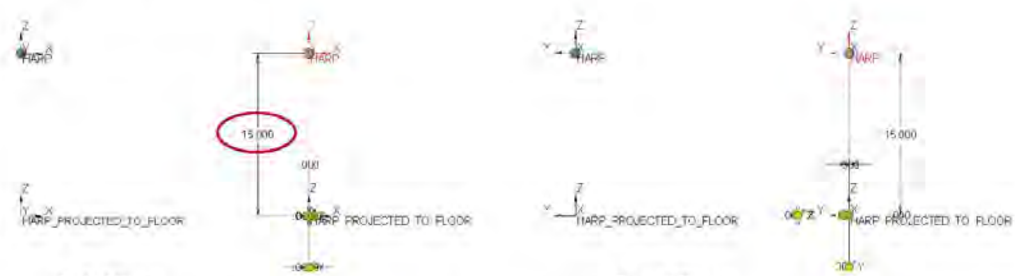
UMTRI Spreadsheet Calculations

	X (in)	Z (in)
HARP	0.000	15.000

GVSC CAD Model Calculations

HARP_X	0.000	in
HARP_Z	15.000	in

GVSC CAD Model Geometry



Side View

Front View

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TEST #6: EYELLIPSE

DEVCOM

UMTRI Spreadsheet Calculations

Eyellipse Centroids	X (in)	Y (in)	Z (in)
Right	-0.750	1.280*	40.519
Left	-0.750	-1.280*	40.519

Side View of Eyellipses (X, Z)		
Axis Length (X)	3.907	in
Axis Length (Z)	4.594	in

Rear View of Eyellipses (Y, Z)		
Axis Length (Y)	1.988	in
Axis Length (Z)	4.594	in

GVSC CAD Model Calculations

EYELLIPSE_CENTROID_X	-0.750	in
EYELLIPSE_CENTROID_Y	1.280*	in
EYELLIPSE_CENTROID_Z	40.519	in
EYELLIPSE_X_AXIS_LENGTH	3.909	in
EYELLIPSE_Y_AXIS_LENGTH	1.990	in
EYELLIPSE_Z_AXIS_LENGTH	4.596	in

*Given value, not calculated

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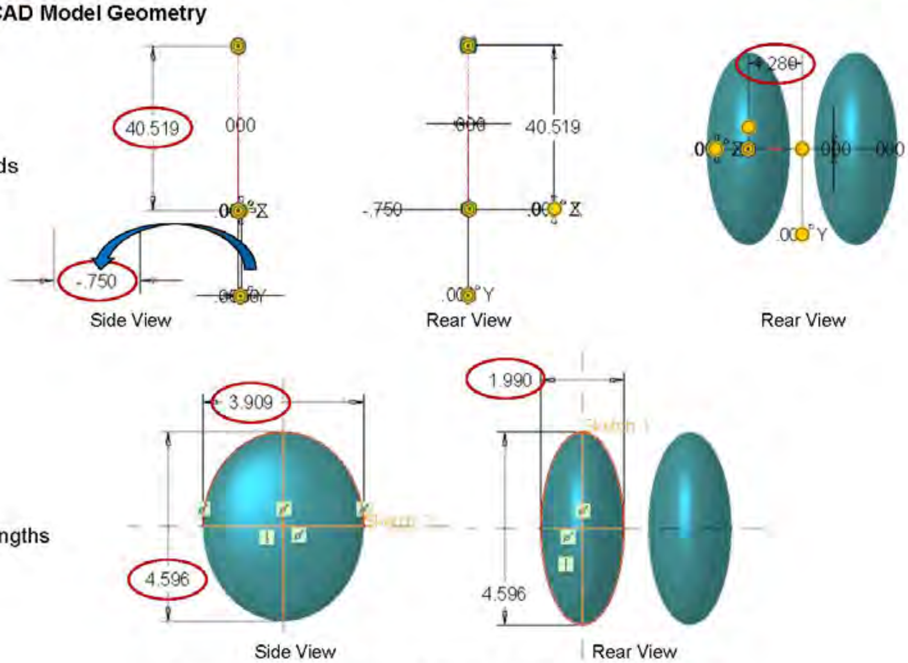
TEST #6: EYELLIPSE (CONT.)

DEVCOM

GVSC CAD Model Geometry

Centroids

Axis Lengths



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TEST #6: KNEE CONTOUR

UMTRI Spreadsheet Calculations

Knee Centroids	X (in)	Y (in)	Z (in)
Right	-16.469	7.594	20.087
Left	-16.469	-7.594	20.087

Side View of Knee Contours (X, Z)		
Axis Length (X)	5.628	in
Axis Length (Z)	7.529	in

Rear View of Knee Contours (Y, Z)		
Axis Length (Y)	9.035	in
Axis Length (Z)	7.529	in

Leg Segment Angle wrt Vertical	0.000*	deg
Thigh Segment Angle wrt Horizontal	22.855	deg

GVSC CAD Model Calculations

KNEE_CONTOUR_WEIGHTED_CENT_X	-16.469	in
KNEE_CONTOUR_WEIGHTED_CENT_Y	7.594	in
KNEE_CONTOUR_WEIGHTED_CENT_Z	20.087	in
KNEE_CONTOUR_X_AXIS_LENGTH	5.630	in
KNEE_CONTOUR_Y_AXIS_LENGTH	9.037	in
KNEE_CONTOUR_Z_AXIS_LENGTH	7.529	in
KNEE_SHIN_ANGLE	0.000*	deg
KNEE_THIGH_ANGLE	22.855	deg

*Given value, not calculated

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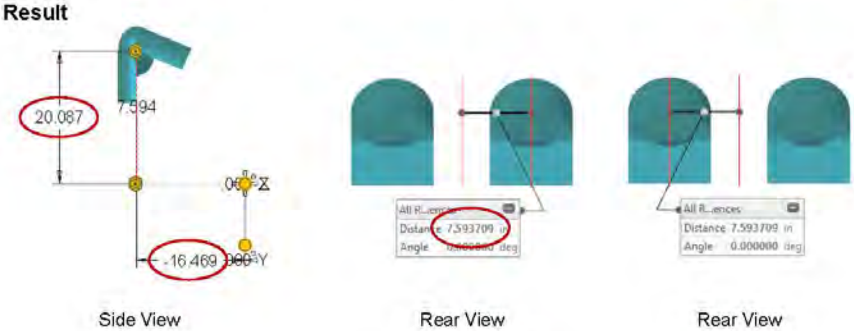
TEST #6: KNEE CONTOUR (CONT.)

GVSC CAD Model Result

Centroids



Axis Lengths
Shin/Thigh Angles

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TEST #6: ELBOW CONTOUR

UMTRI Spreadsheet Calculations

Elbow Centroids	X (in)	Y (in)	Z (in)
Right	2.412	11.585	20.097
Left	2.412	-11.585	20.097

Side View of Elbow Contours (X, Z)		
Axis Length (X)	4.996	in
Axis Length (Z)	5.779	in

Rear View of Elbow Contours (Y, Z)		
Axis Length (Y)	3.683	in
Axis Length (Z)	5.779	in

GVSC CAD Model Calculations

ELBOW_WEIGHTED_CENT_X	2.412	in
ELBOW_WEIGHTED_CENT_Y	11.585	in
ELBOW_WEIGHTED_CENT_Z	20.097	in
ELBOW_X_AXIS_LENGTH	5.000	in
ELBOW_Y_AXIS_LENGTH	3.684	in
ELBOW_Z_AXIS_LENGTH	5.782	in

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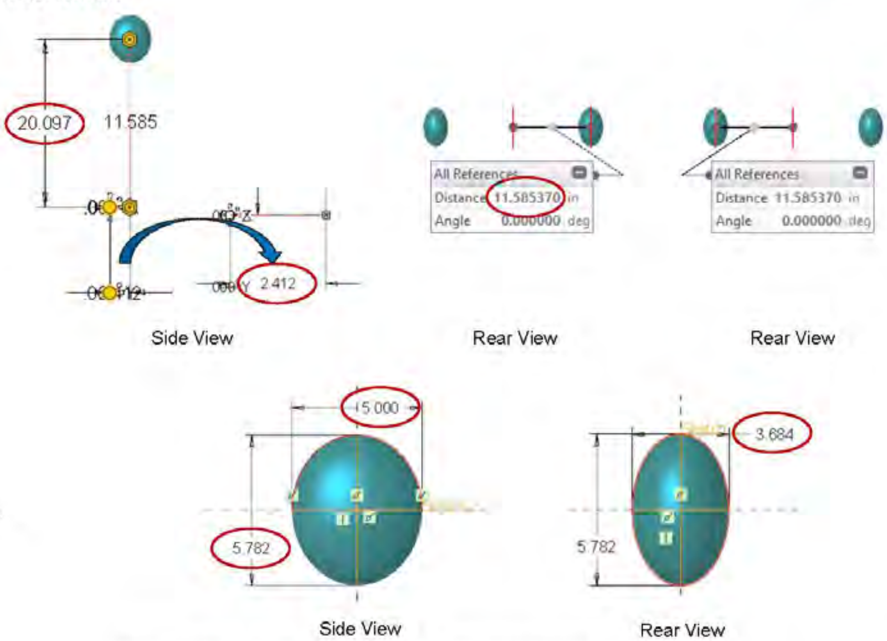
TEST #6: ELBOW CONTOUR (CONT.)

GVSC CAD Model Result

Centroids

Axis Lengths



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TEST #6: BOOT CONTOUR

UMTRI Spreadsheet Calculations

Boot Centroids	X (in)	Y (in)	Z (in)
Right	-24.860	7.594	0.000
Left	-24.860	-7.594	0.000

Side View of Boot Contours (X, Z)		
Axis Length (X)	1.889	in
Axis Length (Z)	4.921	in

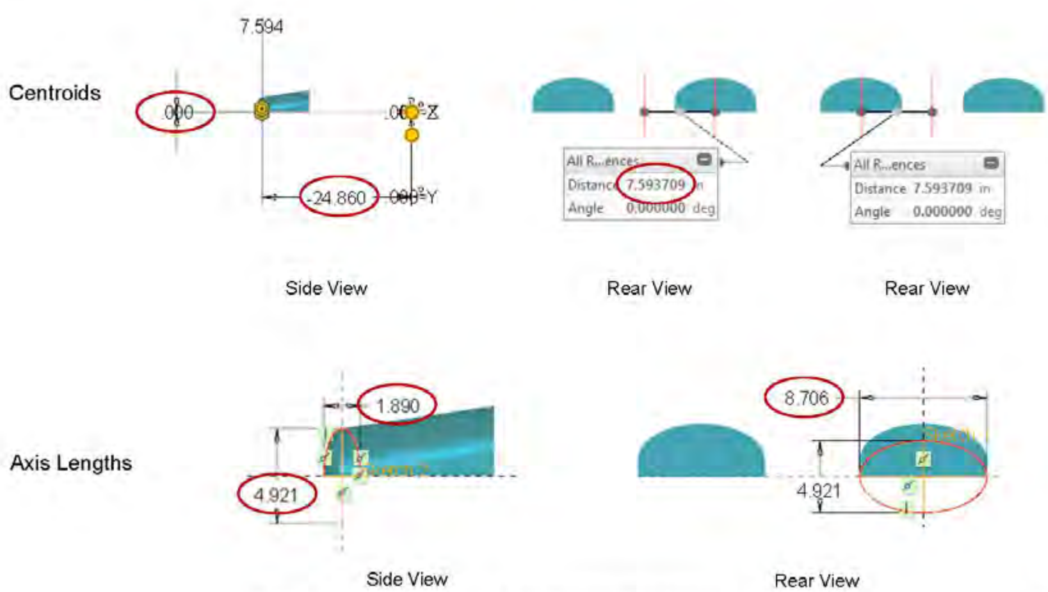
Rear View of Boot Contours (Y, Z)		
Axis Length (Y)	8.704	in
Axis Length (Z)	4.921	in

GVSC CAD Model Calculations

BOOT_TOE_WEIGHTED_CENT_X	-24.860	in
BOOT_TOE_WEIGHTED_CENT_Y	7.594	in
BOOT_TOE_WEIGHTED_CENT_Z	0.000	in
BOOT_TOE_X_AXIS_LENGTH	1.890	in
BOOT_TOE_Y_AXIS_LENGTH	8.706	in
BOOT_TOE_Z_AXIS_LENGTH	4.921	in

TEST #6: BOOT CONTOUR (CONT.)

GVSC CAD Model Result



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TEST #6: VARY ENSEMBLE

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	90%	ACU	15.0	10.0	SAE J826	No

Clearance (2.0 inches), Shown in Yellow

GVSC CAD Model

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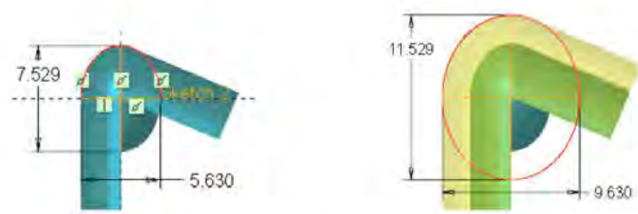
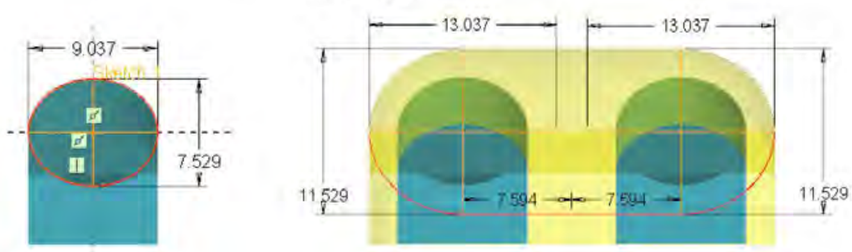
TEST #6: CLEARANCE, KNEE CONTOUR



Sample Calculation: $\frac{1}{2}(11.529\ in. - 7.529\ in.) = 2.000\ in.\ clearance$

Side View



Rear View

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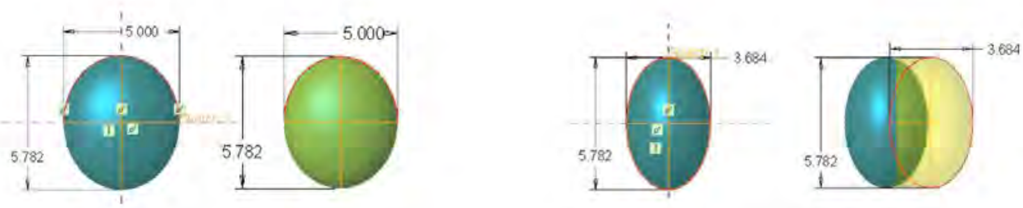
TEST #6: CLEARANCE, ELBOW CONTOUR

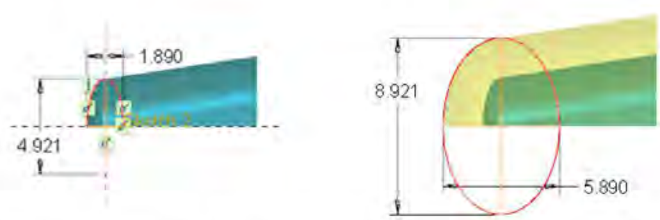
$$Sample\ Calculation: 13.585\ in. - 11.585\ in. = \ 2.000\ in. clearance$$

Rear View



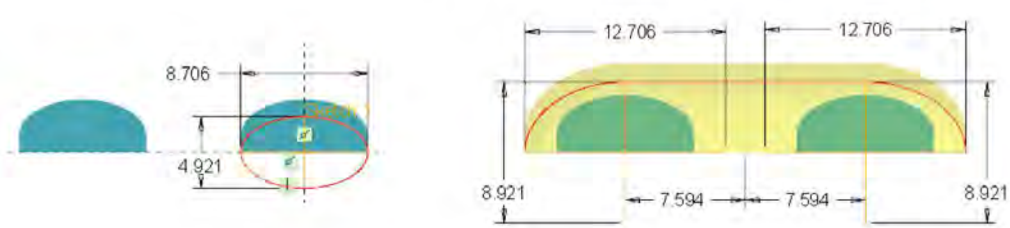
Side View **Rear View**

TEST #6: CLEARANCE, BOOT CONTOUR



$$Sample\ Calculation: \frac{1}{2}(8.921\ in. - 4.921\ in.) = \ 2.000\ in. clearance$$

Side View



Rear View

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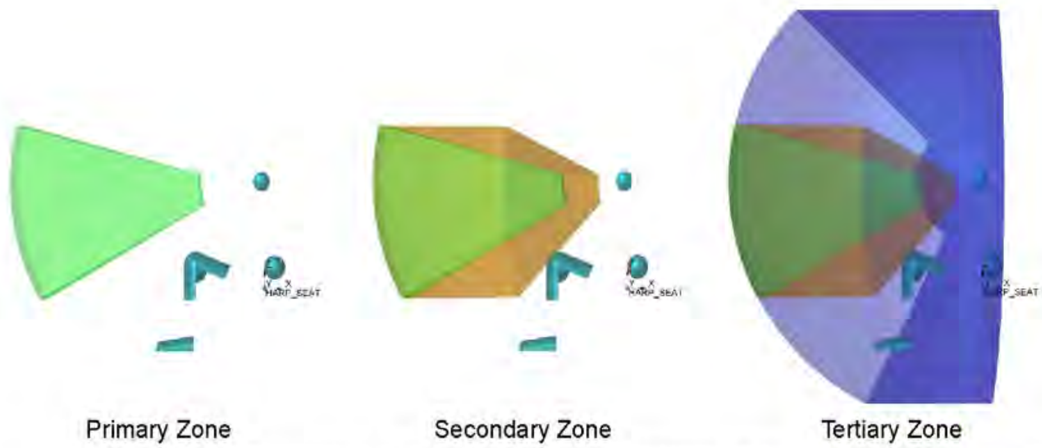
TEST #6: VARY ENSEMBLE

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	90%	ACU	15.0	10.0	SAE J826	No

Vision Zones

Vison zones are constructed geometrically; no calculations are involved.



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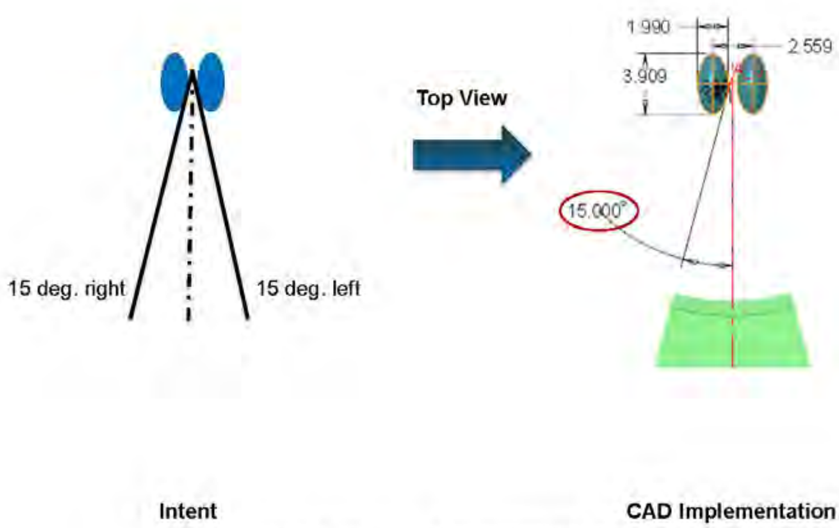
TEST #6: PRIMARY VISION ZONE



DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 228

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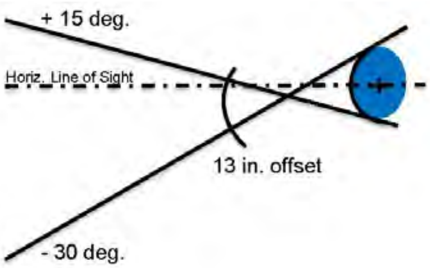
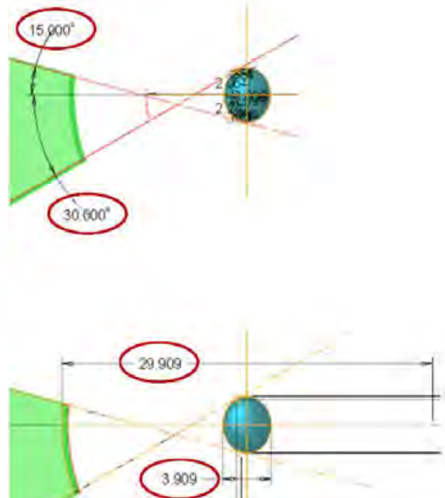
TEST #6: PRIMARY VISION ZONE (CONT.)



Side View



$$\frac{1}{2}(29.909\ in. - 3.909\ in.) = 13.000\ in.$$

Intent

CAD Implementation

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY

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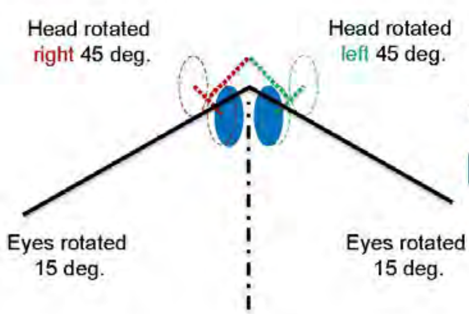
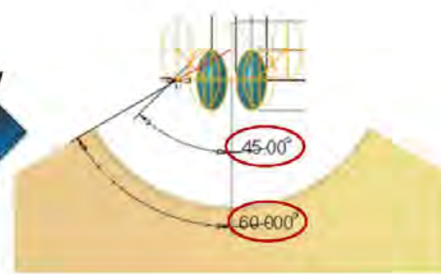
TEST #6: SECONDARY VISION ZONE



Top View



Intent

CAD Implementation

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY

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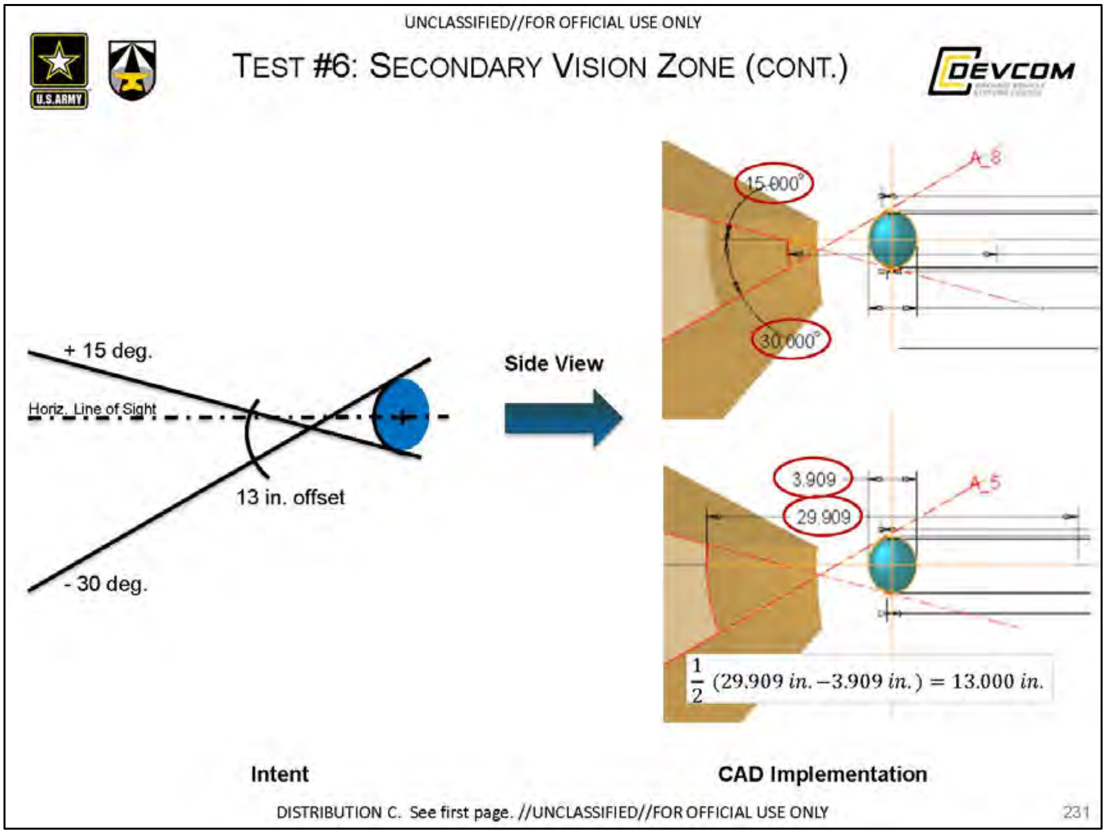
UNCLASSIFIED//FOR OFFICIAL USE ONLY
TEST #6: SECONDARY VISION ZONE (CONT.)
+ 15 deg.
Horiz. Line of Sight
13 in. offset
- 30 deg.
Side View
15.000°
30.000°
3.909
29.909
$\frac{1}{2}(29.909\ in. - 3.909\ in.) = 13.000\ in.$
Intent
CAD Implementation
DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY
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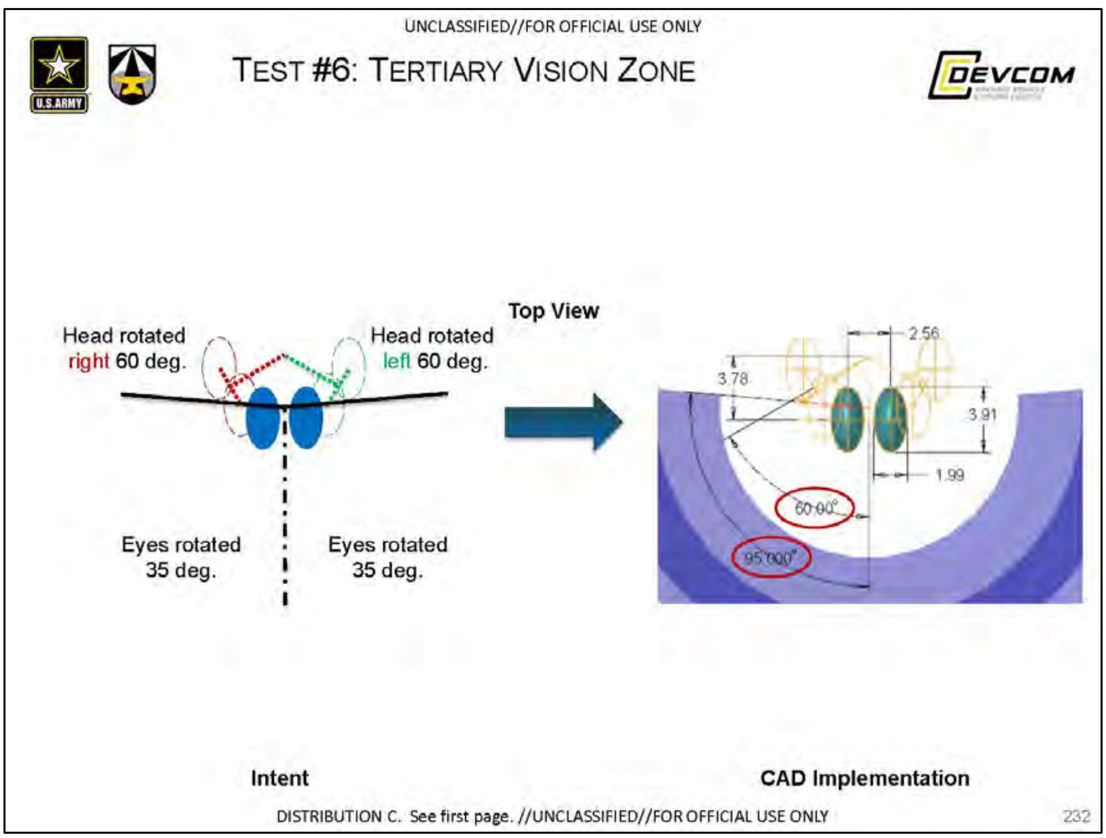
UNCLASSIFIED//FOR OFFICIAL USE ONLY
TEST #6: TERTIARY VISION ZONE
Head rotated right 60 deg.
Head rotated left 60 deg.
Eyes rotated 35 deg.
Eyes rotated 35 deg.
Top View
2.56
3.78
3.91
1.99
60.00°
95.000°
Intent
CAD Implementation
DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY
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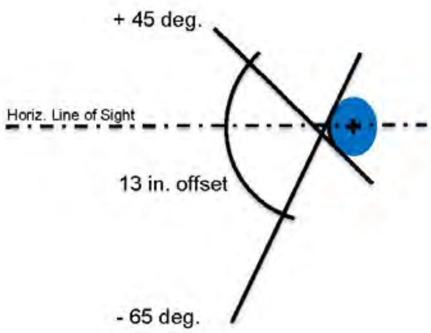
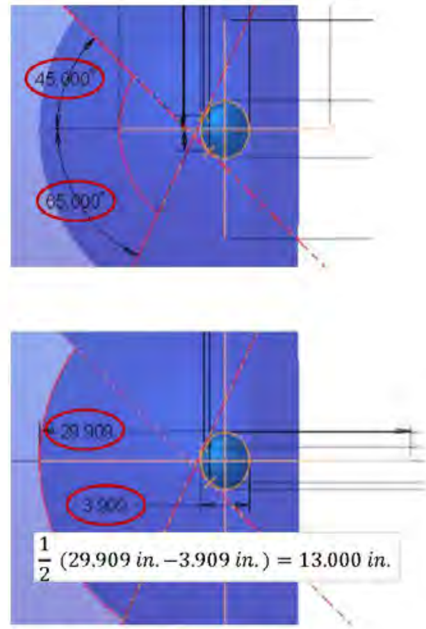
TEST #6: TERTIARY VISION ZONE (CONT.)



Side View



Intent

CAD Implementation

TEST #6: VARY ENSEMBLE

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	90%	ACU	15.0	10.0	SAE J826	No

Boundary Manikin Posture and Position

GVSC CAD Model

TEST #6: RESULTS, MANIKIN POSITIONING

Small Overall Female

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM1_HIP_X	-0.092	in	-0.092	in	0.000	in
POSTURE_DHM1_HIP_Z	14.384	in	14.384	in	0.000	in
POSTURE_DHM1_EYE_X	0.504	in	0.504	in	0.000	in
POSTURE_DHM1_EYE_Z	36.577	in	36.577	in	0.000	in

Small Overall Male

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM2_HIP_X	-0.354	in	-0.354	in	0.000	in
POSTURE_DHM2_HIP_Z	14.489	in	14.489	in	0.000	in
POSTURE_DHM2_EYE_X	-0.206	in	-0.206	in	0.000	in
POSTURE_DHM2_EYE_Z	38.474	in	38.474	in	0.000	in

Average Size Male

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM3_HIP_X	-0.352	in	-0.352	in	0.000	in
POSTURE_DHM3_HIP_Z	14.488	in	14.488	in	0.000	in
POSTURE_DHM3_EYE_X	-0.946	in	-0.946	in	0.000	in
POSTURE_DHM3_EYE_Z	40.824	in	40.824	in	0.000	in

Widest Shoulders Male

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM4_HIP_X	-0.325	in	-0.325	in	0.000	in
POSTURE_DHM4_HIP_Z	14.478	in	14.478	in	0.000	in
POSTURE_DHM4_EYE_X	-1.320	in	-1.320	in	0.000	in
POSTURE_DHM4_EYE_Z	42.179	in	42.179	in	0.000	in

Longest Torso Male

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM5_HIP_X	-0.311	in	-0.311	in	0.000	in
POSTURE_DHM5_HIP_Z	14.472	in	14.472	in	0.000	in
POSTURE_DHM5_EYE_X	-1.330	in	-1.330	in	0.000	in
POSTURE_DHM5_EYE_Z	43.354	in	43.354	in	0.000	in

Longest Legs Male

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM6_HIP_X	-0.480	in	-0.480	in	0.000	in
POSTURE_DHM6_HIP_Z	14.540	in	14.540	in	0.000	in
POSTURE_DHM6_EYE_X	-1.512	in	-1.512	in	0.000	in
POSTURE_DHM6_EYE_Z	41.185	in	41.185	in	0.000	in

Large Overall Male

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM7_HIP_X	-0.712	in	-0.712	in	0.000	in
POSTURE_DHM7_HIP_Z	14.633	in	14.633	in	0.000	in
POSTURE_DHM7_EYE_X	-1.788	in	-1.788	in	0.000	in
POSTURE_DHM7_EYE_Z	43.173	in	43.173	in	0.000	in

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

Largest Observed Differences:
0.000 inches

Values in agreement

TEST #6: SMALL OVERALL FEMALE

UMTRI Spreadsheet Calculations*

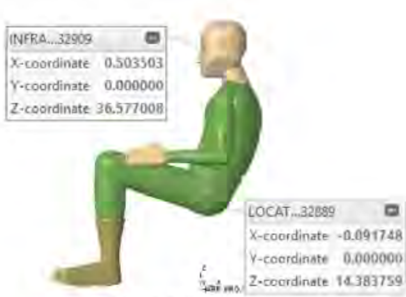
	ACU	PPE	ENC			
Hip re H-point X	-2.3	-31.3	-74.3	→	-0.092	in
Hip re H-point Z	-15.7	-15.7	-15.7	→	14.384	in
Eye re H-point X	12.8	-39.2	-100.2	→	0.504	in
Eye re H-point Z	548.1	548.1	548.1	→	36.577	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM1_HIP_X	-0.092	in
POSTURE_DHM1_HIP_Z	14.384	in
POSTURE_DHM1_EYE_X	0.504	in
POSTURE_DHM1_EYE_Z	36.577	in

GVSC CAD Model Geometry



Side View

Front View

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Test #6: Small Overall Male

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-9.0	-38.0	-81.0	→	-0.354	in
Hip re H-point Z	-13.0	-13.0	-13.0	→	14.489	in
Eye re H-point X	-5.2	-57.2	-118.2	→	-0.206	in
Eye re H-point Z	596.3	596.3	596.3	→	38.474	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM2_HIP_X	-0.354	in
POSTURE_DHM2_HIP_Z	14.489	in
POSTURE_DHM2_EYE_X	-0.206	in
POSTURE_DHM2_EYE_Z	38.474	in

GVSC CAD Model Geometry

Side View

Front View

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Test #6: Average Size Male

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-8.9	-37.9	-80.9	→	-0.352	in
Hip re H-point Z	-13.0	-13.0	-13.0	→	14.488	in
Eye re H-point X	-24.0	-76.0	-137.0	→	-0.946	in
Eye re H-point Z	655.9	655.9	655.9	→	40.824	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM3_HIP_X	-0.352	in
POSTURE_DHM3_HIP_Z	14.488	in
POSTURE_DHM3_EYE_X	-0.946	in
POSTURE_DHM3_EYE_Z	40.824	in

GVSC CAD Model Geometry

Side View

Front View

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TEST #6: WIDEST SHOULDERS MALE

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-8.3	-37.3	-80.3	→	-0.325	in
Hip re H-point Z	-13.3	-13.3	-13.3	→	14.478	in
Eye re H-point X	-33.5	-85.5	-146.5	→	-1.320	in
Eye re H-point Z	690.3	690.3	690.3	→	42.179	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM4_HIP_X	-0.325	in
POSTURE_DHM4_HIP_Z	14.478	in
POSTURE_DHM4_EYE_X	-1.320	in
POSTURE_DHM4_EYE_Z	42.179	in

GVSC CAD Model Geometry

Side View

Front View

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TEST #6: LONGEST TORSO MALE

UMTRI Spreadsheet Calculations*

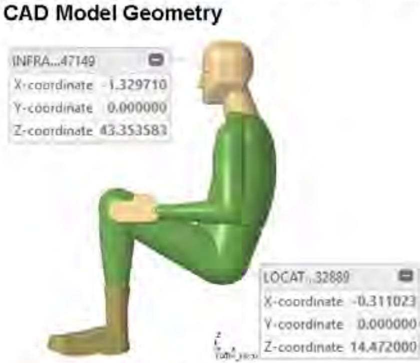
	ACU	PPE	ENC			
Hip re H-point X	-7.9	-36.9	-79.9	→	-0.311	in
Hip re H-point Z	-13.4	-13.4	-13.4	→	14.472	in
Eye re H-point X	-33.8	-85.8	-146.8	→	-1.330	in
Eye re H-point Z	720.2	720.2	720.2	→	43.354	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM5_HIP_X	-0.311	in
POSTURE_DHM5_HIP_Z	14.472	in
POSTURE_DHM5_EYE_X	-1.330	in
POSTURE_DHM5_EYE_Z	43.354	in

GVSC CAD Model Geometry



Side View

Front View

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TEST #6: LONGEST LEGS MALE

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-12.2	-41.2	-84.2	→	-0.480	in
Hip re H-point Z	-11.7	-11.7	-11.7	→	14.540	in
Eye re H-point X	-38.4	-90.4	-151.4	→	-1.512	in
Eye re H-point Z	665.1	665.1	665.1	→	41.185	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM6_HIP_X	-0.480	in
POSTURE_DHM6_HIP_Z	14.540	in
POSTURE_DHM6_EYE_X	-1.512	in
POSTURE_DHM6_EYE_Z	41.185	in

GVSC CAD Model Geometry

Side View

Front View

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TEST #6: LARGE OVERALL MALE

UMTRI Spreadsheet Calculations*

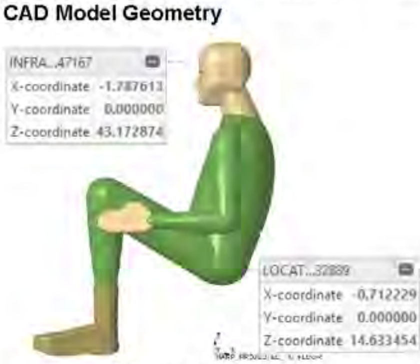
	ACU	PPE	ENC			
Hip re H-point X	-18.1	-47.1	-90.1	→	-0.712	in
Hip re H-point Z	-9.3	-9.3	-9.3	→	14.633	in
Eye re H-point X	-45.4	-97.4	-158.4	→	-1.788	in
Eye re H-point Z	715.6	715.6	715.6	→	43.173	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM7_HIP_X	-0.712	in
POSTURE_DHM7_HIP_Z	14.633	in
POSTURE_DHM7_EYE_X	-1.788	in
POSTURE_DHM7_EYE_Z	43.173	in

GVSC CAD Model Geometry



Side View

Front View

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10.7.7 TEST #7 – VARY TARGET ACCOMMODATION AND ENSEMBLE

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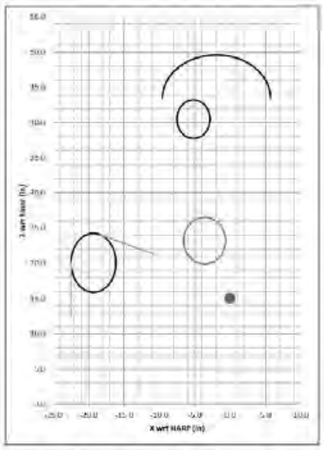
TEST #7: VARY TARGET ACCOMMODATION AND ENSEMBLE

DEVCOM

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
95%	90%	ENC	15.0	10.0	SAE J826	No

Basic Accommodation



UMTRI Spreadsheet

GVSC CAD Model

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TEST #7: TARGET ACCOMMODATION AND ENSEMBLE EFFECTS

DEVCOM

Test #	Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
5	90%	90%	PPE	15.0	10.0	SAE J826	No
7	95%	90%	ENC	15.0	10.0	SAE J826	No

Note: Highlighted values differ from comparison test.

Observations/Notes

- For a given seat, Soldiers wearing ENC sit further forward and rest their elbows further outward from the body than those wearing PPE.
- Increasing Target Accommodation results in larger composite body boundaries.

Side View

— Test #5
Test #7

Front View

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TEST #7: RESULTS, ACCOMMODATION

HARP	UMTRI Value		GVSC Value		Difference	
HARP_X	0.000	in	0.000	in	0.000	in
HARP_Z	15.000	in	15.000	in	0.000	in

Eyellipse	UMTRI Value		GVSC Value		Difference	
EYELLIPSE_CENTROID_X	-5.196	in	-5.196	in	0.000	in
EYELLIPSE_CENTROID_Y (+/-)	1.280	in	1.280	in	0.000	in
EYELLIPSE_CENTROID_Z	40.483	in	40.485	in	0.002	in
EYELLIPSE_X_AXIS_LENGTH	4.656	in	4.656	in	0.001	in
EYELLIPSE_Y_AXIS_LENGTH	2.369	in	2.369	in	0.001	in
EYELLIPSE_Z_AXIS_LENGTH	5.492	in	5.490	in	0.002	in

Helmet Contour	UMTRI Value		GVSC Value		Difference	
HELMET_CONTOUR_CENTROID_X	-1.948	in	-1.948	in	0.000	in
HELMET_CONTOUR_CENTROID_Y (+/-)	2.185	in	2.185	in	0.000	in
HELMET_CONTOUR_CENTROID_Z	43.468	in	43.469	in	0.002	in
HELMET_CONTOUR_X_AXIS_LENGTH	15.258	in	15.259	in	0.001	in
HELMET_CONTOUR_Y_AXIS_LENGTH	10.038	in	10.039	in	0.001	in
HELMET_CONTOUR_Z_AXIS_LENGTH	12.264	in	12.262	in	0.002	in

Knee Contour	UMTRI Value		GVSC Value		Difference	
KNEE_CONTOUR_WEIGHTED_CENT_X	-19.303	in	-19.303	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Y (+/-)	7.594	in	7.594	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Z	20.087	in	20.087	in	0.000	in
KNEE_CONTOUR_X_AXIS_LENGTH	6.348	in	6.348	in	0.001	in
KNEE_CONTOUR_Y_AXIS_LENGTH	9.951	in	9.951	in	0.000	in
KNEE_CONTOUR_Z_AXIS_LENGTH	8.354	in	8.348	in	0.005	in
KNEE_SHIN_ANGLE	0.000	deg	0.000	deg	0.000	deg
KNEE_THIGH_ANGLE	19.778	deg	19.778	deg	0.000	deg

Elbow Contour	UMTRI Value		GVSC Value		Difference	
ELBOW_WEIGHTED_CENT_X	-3.611	in	-3.611	in	0.000	in
ELBOW_WEIGHTED_CENT_Y	14.530	in	14.530	in	0.000	in
ELBOW_WEIGHTED_CENT_Z	23.242	in	23.242	in	0.000	in
ELBOW_X_AXIS_LENGTH	5.953	in	5.955	in	0.002	in
ELBOW_Y_AXIS_LENGTH	4.409	in	4.407	in	0.001	in
ELBOW_Z_AXIS_LENGTH	6.624	in	6.625	in	0.001	in

Boot Contour	UMTRI Value		GVSC Value		Difference	
BOOT_TOE_WEIGHTED_CENT_X	-27.695	in	-27.695	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Y	7.594	in	7.594	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Z	0.000	in	0.000	in	0.000	in
BOOT_TOE_X_AXIS_LENGTH	2.199	in	2.200	in	0.001	in
BOOT_TOE_Y_AXIS_LENGTH	9.620	in	9.620	in	0.000	in
BOOT_TOE_Z_AXIS_LENGTH	4.921	in	4.921	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
0.000 degrees

Values in agreement

TEST #7: SEAT HARP

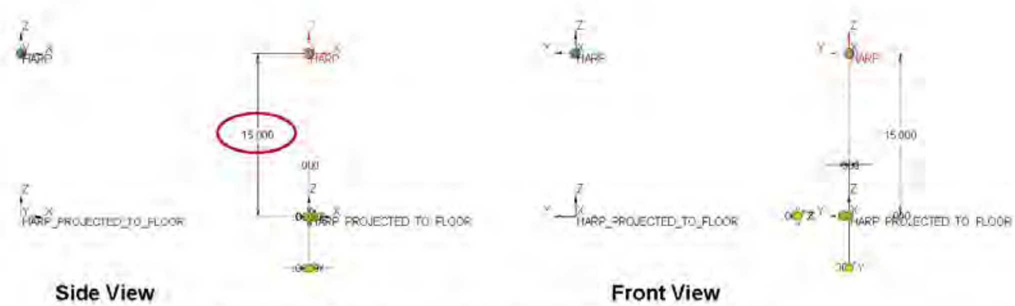
UMTRI Spreadsheet Calculations

	X (in)	Z (in)
HARP	0.000	15.000

GVSC CAD Model Calculations

HARP_X	0.000	in
HARP_Z	15.000	in

GVSC CAD Model Geometry



TEST #7: EYELLIPSE

UMTRI Spreadsheet Calculations

Eyellipse Centroids	X (in)	Y (in)	Z (in)
Right	-5.196	1.280*	40.483
Left	-5.196	-1.280*	40.483

Side View of Eyellipses (X, Z)		
Axis Length (X)	4.656	in
Axis Length (Z)	5.492	in

Rear View of Eyellipses (Y, Z)		
Axis Length (Y)	2.369	in
Axis Length (Z)	5.492	in

GVSC CAD Model Calculations

EYELLIPSE_CENTROID_X	-5.196	in
EYELLIPSE_CENTROID_Y	1.280*	in
EYELLIPSE_CENTROID_Z	40.485	in
EYELLIPSE_X_AXIS_LENGTH	4.656	in
EYELLIPSE_Y_AXIS_LENGTH	2.369	in
EYELLIPSE_Z_AXIS_LENGTH	5.490	in

*Given value, not calculated

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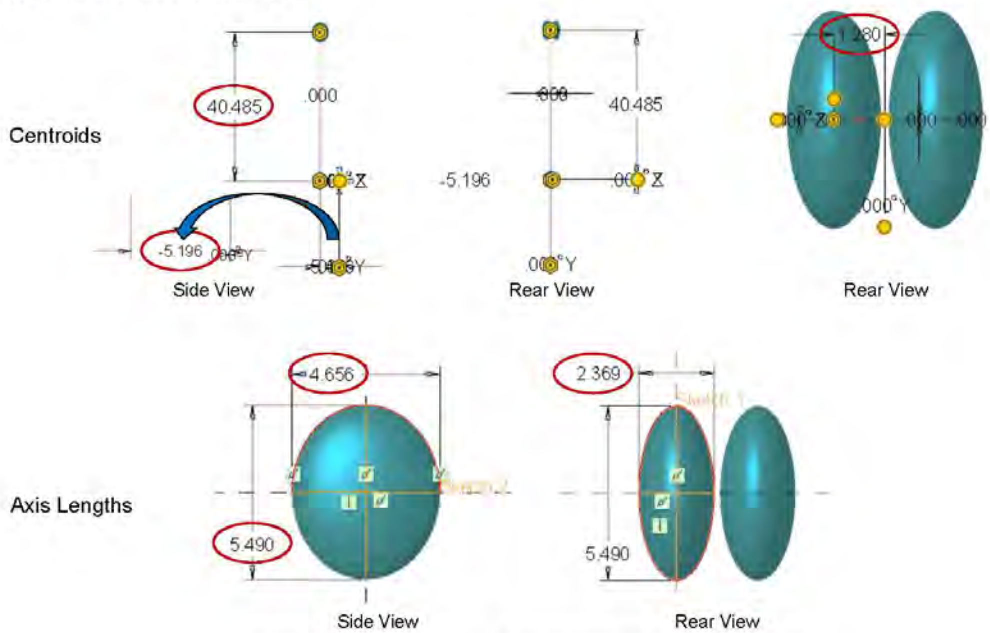
TEST #7: EYELLIPSE (CONT.)

GVSC CAD Model Geometry



TEST #7: HELMET CONTOUR

UMTRI Spreadsheet Calculations

Construction Centroids	X (in)	Y (in)	Z (in)
Right	-1.948	2.185*	43.468
Left	-1.948	-2.185*	43.468

Side View of Helmet Contour (X, Z)

Axis Length (X)	15.258	in
Axis Length (Z)	12.264	in

Rear View of Helmet Contour (Y, Z)

Axis Length (Y)	10.038	in
Axis Length (Z)	12.264	in

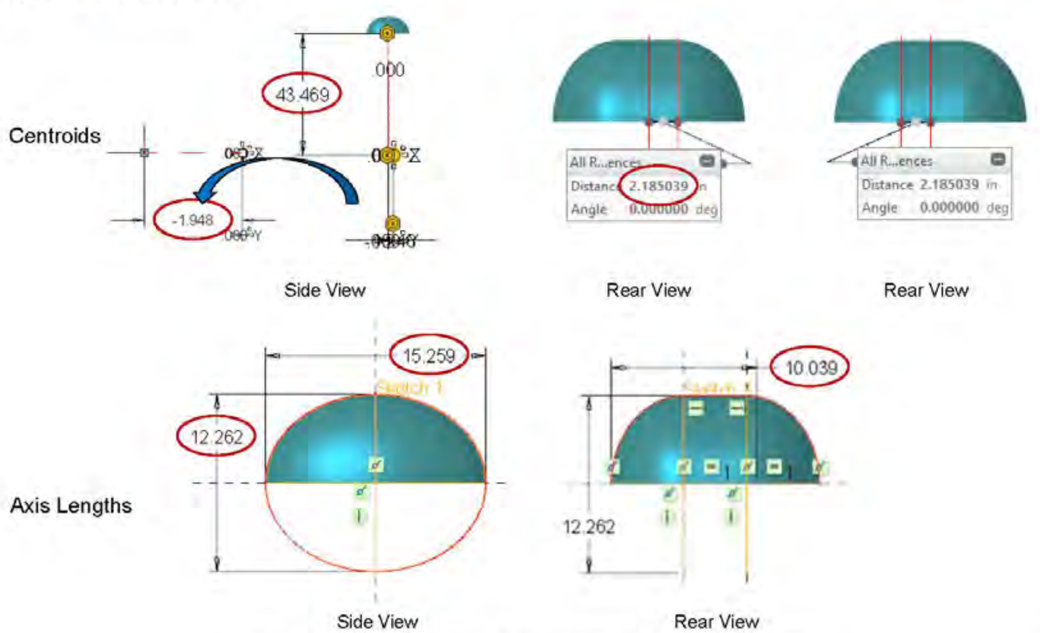
GVSC CAD Model Calculations

HELMET_CONTOUR_CENTROID_X	-1.948	in
HELMET_CONTOUR_CENTROID_Y	2.185*	in
HELMET_CONTOUR_CENTROID_Z	43.469	in
HELMET_CONTOUR_X_AXIS_LENGTH	15.259	in
HELMET_CONTOUR_Y_AXIS_LENGTH	10.039	in
HELMET_CONTOUR_Z_AXIS_LENGTH	12.262	in

*Given value, not calculated

TEST #7: HELMET CONTOUR (CONT.)

GVSC CAD Model Result



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TEST #7: KNEE CONTOUR

UMTRI Spreadsheet Calculations

Knee Centroids	X (in)	Y (in)	Z (in)
Right	-19.303	7.594	20.087
Left	-19.303	-7.594	20.087

Side View of Knee Contours (X, Z)		
Axis Length (X)	6.346	in
Axis Length (Z)	8.354	in

Rear View of Knee Contours (Y, Z)		
Axis Length (Y)	9.951	in
Axis Length (Z)	8.354	in

Leg Segment Angle wrt Vertical	0.000*	deg
Thigh Segment Angle wrt Horizontal	19.778	deg

GVSC CAD Model Calculations

KNEE_CONTOUR_WEIGHTED_CENT_X	-19.303	in
KNEE_CONTOUR_WEIGHTED_CENT_Y	7.594	in
KNEE_CONTOUR_WEIGHTED_CENT_Z	20.087	in
KNEE_CONTOUR_X_AXIS_LENGTH	6.348	in
KNEE_CONTOUR_Y_AXIS_LENGTH	9.951	in
KNEE_CONTOUR_Z_AXIS_LENGTH	8.348	in
KNEE_SHIN_ANGLE	0.000*	deg
KNEE_THIGH_ANGLE	19.778	deg

*Given value, not calculated

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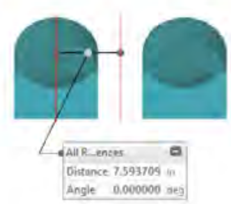
TEST #7: KNEE CONTOUR (CONT.)

GVSC CAD Model Result

Centroids

Side View

Rear View

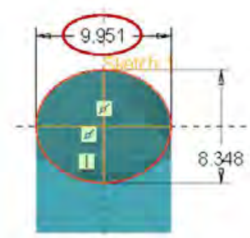


Rear View

Axis Lengths
Shin/Thigh Angles

Side View

Side View



Rear View

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 252

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TEST #7: ELBOW CONTOUR

UMTRI Spreadsheet Calculations

Elbow Centroids	X (in)	Y (in)	Z (in)
Right	-3.611	14.530	23.242
Left	-3.611	-14.530	23.242

Side View of Elbow Contours (X, Z)		
Axis Length (X)	5.953	in
Axis Length (Z)	6.624	in

Rear View of Elbow Contours (Y, Z)		
Axis Length (Y)	4.409	in
Axis Length (Z)	6.624	in

GVSC CAD Model Calculations

ELBOW_WEIGHTED_CENT_X	-3.611	in
ELBOW_WEIGHTED_CENT_Y	14.530	in
ELBOW_WEIGHTED_CENT_Z	23.242	in
ELBOW_X_AXIS_LENGTH	5.955	in
ELBOW_Y_AXIS_LENGTH	4.407	in
ELBOW_Z_AXIS_LENGTH	6.625	in

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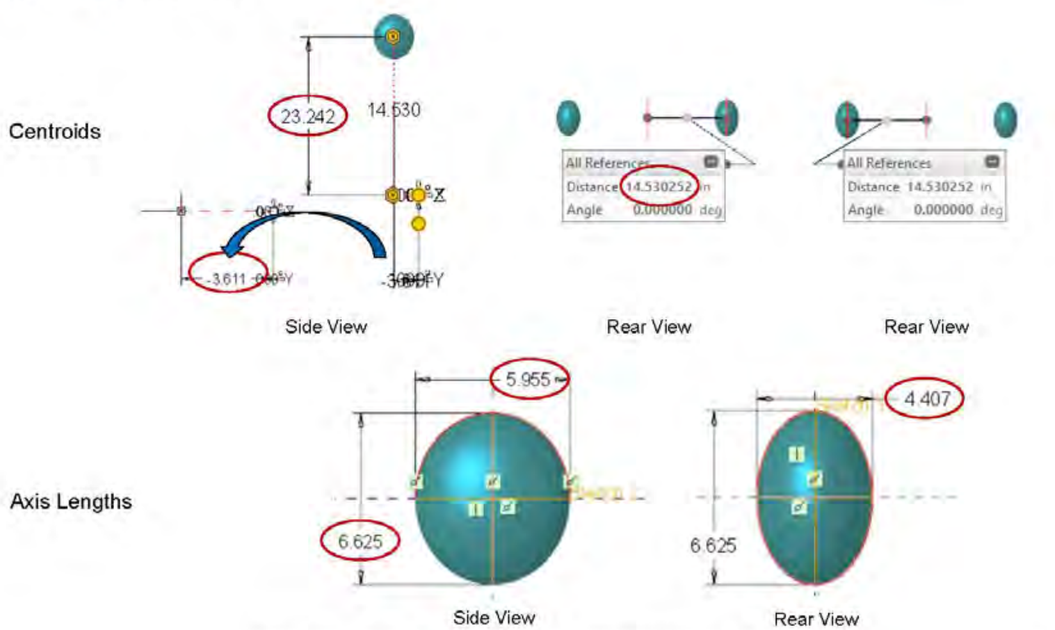
TEST #7: ELBOW CONTOUR (CONT.)

GVSC CAD Model Result



DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 254

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TEST #7: BOOT CONTOUR

UMTRI Spreadsheet Calculations

Boot Centroids	X (in)	Y (in)	Z (in)
Right	-27.695	7.594	0.000
Left	-27.695	-7.594	0.000

Side View of Boot Contours (X, Z)

Axis Length (X)	2.199	in
Axis Length (Z)	4.921	in

Rear View of Boot Contours (Y, Z)

Axis Length (Y)	9.620	in
Axis Length (Z)	4.921	in

GVSC CAD Model Calculations

BOOT_TOE_WEIGHTED_CENT_X	-27.695	in
BOOT_TOE_WEIGHTED_CENT_Y	7.594	in
BOOT_TOE_WEIGHTED_CENT_Z	0.000	in
BOOT_TOE_X_AXIS_LENGTH	2.200	in
BOOT_TOE_Y_AXIS_LENGTH	9.620	in
BOOT_TOE_Z_AXIS_LENGTH	4.921	in

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 255

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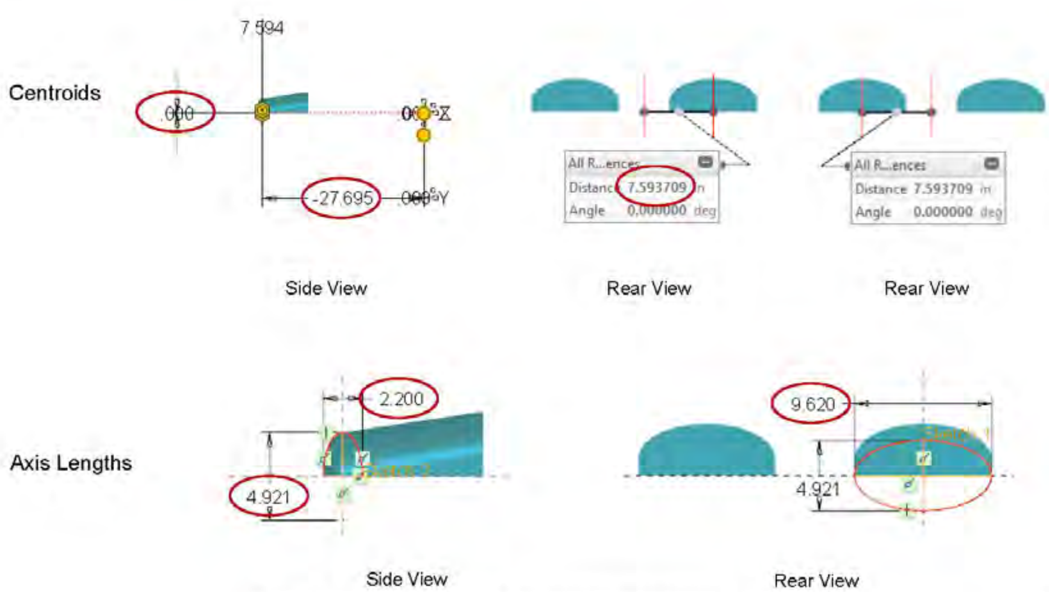
TEST #7: BOOT CONTOUR (CONT.)

GVSC CAD Model Result



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TEST #7: VARY TARGET ACCOMMODATION AND ENSEMBLE

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
95%	90%	ENC	15.0	10.0	SAE J826	No

Clearance (2.0 inches), Shown in Yellow

GVSC CAD Model

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 257

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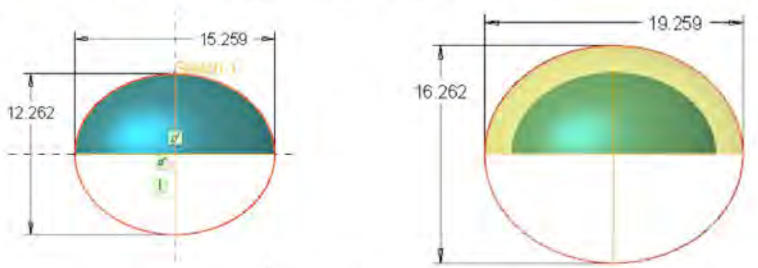
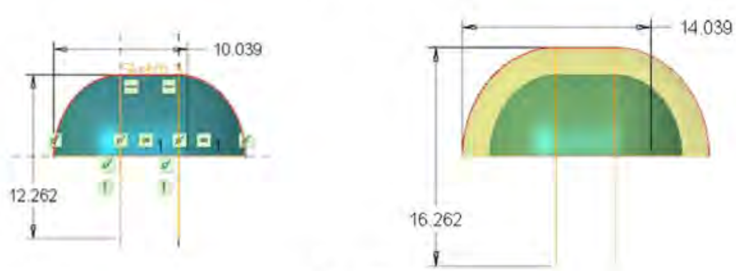
TEST #7: CLEARANCE, HELMET CONTOUR



Sample Calculation: $\frac{1}{2}(19.259\ in. - 15.259\ in.) = 2.000\ in.\ clearance$

Side View



Rear View

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 258

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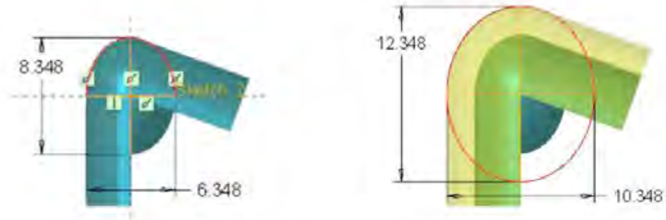
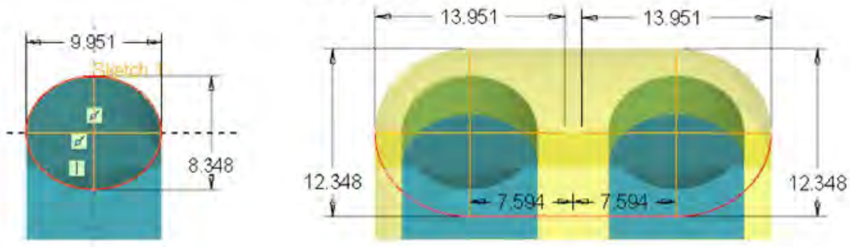
TEST #7: CLEARANCE, KNEE CONTOUR



$$Sample\ Calculation: \frac{1}{2}(12.348\ in. - 8.348\ in.) = 2.000\ in.\ clearance$$

Side View



Rear View

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY

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TEST #7: CLEARANCE, ELBOW CONTOUR

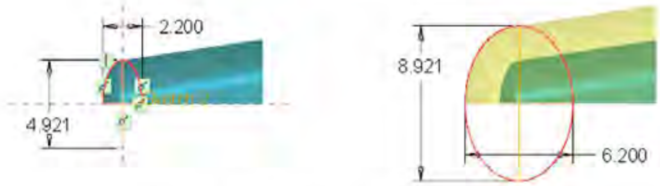
$$Sample\ Calculation: 16.530\ in. - 14.530\ in. = 2.000\ in.\ clearance$$

Rear View

Side View **Rear View**

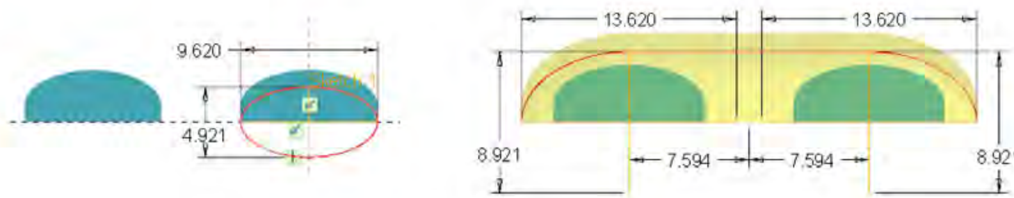
DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY

TEST #7: CLEARANCE, BOOT CONTOUR



$$\text{Sample Calculation: } \frac{1}{2}\,(8.921\ in. - 4.921\ in.) = 2.000\ in.\,clearance$$

Side View



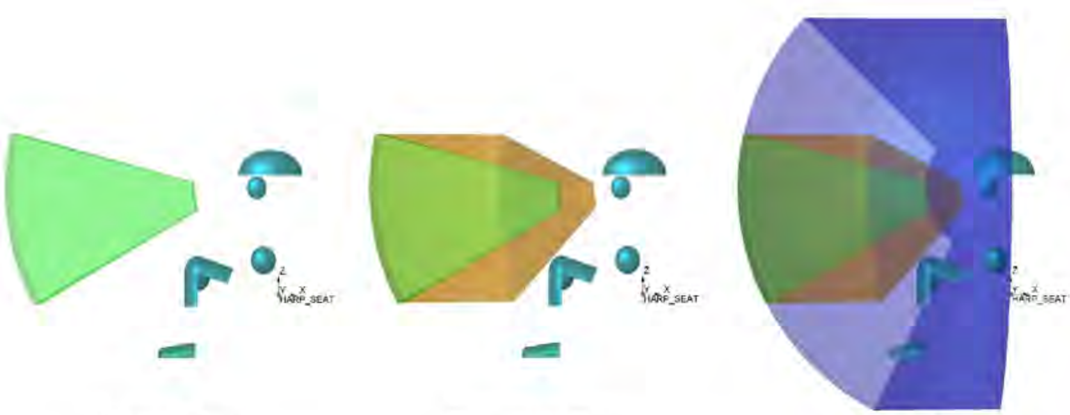
Rear View

TEST #7: VARY TARGET ACCOMMODATION AND ENSEMBLE

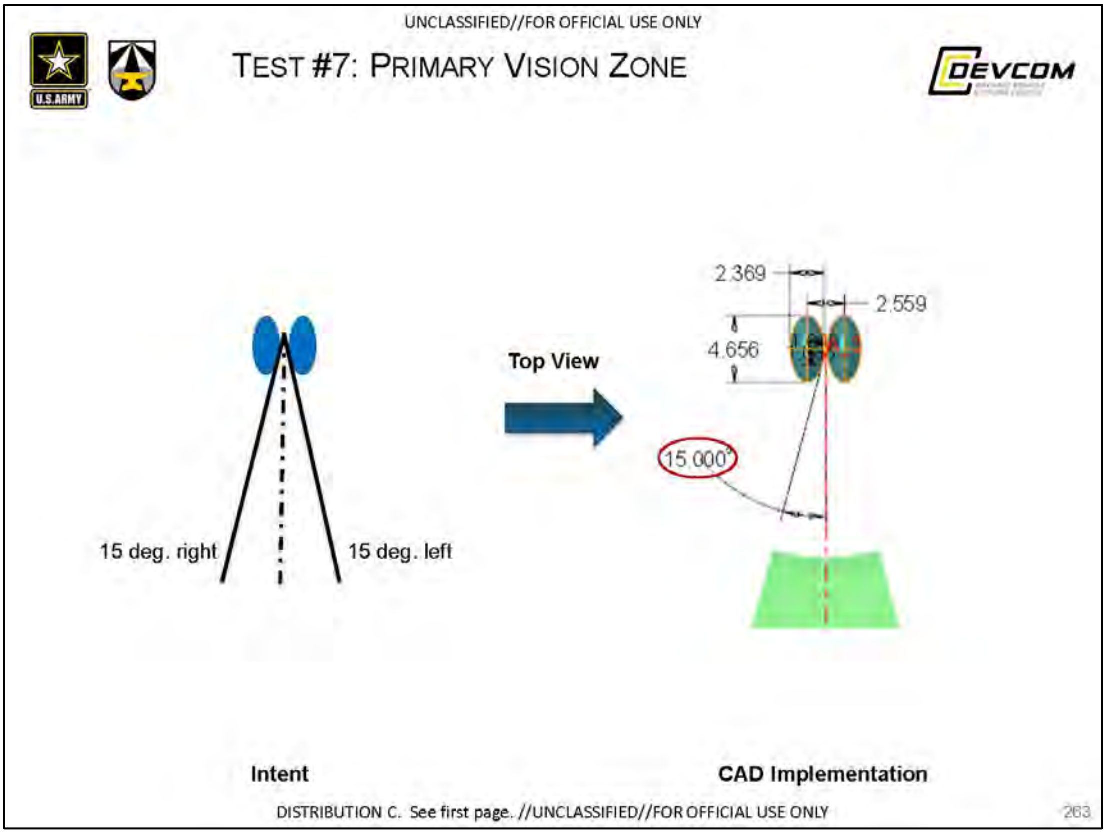
Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
95%	90%	ENC	15.0	10.0	SAE J826	No

Vision Zones

Vison zones are constructed geometrically; no calculations are involved.



Primary Zone Secondary Zone Tertiary Zone


UNCLASSIFIED//FOR OFFICIAL USE ONLY
TEST #7: PRIMARY VISION ZONE
DEVCOM
2.369
2.559
4.656
Top View
15.000°
15 deg. right
15 deg. left
Intent
CAD Implementation
DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY
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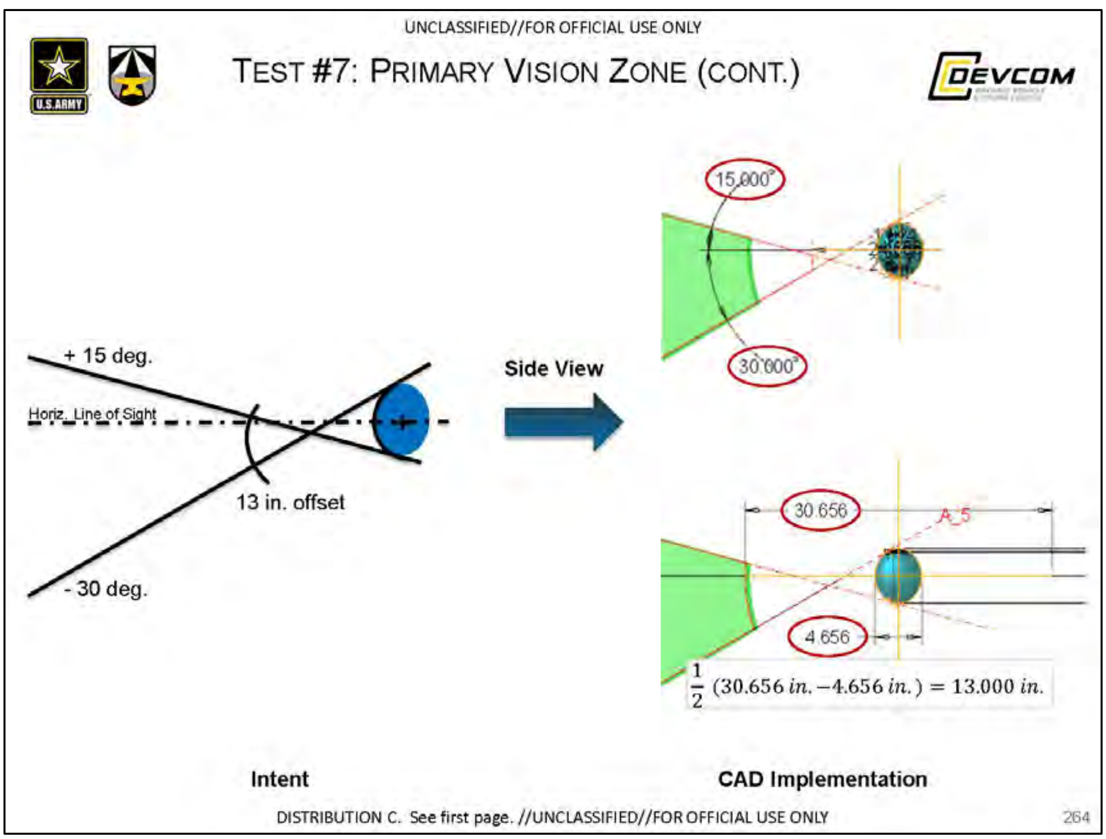
UNCLASSIFIED//FOR OFFICIAL USE ONLY
TEST #7: PRIMARY VISION ZONE (CONT.)
DEVCOM
15.000°
30.000°
+ 15 deg.
Horiz. Line of Sight
Side View
13 in. offset
- 30 deg.
30.656
A_5
4.656
$\frac{1}{2}(30.656\,in. - 4.656\,in.) = 13.000\,in.$
Intent
CAD Implementation
DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY
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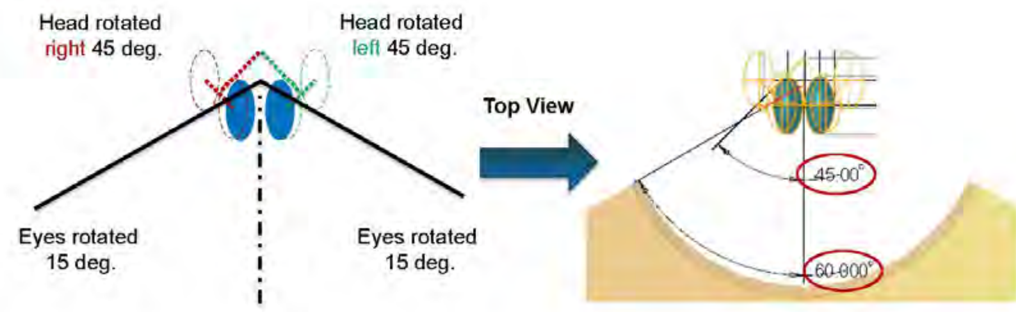
TEST #7: SECONDARY VISION ZONE



Intent **CAD Implementation**

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 265

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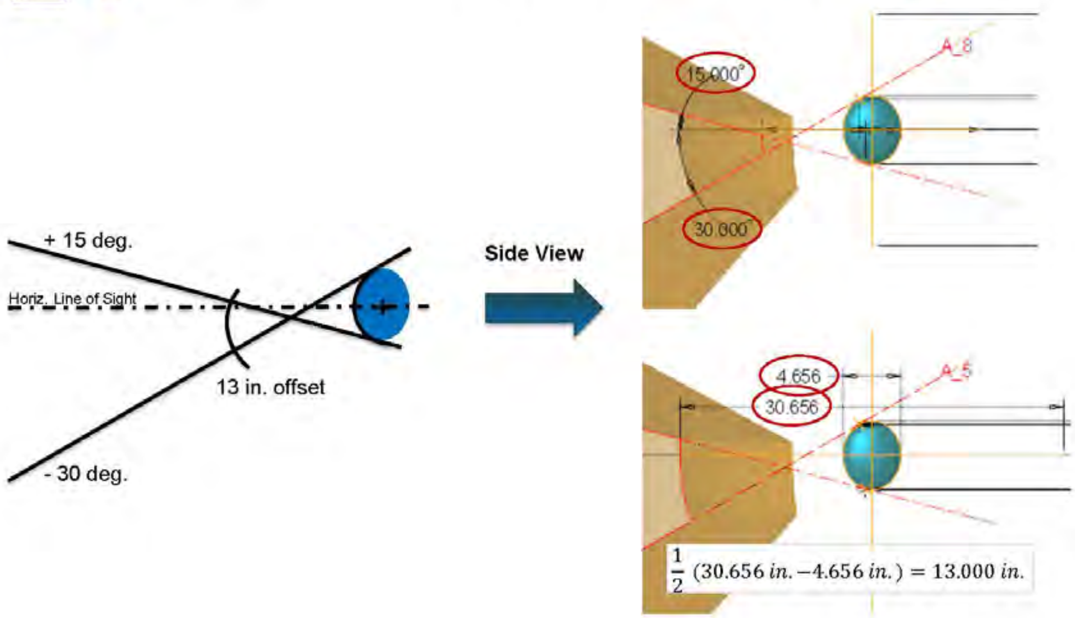
TEST #7: SECONDARY VISION ZONE (CONT.)



Intent **CAD Implementation**

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 266

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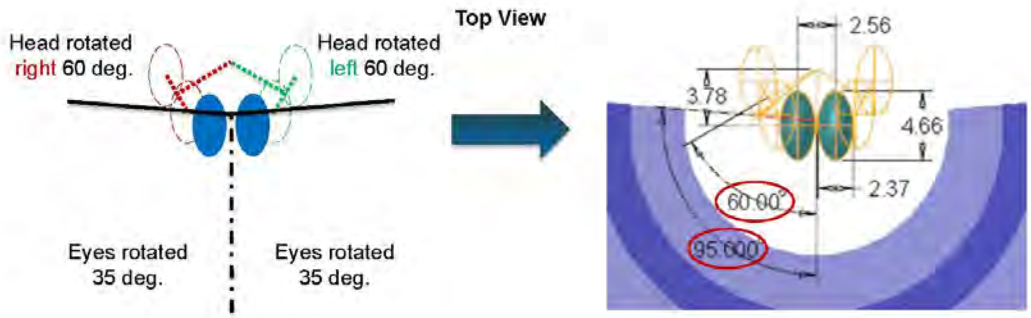
TEST #7: TERTIARY VISION ZONE



Intent **CAD Implementation**

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 267

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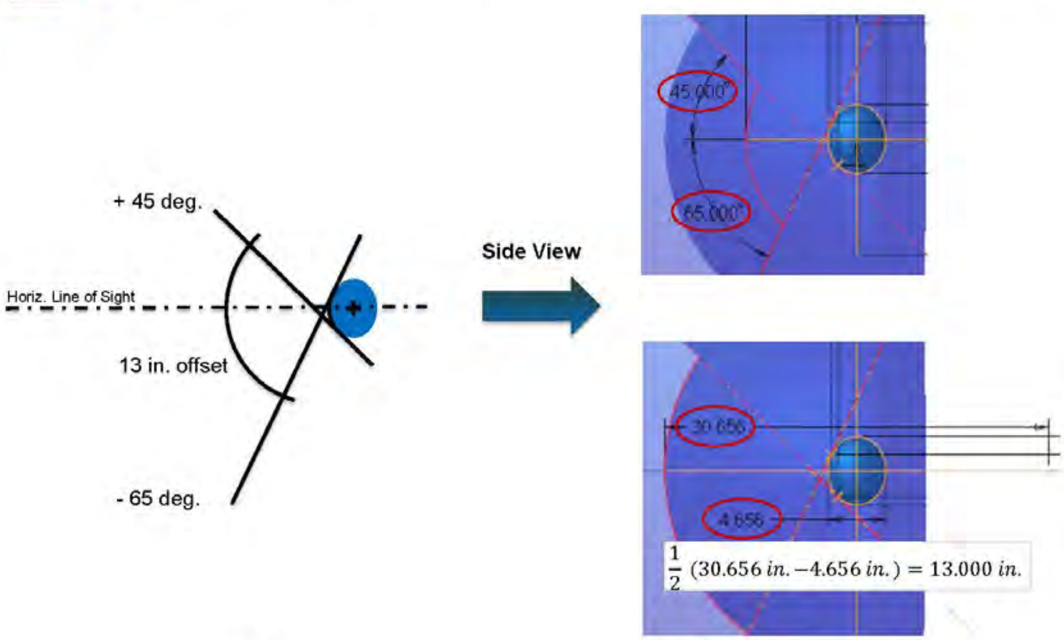
TEST #7: TERTIARY VISION ZONE (CONT.)



Intent **CAD Implementation**

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 268

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TEST #7: VARY TARGET ACCOMMODATION AND ENSEMBLE

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
95%	90%	ENC	15.0	10.0	SAE J826	No

Boundary Manikin Posture and Position

GVSC CAD Model

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 269

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TEST #7: RESULTS, MANIKIN POSITIONING

Small Overall Female

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM1_HIP_X	-2.926	in	-2.926	in	0.000	in
POSTURE_DHM1_HIP_Z	14.384	in	14.384	in	0.000	in
POSTURE_DHM1_EYE_X	-3.945	in	-3.945	in	0.000	in
POSTURE_DHM1_EYE_Z	36.577	in	36.577	in	0.000	in

Small Overall Male

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM2_HIP_X	-3.189	in	-3.189	in	0.000	in
POSTURE_DHM2_HIP_Z	14.489	in	14.489	in	0.000	in
POSTURE_DHM2_EYE_X	-4.654	in	-4.654	in	0.000	in
POSTURE_DHM2_EYE_Z	38.474	in	38.474	in	0.000	in

Average Size Male

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM3_HIP_X	-3.187	in	-3.187	in	0.000	in
POSTURE_DHM3_HIP_Z	14.488	in	14.488	in	0.000	in
POSTURE_DHM3_EYE_X	-5.395	in	-5.395	in	0.000	in
POSTURE_DHM3_EYE_Z	40.824	in	40.824	in	0.000	in

Widest Shoulders Male

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM4_HIP_X	-3.160	in	-3.160	in	0.000	in
POSTURE_DHM4_HIP_Z	14.478	in	14.478	in	0.000	in
POSTURE_DHM4_EYE_X	-5.769	in	-5.769	in	0.000	in
POSTURE_DHM4_EYE_Z	42.179	in	42.179	in	0.000	in

Longest Torso Male

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM5_HIP_X	-3.146	in	-3.146	in	0.000	in
POSTURE_DHM5_HIP_Z	14.472	in	14.472	in	0.000	in
POSTURE_DHM5_EYE_X	-5.779	in	-5.779	in	0.000	in
POSTURE_DHM5_EYE_Z	43.354	in	43.354	in	0.000	in

Longest Legs Male

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM6_HIP_X	-3.315	in	-3.315	in	0.000	in
POSTURE_DHM6_HIP_Z	14.540	in	14.540	in	0.000	in
POSTURE_DHM6_EYE_X	-5.961	in	-5.961	in	0.000	in
POSTURE_DHM6_EYE_Z	41.185	in	41.185	in	0.000	in

Large Overall Male

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM7_HIP_X	-3.547	in	-3.547	in	0.000	in
POSTURE_DHM7_HIP_Z	14.633	in	14.633	in	0.000	in
POSTURE_DHM7_EYE_X	-6.236	in	-6.236	in	0.000	in
POSTURE_DHM7_EYE_Z	43.173	in	43.173	in	0.000	in

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

Largest Observed Differences:
0.000 inches

Values in agreement

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 270

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TEST #7: SMALL OVERALL FEMALE

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-2.3	-31.3	-74.3	→	-2.926	in
Hip re H-point Z	-15.7	-15.7	-15.7	→	14.384	in
Eye re H-point X	12.8	-39.2	-100.2	→	-3.945	in
Eye re H-point Z	548.1	548.1	548.1	→	36.577	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM1_HIP_X	-2.926	in
POSTURE_DHM1_HIP_Z	14.384	in
POSTURE_DHM1_EYE_X	-3.945	in
POSTURE_DHM1_EYE_Z	36.577	in

GVSC CAD Model Geometry

Side View

Front View

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TEST #7: SMALL OVERALL MALE

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-9.0	-38.0	-81.0	→	-3.189	in
Hip re H-point Z	-13.0	-13.0	-13.0	→	14.489	in
Eye re H-point X	-5.2	-57.2	-118.2	→	-4.654	in
Eye re H-point Z	596.3	596.3	596.3	→	38.474	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM2_HIP_X	-3.189	in
POSTURE_DHM2_HIP_Z	14.489	in
POSTURE_DHM2_EYE_X	-4.654	in
POSTURE_DHM2_EYE_Z	38.474	in

GVSC CAD Model Geometry

Side View

Front View

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TEST #7: AVERAGE SIZE MALE

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-8.9	-37.9	-80.9	→	-3.187	in
Hip re H-point Z	-13.0	-13.0	-13.0	→	14.488	in
Eye re H-point X	-24.0	-76.0	-137.0	→	-5.395	in
Eye re H-point Z	655.9	655.9	655.9	→	40.824	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM3_HIP_X	-3.187	in
POSTURE_DHM3_HIP_Z	14.488	in
POSTURE_DHM3_EYE_X	-5.395	in
POSTURE_DHM3_EYE_Z	40.824	in

GVSC CAD Model Geometry

Side View

Front View

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TEST #7: WIDEST SHOULDERS MALE

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-8.3	-37.3	-80.3	→	-3.160	in
Hip re H-point Z	-13.3	-13.3	-13.3	→	14.478	in
Eye re H-point X	-33.5	-85.5	-146.5	→	-5.769	in
Eye re H-point Z	690.3	690.3	690.3	→	42.179	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM4_HIP_X	-3.160	in
POSTURE_DHM4_HIP_Z	14.478	in
POSTURE_DHM4_EYE_X	-5.769	in
POSTURE_DHM4_EYE_Z	42.179	in

GVSC CAD Model Geometry

Side View

Front View

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Test #7: Longest Torso Male

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-7.9	-36.9	-79.9	→	-3.146	in
Hip re H-point Z	-13.4	-13.4	-13.4	→	14.472	in
Eye re H-point X	-33.8	-85.8	-146.8	→	-5.779	in
Eye re H-point Z	720.2	720.2	720.2	→	43.354	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM5_HIP_X	-3.146	in
POSTURE_DHM5_HIP_Z	14.472	in
POSTURE_DHM5_EYE_X	-5.779	in
POSTURE_DHM5_EYE_Z	43.354	in

GVSC CAD Model Geometry

Side View


Front View

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Test #7: Longest Legs Male

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-12.2	-41.2	-84.2	→	-3.315	in
Hip re H-point Z	-11.7	-11.7	-11.7	→	14.540	in
Eye re H-point X	-38.4	-90.4	-151.4	→	-5.961	in
Eye re H-point Z	665.1	665.1	665.1	→	41.185	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM6_HIP_X	-3.315	in
POSTURE_DHM6_HIP_Z	14.540	in
POSTURE_DHM6_EYE_X	-5.961	in
POSTURE_DHM6_EYE_Z	41.185	in

GVSC CAD Model Geometry

Side View


Front View

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 276

TEST #7: LARGE OVERALL MALE

DEVCOM

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-18.1	-47.1	-90.1	→	-3.547	in
Hip re H-point Z	-9.3	-9.3	-9.3	→	14.633	in
Eye re H-point X	-45.4	-97.4	-158.4	→	-6.236	in
Eye re H-point Z	715.6	715.6	715.6	→	43.173	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM7_HIP_X	-3.547	in
POSTURE_DHM7_HIP_Z	14.633	in
POSTURE_DHM7_EYE_X	-6.236	in
POSTURE_DHM7_EYE_Z	43.173	in

GVSC CAD Model Geometry

Side View Front View

10.7.8 TEST #8 – VARY GENDER MIX

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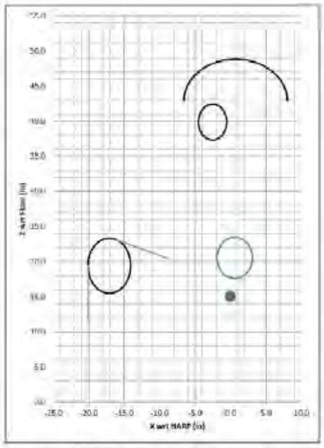
TEST #8: VARY GENDER MIX

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	50%	PPE	15.0	10.0	SAE J826	No

Basic Accommodation



UMTRI Spreadsheet

GVSC CAD Model

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TEST #8: GENDER MIX EFFECTS

Test #	Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
5	90%	90%	PPE	15.0	10.0	SAE J826	No
8	90%	50%	PPE	15.0	10.0	SAE J826	No

Note: Highlighted values differ from comparison test.

Observations/Notes

- Because females are physically smaller than males, decreasing the percentage of males decreases the overall resultant occupant space.

Side View

— Test #5
Test #8

Front View

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TEST #8: RESULTS, ACCOMMODATION

DEVCOM

HARP	UMTRI Value		GVSC Value		Difference	
HARP_X	0.000	in	0.000	in	0.000	in
HARP_Z	15.000	in	15.000	in	0.000	in

Eyellipse	UMTRI Value		GVSC Value		Difference	
EYELLIPSE_CENTROID_X	-2.540	in	-2.540	in	0.000	in
EYELLIPSE_CENTROID_Y (+/-)	1.280	in	1.280	in	0.000	in
EYELLIPSE_CENTROID_Z	39.880	in	39.980	in	0.000	in
EYELLIPSE_X_AXIS_LENGTH	3.993	in	3.995	in	0.002	in
EYELLIPSE_Y_AXIS_LENGTH	1.988	in	1.990	in	0.001	in
EYELLIPSE_Z_AXIS_LENGTH	5.098	in	5.097	in	0.000	in

Helmet Contour	UMTRI Value		GVSC Value		Difference	
HELMET_CONTOUR_CENTROID_X	0.708	in	0.708	in	0.000	in
HELMET_CONTOUR_CENTROID_Y (+/-)	2.185	in	2.185	in	0.000	in
HELMET_CONTOUR_CENTROID_Z	42.865	in	42.865	in	0.000	in
HELMET_CONTOUR_X_AXIS_LENGTH	14.596	in	14.597	in	0.002	in
HELMET_CONTOUR_Y_AXIS_LENGTH	9.657	in	9.659	in	0.001	in
HELMET_CONTOUR_Z_AXIS_LENGTH	11.869	in	11.869	in	0.000	in

Knee Contour	UMTRI Value		GVSC Value		Difference	
KNEE_CONTOUR_WEIGHTED_CENT_X	-17.097	in	-17.097	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Y (+/-)	7.135	in	7.135	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Z	19.425	in	19.425	in	0.000	in
KNEE_CONTOUR_X_AXIS_LENGTH	6.029	in	6.029	in	0.000	in
KNEE_CONTOUR_Y_AXIS_LENGTH	9.212	in	9.214	in	0.001	in
KNEE_CONTOUR_Z_AXIS_LENGTH	7.843	in	7.843	in	0.000	in
KNEE_SHIN_ANGLE	0.000	deg	0.000	deg	0.000	deg
KNEE_THIGH_ANGLE	20.167	deg	20.167	deg	0.000	deg

Elbow Contour	UMTRI Value		GVSC Value		Difference	
ELBOW_WEIGHTED_CENT_X	0.582	in	0.582	in	0.000	in
ELBOW_WEIGHTED_CENT_Y	11.852	in	11.852	in	0.000	in
ELBOW_WEIGHTED_CENT_Z	20.539	in	20.539	in	0.000	in
ELBOW_X_AXIS_LENGTH	5.006	in	5.009	in	0.003	in
ELBOW_Y_AXIS_LENGTH	3.857	in	3.857	in	0.000	in
ELBOW_Z_AXIS_LENGTH	5.843	in	5.845	in	0.002	in

Boot Contour	UMTRI Value		GVSC Value		Difference	
BOOT_TOE_WEIGHTED_CENT_X	-25.302	in	-25.302	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Y	7.135	in	7.135	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Z	0.000	in	0.000	in	0.000	in
BOOT_TOE_X_AXIS_LENGTH	2.989	in	2.989	in	0.001	in
BOOT_TOE_Y_AXIS_LENGTH	8.882	in	8.883	in	0.001	in
BOOT_TOE_Z_AXIS_LENGTH	4.921	in	4.921	in	0.000	in

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

Largest Observed Differences:
0.003 inches
0.000 degrees

Values in agreement

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TEST #8: SEAT HARP

DEVCOM

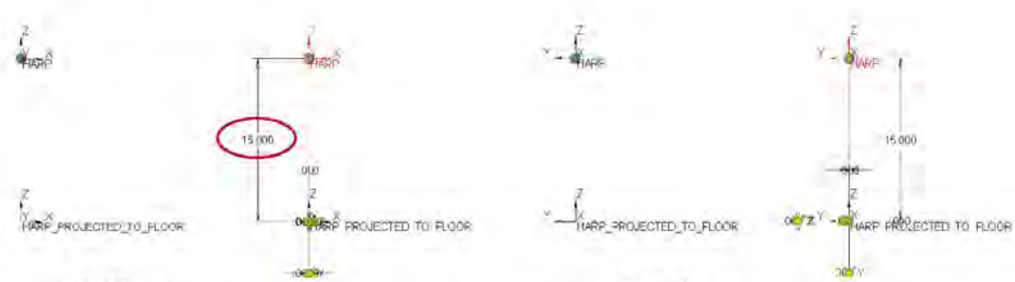
UMTRI Spreadsheet Calculations

	X (in)	Z (in)
HARP	0.000	15.000

GVSC CAD Model Calculations

HARP_X	0.000	in
HARP_Z	15.000	in

GVSC CAD Model Geometry



Side View **Front View**

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TEST #8: EYELLIPSE

DEVCOM

UMTRI Spreadsheet Calculations

Eyellipse Centroids	X (in)	Y (in)	Z (in)
Right	-2.540	1.280*	39.880
Left	-2.540	-1.280*	39.880

Side View of Eyellipses (X, Z)		
Axis Length (X)	3.993	in
Axis Length (Z)	5.098	in

Rear View of Eyellipses (Y, Z)		
Axis Length (Y)	1.988	in
Axis Length (Z)	5.098	in

GVSC CAD Model Calculations

EYELLIPSE_CENTROID_X	-2.540	in
EYELLIPSE_CENTROID_Y	1.280*	in
EYELLIPSE_CENTROID_Z	39.880	in
EYELLIPSE_X_AXIS_LENGTH	3.995	in
EYELLIPSE_Y_AXIS_LENGTH	1.990	in
EYELLIPSE_Z_AXIS_LENGTH	5.097	in

*Given value, not calculated

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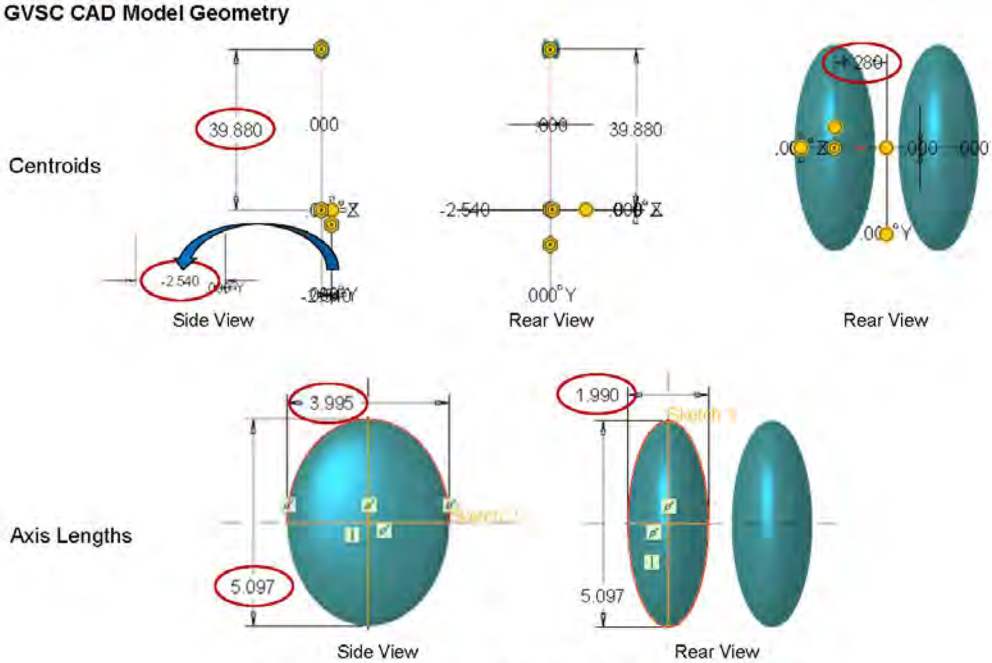
TEST #8: EYELLIPSE (CONT.)

DEVCOM

GVSC CAD Model Geometry



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TEST #8: HELMET CONTOUR

UMTRI Spreadsheet Calculations

Construction Centroids	X (in)	Y (in)	Z (in)
Right	0.708	2.185*	42.865
Left	0.708	-2.185*	42.865

Side View of Helmet Contour (X, Z)		
Axis Length (X)	14.596	in
Axis Length (Z)	11.869	in

Rear View of Helmet Contour (Y, Z)		
Axis Length (Y)	9.657	in
Axis Length (Z)	11.869	in

GVSC CAD Model Calculations

HELMET_CONTOUR_CENTROID_X	0.708	in
HELMET_CONTOUR_CENTROID_Y	2.185*	in
HELMET_CONTOUR_CENTROID_Z	42.865	in
HELMET_CONTOUR_X_AXIS_LENGTH	14.597	in
HELMET_CONTOUR_Y_AXIS_LENGTH	9.659	in
HELMET_CONTOUR_Z_AXIS_LENGTH	11.869	in

*Given value, not calculated

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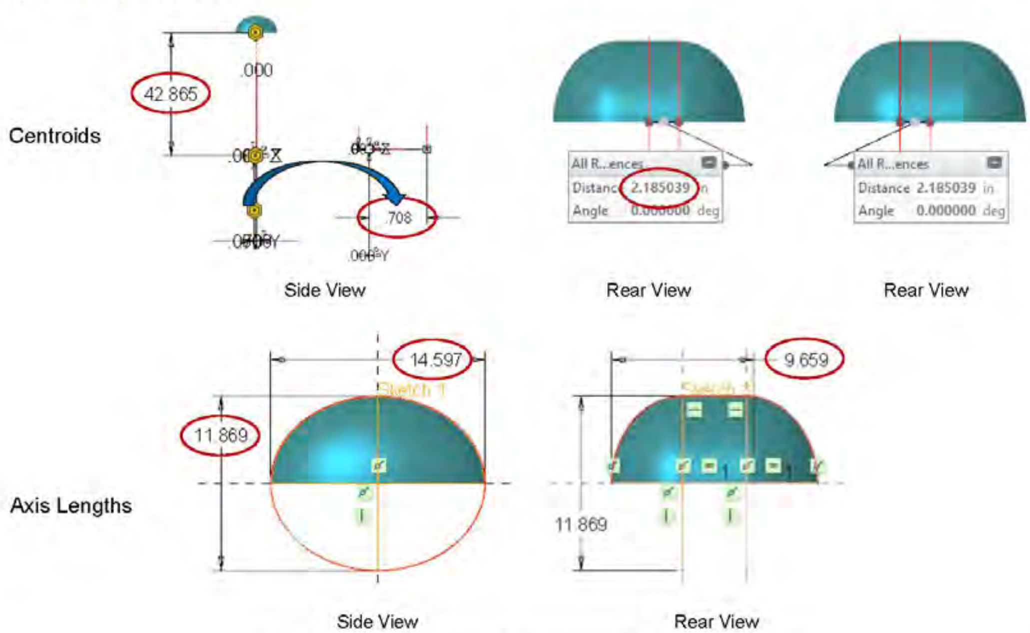
TEST #8: HELMET CONTOUR (CONT.)

GVSC CAD Model Result



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TEST #8: KNEE CONTOUR

UMTRI Spreadsheet Calculations

Knee Centroids	X (in)	Y (in)	Z (in)
Right	-17.097	7.135	19.425
Left	-17.097	-7.135	19.425

Side View of Knee Contours (X, Z)		
Axis Length (X)	6.029	in
Axis Length (Z)	7.843	in
Rear View of Knee Contours (Y, Z)		
Axis Length (Y)	9.212	in
Axis Length (Z)	7.843	in
Leg Segment Angle wrt Vertical	0.000*	deg
Thigh Segment Angle wrt Horizontal	20.167	deg

GVSC CAD Model Calculations

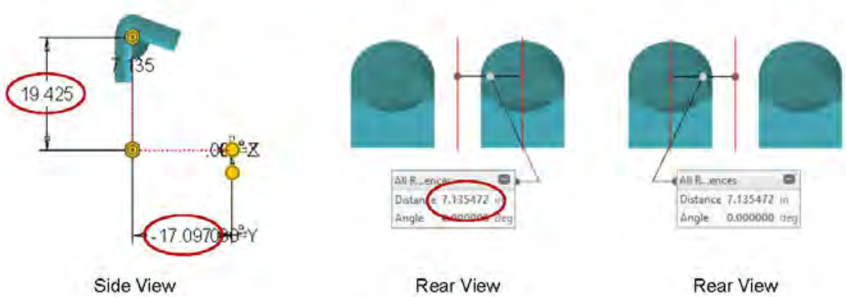
KNEE_CONTOUR_WEIGHTED_CENT_X	-17.097	in
KNEE_CONTOUR_WEIGHTED_CENT_Y	7.135	in
KNEE_CONTOUR_WEIGHTED_CENT_Z	19.425	in
KNEE_CONTOUR_X_AXIS_LENGTH	6.029	in
KNEE_CONTOUR_Y_AXIS_LENGTH	9.214	in
KNEE_CONTOUR_Z_AXIS_LENGTH	7.843	in
KNEE_SHIN_ANGLE	0.000*	deg
KNEE_THIGH_ANGLE	20.167	deg

*Given value, not calculated

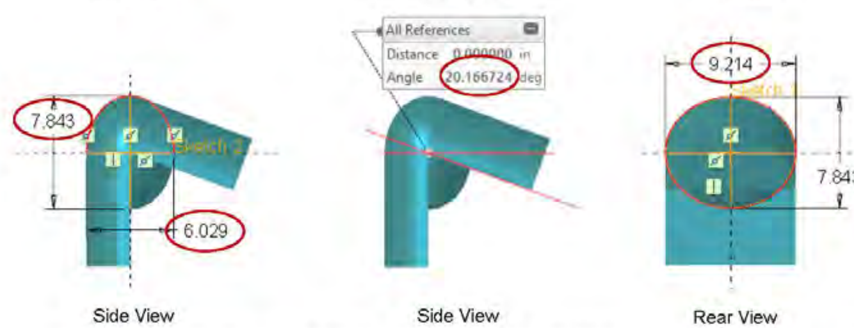
TEST #8: KNEE CONTOUR (CONT.)

GVSC CAD Model Result

Centroids



Axis Lengths
Shin/Thigh Angles



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TEST #8: ELBOW CONTOUR

UMTRI Spreadsheet Calculations

Elbow Centroids	X (in)	Y (in)	Z (in)
Right	0.582	11.852	20.539
Left	0.582	-11.852	20.539

Side View of Elbow Contours (X, Z)		
Axis Length (X)	5.006	in
Axis Length (Z)	5.843	in

Rear View of Elbow Contours (Y, Z)		
Axis Length (Y)	3.857	in
Axis Length (Z)	5.843	in

GVSC CAD Model Calculations

ELBOW_WEIGHTED_CENT_X	0.582	in
ELBOW_WEIGHTED_CENT_Y	11.852	in
ELBOW_WEIGHTED_CENT_Z	20.539	in
ELBOW_X_AXIS_LENGTH	5.009	in
ELBOW_Y_AXIS_LENGTH	3.857	in
ELBOW_Z_AXIS_LENGTH	5.845	in

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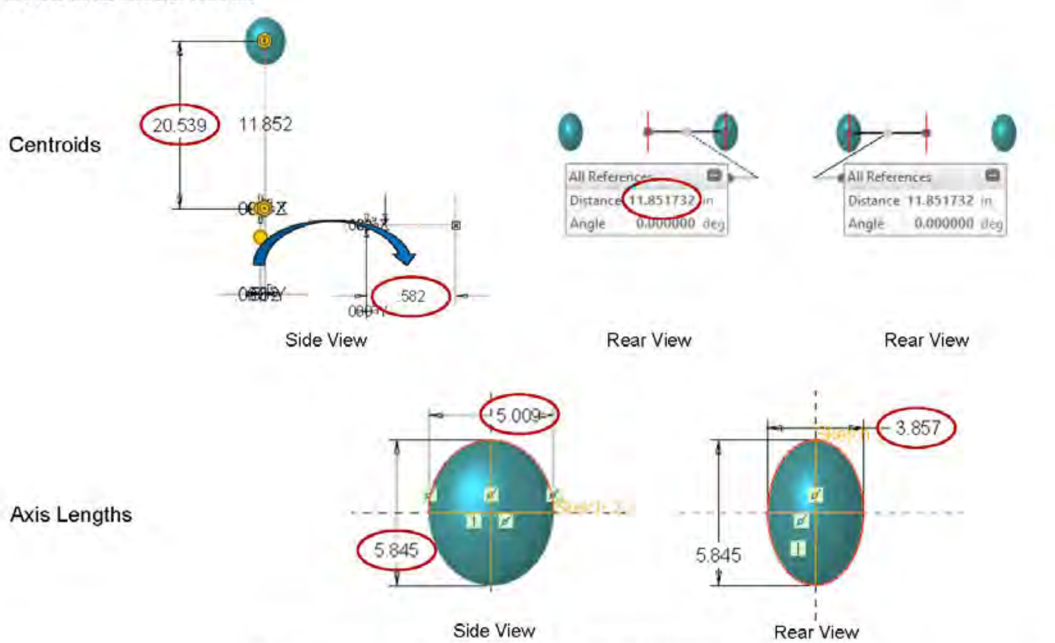
TEST #8: ELBOW CONTOUR (CONT.)

GVSC CAD Model Result



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TEST #8: BOOT CONTOUR

UMTRI Spreadsheet Calculations

Boot Centroids	X (in)	Y (in)	Z (in)
Right	-25.302	7.135	0.000
Left	-25.302	-7.135	0.000

Side View of Boot Contours (X, Z)		
Axis Length (X)	2.988	in
Axis Length (Z)	4.921	in

Rear View of Boot Contours (Y, Z)		
Axis Length (Y)	8.882	in
Axis Length (Z)	4.921	in

GVSC CAD Model Calculations

BOOT_TOE_WEIGHTED_CENT_X	-25.302	in
BOOT_TOE_WEIGHTED_CENT_Y	7.135	in
BOOT_TOE_WEIGHTED_CENT_Z	0.000	in
BOOT_TOE_X_AXIS_LENGTH	2.989	in
BOOT_TOE_Y_AXIS_LENGTH	8.883	in
BOOT_TOE_Z_AXIS_LENGTH	4.921	in

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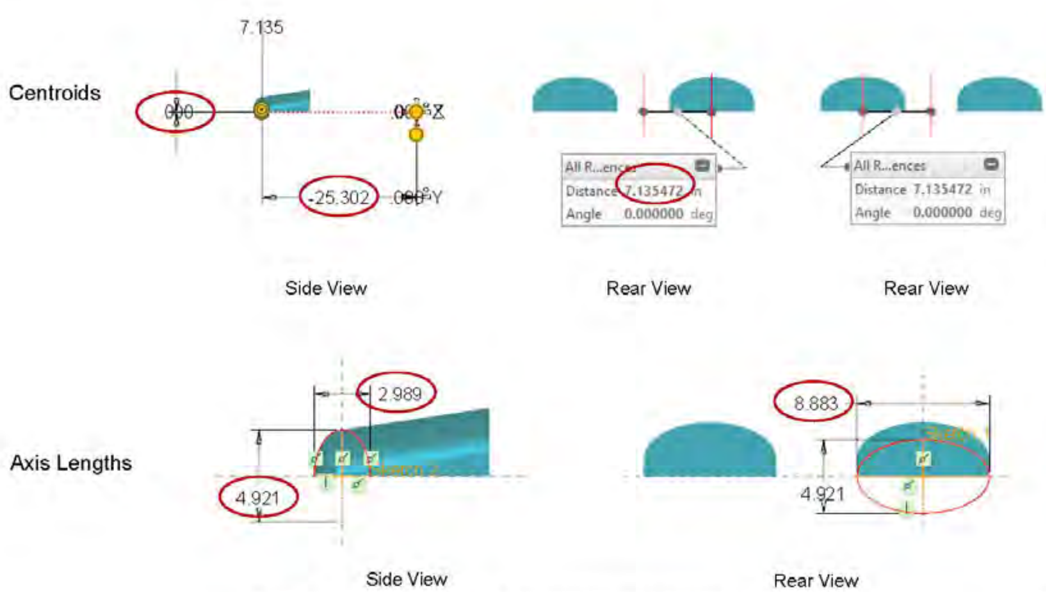
TEST #8: BOOT CONTOUR (CONT.)

GVSC CAD Model Result



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Test #8: Vary Gender Mix

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	50%	PPE	15.0	10.0	SAE J826	No

Clearance (2.0 inches), Shown in Yellow

GVSC CAD Model

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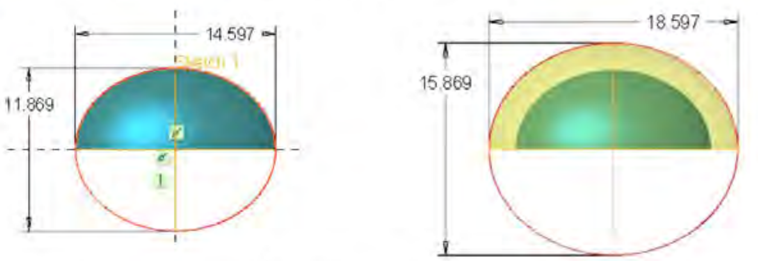
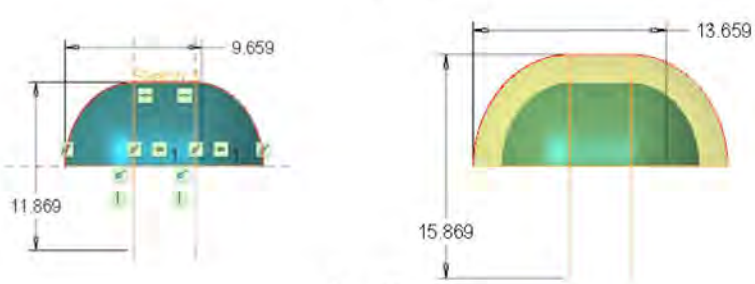
Test #8: Clearance, Helmet Contour

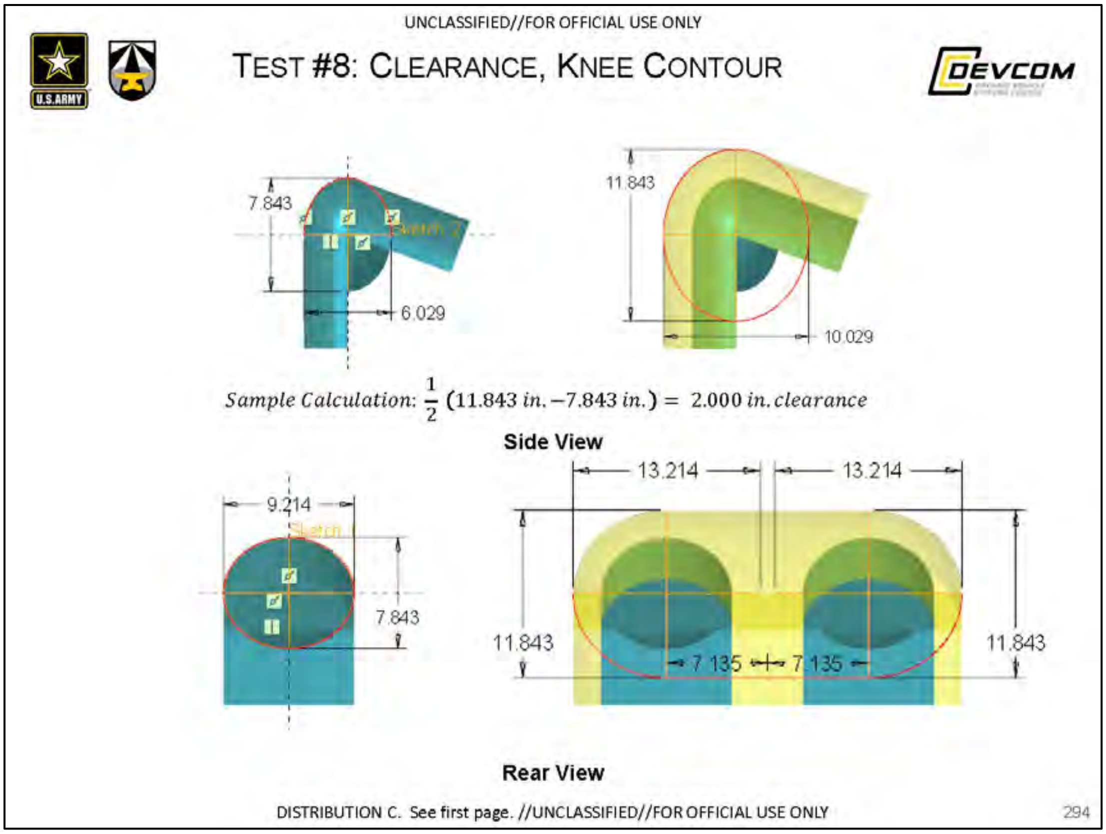


$$\textit{Sample Calculation: } \frac{1}{2}(18.597\ in. - 14.597\ in.) = 2.000\ in.\ clearance$$

Side View



Rear View


UNCLASSIFIED//FOR OFFICIAL USE ONLY
TEST #8: CLEARANCE, KNEE CONTOUR
7.843
6.029
11.843
10.029
Sample Calculation: $\frac{1}{2}$ (11.843 in. − 7.843 in.) = 2.000 in. clearance
Side View
9.214
7.843
13.214
13.214
11.843
7.135
7.135
11.843
Rear View
DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY
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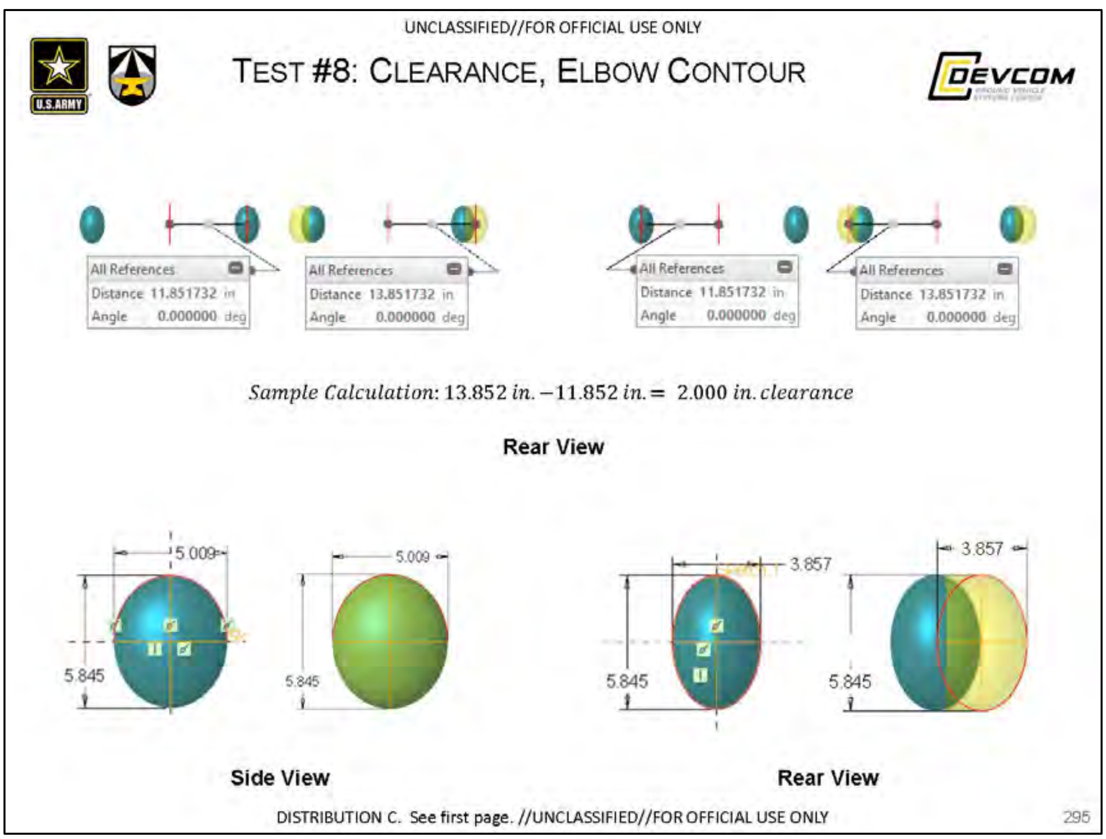
UNCLASSIFIED//FOR OFFICIAL USE ONLY
TEST #8: CLEARANCE, ELBOW CONTOUR
All References
Distance 11.851732 in
Angle 0.000000 deg
All References
Distance 13.851732 in
Angle 0.000000 deg
All References
Distance 11.851732 in
Angle 0.000000 deg
All References
Distance 13.851732 in
Angle 0.000000 deg
Sample Calculation: 13.852 in. − 11.852 in. = 2.000 in. clearance
Rear View
5.009
5.845
5.009
5.845
3.857
5.845
3.857
5.845
Side View
Rear View
DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY
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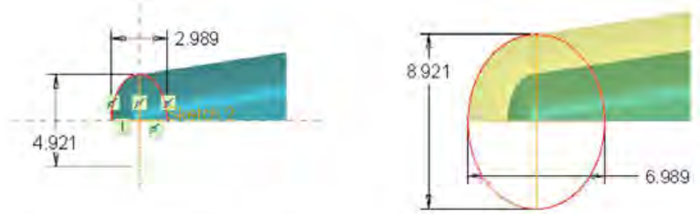
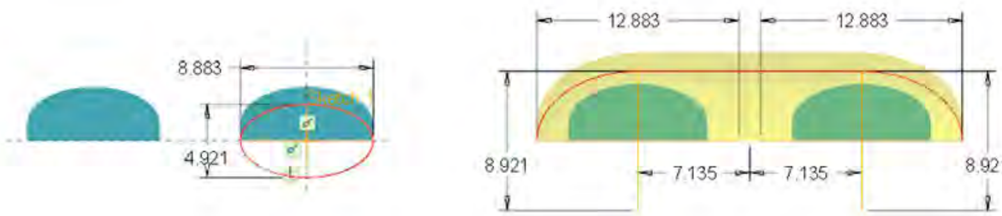
TEST #8: CLEARANCE, BOOT CONTOUR



$$Sample\ Calculation: \frac{1}{2}\,(8.921\ in. - 4.921\ in.) = 2.000\ in.\ clearance$$

Side View



Rear View

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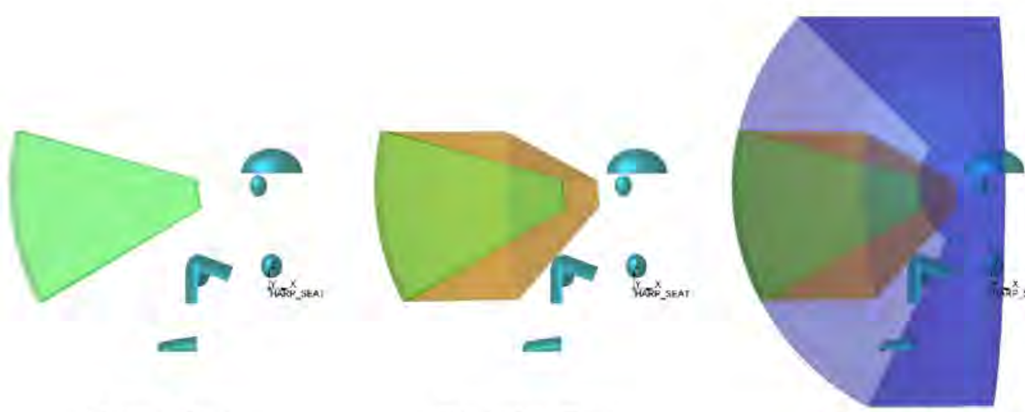
TEST #8: VARY GENDER MIX

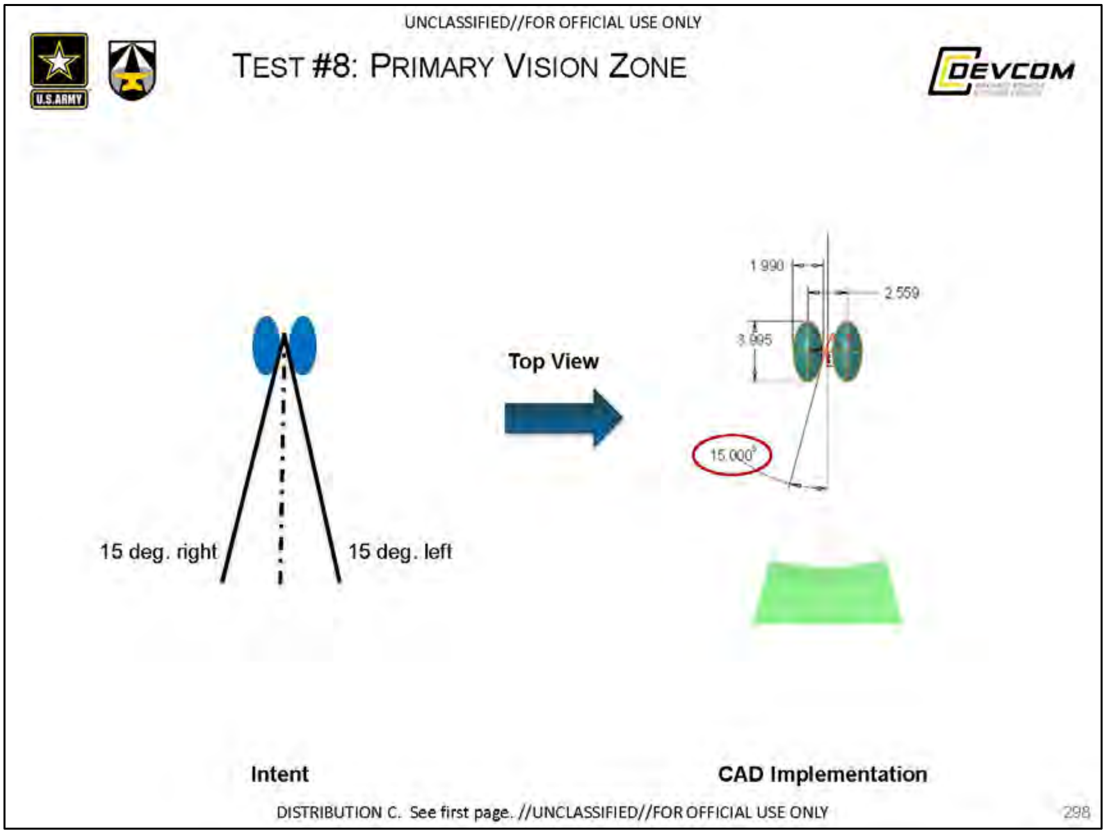
Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	50%	PPE	15.0	10.0	SAE J826	No

Vision Zones

Vison zones are constructed geometrically; no calculations are involved.



Primary Zone | Secondary Zone | Tertiary Zone


UNCLASSIFIED//FOR OFFICIAL USE ONLY
TEST #8: PRIMARY VISION ZONE
U.S.ARMY
DEVCOM
1.990
2.559
3.995
15.000°
15 deg. right
15 deg. left
Top View
Intent
CAD Implementation
DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY
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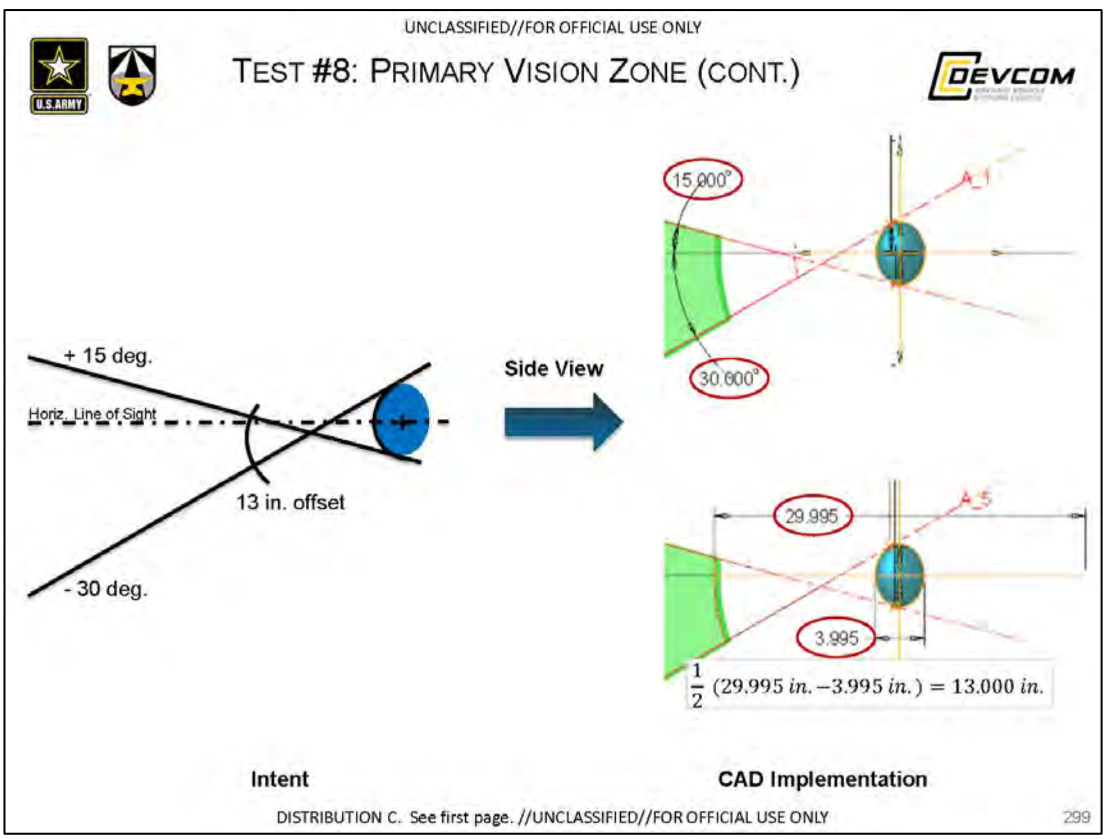
UNCLASSIFIED//FOR OFFICIAL USE ONLY
TEST #8: PRIMARY VISION ZONE (CONT.)
U.S.ARMY
DEVCOM
+ 15 deg.
Horiz. Line of Sight
13 in. offset
- 30 deg.
Side View
15.000°
30.000°
A_1
29.995
A_5
3.995
$\frac{1}{2}(29.995\ in. - 3.995\ in.) = 13.000\ in.$
Intent
CAD Implementation
DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY
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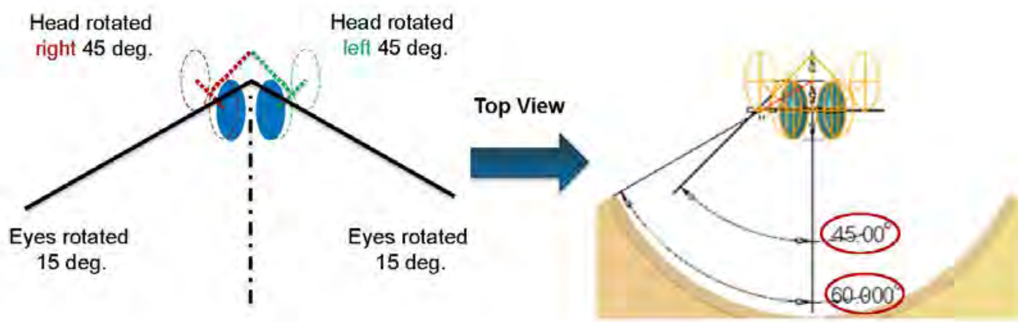
Test #8: Secondary Vision Zone



Intent **CAD Implementation**

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 300

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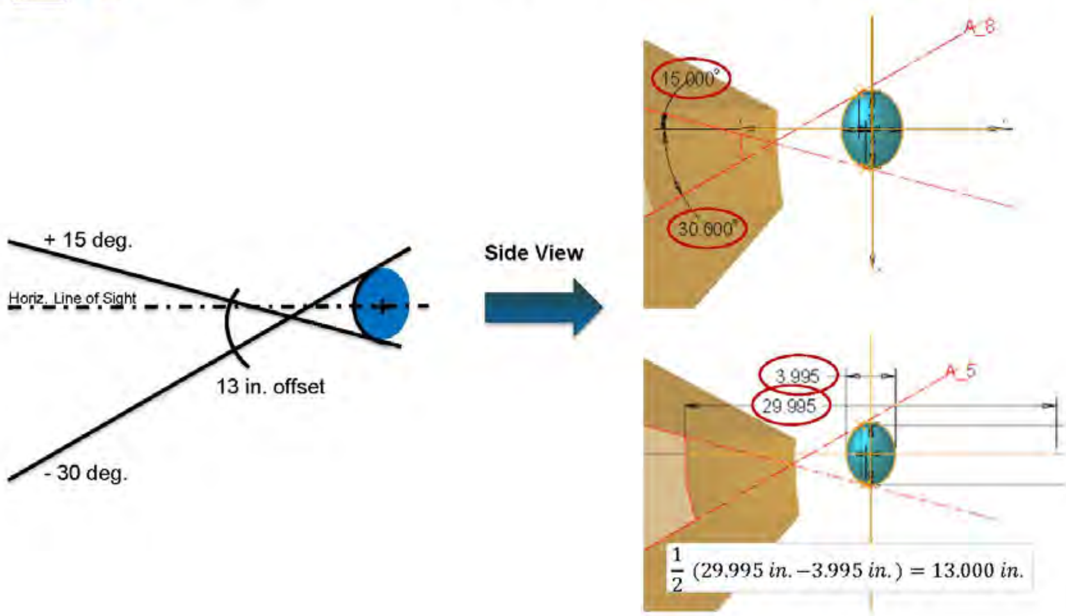
Test #8: Secondary Vision Zone (cont.)



Intent **CAD Implementation**

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 301

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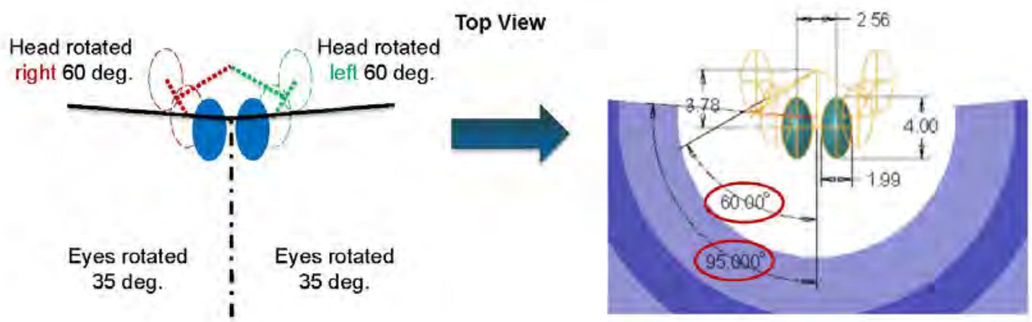
TEST #8: TERTIARY VISION ZONE



Intent

CAD Implementation

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY

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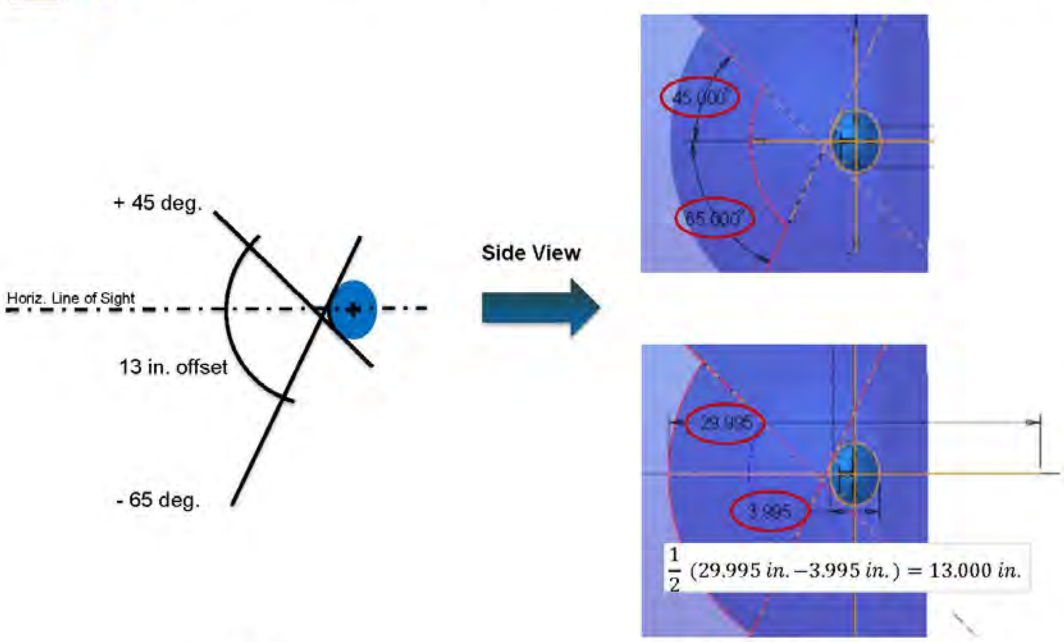
TEST #8: TERTIARY VISION ZONE (CONT.)



Intent

CAD Implementation

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY

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TEST #8: VARY GENDER MIX

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	50%	PPE	15.0	10.0	SAE J826	No

Boundary Manikin Posture and Position

GVSC CAD Model

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY

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TEST #8: RESULTS, MANIKIN POSITIONING

	UMTRI Value		GVSC Value		Difference	
Small Overall Female						
POSTURE_DHM1_HIP_X	-1.233	in	-1.233	in	0.000	in
POSTURE_DHM1_HIP_Z	14.384	in	14.384	in	0.000	in
POSTURE_DHM1_EYE_X	-1.544	in	-1.544	in	0.000	in
POSTURE_DHM1_EYE_Z	36.577	in	36.577	in	0.000	in
Small Overall Male						
POSTURE_DHM2_HIP_X	-1.496	in	-1.496	in	0.000	in
POSTURE_DHM2_HIP_Z	14.489	in	14.489	in	0.000	in
POSTURE_DHM2_EYE_X	-2.253	in	-2.253	in	0.000	in
POSTURE_DHM2_EYE_Z	38.474	in	38.474	in	0.000	in
Average Size Male						
POSTURE_DHM3_HIP_X	-1.494	in	-1.494	in	0.000	in
POSTURE_DHM3_HIP_Z	14.488	in	14.488	in	0.000	in
POSTURE_DHM3_EYE_X	-2.994	in	-2.994	in	0.000	in
POSTURE_DHM3_EYE_Z	40.824	in	40.824	in	0.000	in
Widest Shoulders Male						
POSTURE_DHM4_HIP_X	-1.467	in	-1.467	in	0.000	in
POSTURE_DHM4_HIP_Z	14.478	in	14.478	in	0.000	in
POSTURE_DHM4_EYE_X	-3.368	in	-3.368	in	0.000	in
POSTURE_DHM4_EYE_Z	42.179	in	42.179	in	0.000	in
Longest Torso Male						
POSTURE_DHM5_HIP_X	-1.453	in	-1.453	in	0.000	in
POSTURE_DHM5_HIP_Z	14.472	in	14.472	in	0.000	in
POSTURE_DHM5_EYE_X	-3.377	in	-3.377	in	0.000	in
POSTURE_DHM5_EYE_Z	43.354	in	43.354	in	0.000	in
Longest Legs Male						
POSTURE_DHM6_HIP_X	-1.622	in	-1.622	in	0.000	in
POSTURE_DHM6_HIP_Z	14.540	in	14.540	in	0.000	in
POSTURE_DHM6_EYE_X	-3.559	in	-3.559	in	0.000	in
POSTURE_DHM6_EYE_Z	41.185	in	41.185	in	0.000	in
Large Overall Male						
POSTURE_DHM7_HIP_X	-1.654	in	-1.654	in	0.000	in
POSTURE_DHM7_HIP_Z	14.633	in	14.633	in	0.000	in
POSTURE_DHM7_EYE_X	-3.835	in	-3.835	in	0.000	in
POSTURE_DHM7_EYE_Z	43.173	in	43.173	in	0.000	in

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

Largest Observed Differences:
0.000 inches

Values in agreement

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY

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TEST #8: SMALL OVERALL FEMALE

DEVCOM

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-2.3	-31.3	-74.3	→	-1.233	in
Hip re H-point Z	-15.7	-15.7	-15.7	→	14.384	in
Eye re H-point X	12.8	-39.2	-100.2	→	-1.544	in
Eye re H-point Z	548.1	548.1	548.1	→	36.577	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM1_HIP_X	-1.233	in
POSTURE_DHM1_HIP_Z	14.384	in
POSTURE_DHM1_EYE_X	-1.544	in
POSTURE_DHM1_EYE_Z	36.577	in

GVSC CAD Model Geometry

Side View

Front View

TEST #8: SMALL OVERALL MALE

DEVCOM

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-9.0	-38.0	-81.0	→	-1.496	in
Hip re H-point Z	-13.0	-13.0	-13.0	→	14.489	in
Eye re H-point X	-5.2	-57.2	-118.2	→	-2.253	in
Eye re H-point Z	596.3	596.3	596.3	→	38.474	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM2_HIP_X	-1.496	in
POSTURE_DHM2_HIP_Z	14.489	in
POSTURE_DHM2_EYE_X	-2.253	in
POSTURE_DHM2_EYE_Z	38.474	in

GVSC CAD Model Geometry

Side View

Front View

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TEST #8: AVERAGE SIZE MALE

DEVCOM

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-8.9	-37.9	-80.9	→	-1.494	in
Hip re H-point Z	-13.0	-13.0	-13.0	→	14.488	in
Eye re H-point X	-24.0	-76.0	-137.0	→	-2.994	in
Eye re H-point Z	655.9	655.9	655.9	→	40.824	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM3_HIP_X	-1.494	in
POSTURE_DHM3_HIP_Z	14.488	in
POSTURE_DHM3_EYE_X	-2.994	in
POSTURE_DHM3_EYE_Z	40.824	in

GVSC CAD Model Geometry

Side View

Front View

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 308

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TEST #8: WIDEST SHOULDERS MALE

DEVCOM

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-8.3	-37.3	-80.3	→	-1.467	in
Hip re H-point Z	-13.3	-13.3	-13.3	→	14.478	in
Eye re H-point X	-33.5	-85.5	-146.5	→	-3.368	in
Eye re H-point Z	690.3	690.3	690.3	→	42.179	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM4_HIP_X	-1.467	in
POSTURE_DHM4_HIP_Z	14.478	in
POSTURE_DHM4_EYE_X	-3.368	in
POSTURE_DHM4_EYE_Z	42.179	in

GVSC CAD Model Geometry

Side View

Front View

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 309

TEST #8: LONGEST TORSO MALE

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-7.9	-36.9	-79.9	→	-1.453	in
Hip re H-point Z	-13.4	-13.4	-13.4	→	14.472	in
Eye re H-point X	-33.8	-85.8	-146.8	→	-3.377	in
Eye re H-point Z	720.2	720.2	720.2	→	43.354	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM5_HIP_X	-1.453	in
POSTURE_DHM5_HIP_Z	14.472	in
POSTURE_DHM5_EYE_X	-3.377	in
POSTURE_DHM5_EYE_Z	43.354	in

GVSC CAD Model Geometry

Side View

Front View

TEST #8: LONGEST LEGS MALE

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-12.2	-41.2	-84.2	→	-1.622	in
Hip re H-point Z	-11.7	-11.7	-11.7	→	14.540	in
Eye re H-point X	-38.4	-90.4	-151.4	→	-3.559	in
Eye re H-point Z	665.1	665.1	665.1	→	41.185	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM6_HIP_X	-1.622	in
POSTURE_DHM6_HIP_Z	14.540	in
POSTURE_DHM6_EYE_X	-3.559	in
POSTURE_DHM6_EYE_Z	41.185	in

GVSC CAD Model Geometry

Side View

Front View

Test #8: Large Overall Male

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-18.1	-47.1	-90.1	→	-1.854	in
Hip re H-point Z	-9.3	-9.3	-9.3	→	14.633	in
Eye re H-point X	-45.4	-97.4	-158.4	→	-3.835	in
Eye re H-point Z	715.6	715.6	715.6	→	43.173	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM7_HIP_X	-1.854	in
POSTURE_DHM7_HIP_Z	14.633	in
POSTURE_DHM7_EYE_X	-3.835	in
POSTURE_DHM7_EYE_Z	43.173	in

GVSC CAD Model Geometry

Side View

Front View

10.7.9 TEST #9 – VARY GENDER MIX

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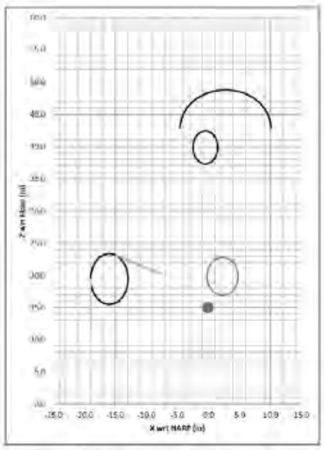
TEST #9: VARY GENDER MIX

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	50%	ACU	15.0	10.0	SAE J826	No

Basic Accommodation



UMTRI Spreadsheet

GVSC CAD Model

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TEST #9: GENDER MIX EFFECTS

Test #	Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
6	90%	90%	ACU	15.0	10.0	SAE J826	No
9	90%	50%	ACU	15.0	10.0	SAE J826	No

Note: Highlighted values differ from comparison test

Observations/Notes

- Because females are physically smaller than males, decreasing the percentage of males decreases the overall resultant occupant space.

Side View

— Test #6
Test #9

Front View

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TEST #9: RESULTS, ACCOMMODATION

HARP						
	UMTRI Value		GVSC Value		Difference	
HARP_X	0.000	in	0.000	in	0.000	in
HARP_Z	15.000	in	15.000	in	0.000	in

Eyellipse						
	UMTRI Value		GVSC Value		Difference	
EYELLIPSE_CENTROID_X	-0.493	in	-0.493	in	0.000	in
EYELLIPSE_CENTROID_Y (+/-)	1.280	in	1.280	in	0.000	in
EYELLIPSE_CENTROID_Z	39.880	in	39.880	in	0.000	in
EYELLIPSE_X_AXIS_LENGTH	3.993	in	3.995	in	0.002	in
EYELLIPSE_Y_AXIS_LENGTH	1.988	in	1.990	in	0.001	in
EYELLIPSE_Z_AXIS_LENGTH	5.098	in	5.097	in	0.000	in

Helmet Contour

The ACU ensemble does not include a helmet

Knee Contour						
	UMTRI Value		GVSC Value		Difference	
KNEE_CONTOUR_WEIGHTED_CENT_X	-15.955	in	-15.955	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Y (+/-)	7.135	in	7.135	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Z	19.425	in	19.425	in	0.000	in
KNEE_CONTOUR_X_AXIS_LENGTH	6.029	in	6.029	in	0.000	in
KNEE_CONTOUR_Y_AXIS_LENGTH	9.212	in	9.214	in	0.001	in
KNEE_CONTOUR_Z_AXIS_LENGTH	7.843	in	7.843	in	0.000	in
KNEE_SHIN_ANGLE	0.000	deg	0.000	deg	0.000	deg
KNEE_THIGH_ANGLE	21.482	deg	21.482	deg	0.000	deg

Elbow Contour						
	UMTRI Value		GVSC Value		Difference	
ELBOW_WEIGHTED_CENT_X	2.274	in	2.274	in	0.000	in
ELBOW_WEIGHTED_CENT_Y	11.139	in	11.139	in	0.000	in
ELBOW_WEIGHTED_CENT_Z	19.842	in	19.842	in	0.000	in
ELBOW_X_AXIS_LENGTH	5.006	in	5.009	in	0.003	in
ELBOW_Y_AXIS_LENGTH	3.857	in	3.857	in	0.000	in
ELBOW_Z_AXIS_LENGTH	5.843	in	5.845	in	0.002	in

Boot Contour						
	UMTRI Value		GVSC Value		Difference	
BOOT_TOE_WEIGHTED_CENT_X	-24.160	in	-24.160	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Y	7.135	in	7.135	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Z	0.000	in	0.000	in	0.000	in
BOOT_TOE_X_AXIS_LENGTH	2.988	in	2.989	in	0.001	in
BOOT_TOE_Y_AXIS_LENGTH	8.882	in	8.883	in	0.001	in
BOOT_TOE_Z_AXIS_LENGTH	4.921	in	4.921	in	0.000	in

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

Largest Observed Differences:
0.003 inches
0.000 degrees

Values in agreement

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 315

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TEST #9: SEAT HARP

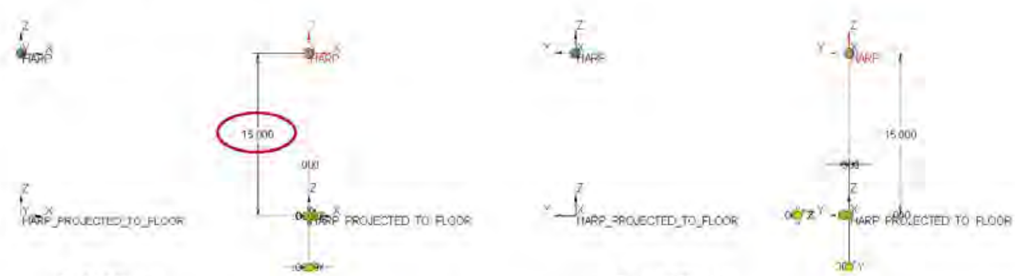
UMTRI Spreadsheet Calculations

	X (in)	Z (in)
HARP	0.000	15.000

GVSC CAD Model Calculations

HARP_X	0.000	in
HARP_Z	15.000	in

GVSC CAD Model Geometry



Side View **Front View**

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TEST #9: EYELLIPSE

DEVCOM

UMTRI Spreadsheet Calculations

Eyellipse Centroids	X (in)	Y (in)	Z (in)
Right	-0.493	1.280*	39.880
Left	-0.493	-1.280*	39.880

Side View of Eyellipses (X, Z)		
Axis Length (X)	3.993	in
Axis Length (Z)	5.098	in

Rear View of Eyellipses (Y, Z)		
Axis Length (Y)	1.988	in
Axis Length (Z)	5.098	in

GVSC CAD Model Calculations

EYELLIPSE_CENTROID_X	-0.493	in
EYELLIPSE_CENTROID_Y	1.280*	in
EYELLIPSE_CENTROID_Z	39.880	in
EYELLIPSE_X_AXIS_LENGTH	3.995	in
EYELLIPSE_Y_AXIS_LENGTH	1.990	in
EYELLIPSE_Z_AXIS_LENGTH	5.097	in

*Given value, not calculated

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 317

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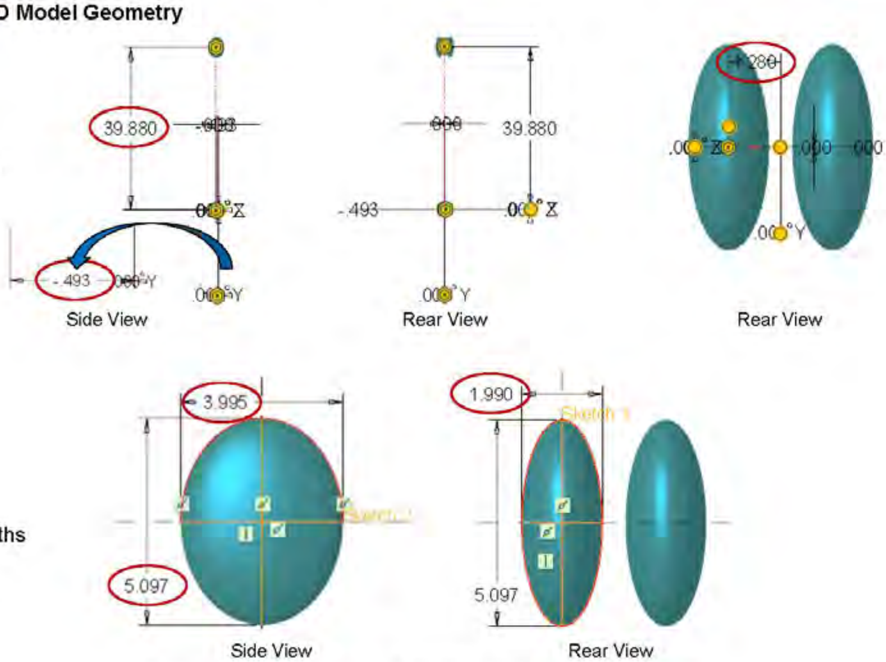
TEST #9: EYELLIPSE (CONT.)

DEVCOM

GVSC CAD Model Geometry

Centroids



Axis Lengths

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 318

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TEST #9: KNEE CONTOUR

UMTRI Spreadsheet Calculations

Knee Centroids	X (in)	Y (in)	Z (in)
Right	-15.955	7.135	19.425
Left	-15.955	-7.135	19.425

Side View of Knee Contours (X, Z)		
Axis Length (X)	6.029	in
Axis Length (Z)	7.843	in
Rear View of Knee Contours (Y, Z)		
Axis Length (Y)	9.212	in
Axis Length (Z)	7.843	in
Leg Segment Angle wrt Vertical	0.000*	deg
Thigh Segment Angle wrt Horizontal	21.482	deg

GVSC CAD Model Calculations

KNEE_CONTOUR_WEIGHTED_CENT_X	-15.955	in
KNEE_CONTOUR_WEIGHTED_CENT_Y	7.135	in
KNEE_CONTOUR_WEIGHTED_CENT_Z	19.425	in
KNEE_CONTOUR_X_AXIS_LENGTH	6.029	in
KNEE_CONTOUR_Y_AXIS_LENGTH	9.214	in
KNEE_CONTOUR_Z_AXIS_LENGTH	7.843	in
KNEE_SHIN_ANGLE	0.000*	deg
KNEE_THIGH_ANGLE	21.482	deg

*Given value, not calculated

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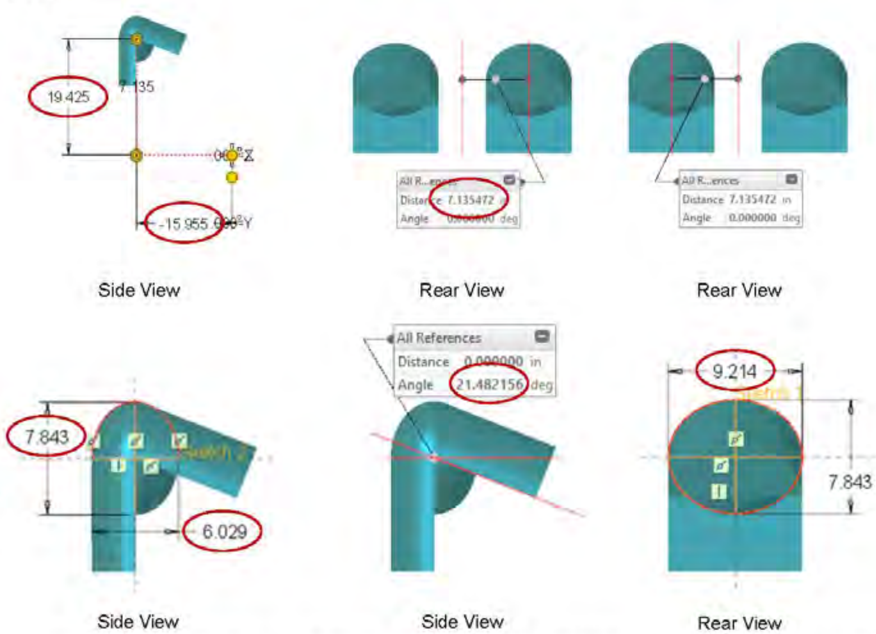
TEST #9: KNEE CONTOUR (CONT.)

GVSC CAD Model Result

Centroids

Axis Lengths
Shin/Thigh Angles



DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 320

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TEST #9: ELBOW CONTOUR

UMTRI Spreadsheet Calculations

Elbow Centroids	X (in)	Y (in)	Z (in)
Right	2.274	11.139	19.842
Left	2.274	-11.139	19.842

Side View of Elbow Contours (X, Z)		
Axis Length (X)	5.006	in
Axis Length (Z)	5.843	in

Rear View of Elbow Contours (Y, Z)		
Axis Length (Y)	3.857	in
Axis Length (Z)	5.843	in

GVSC CAD Model Calculations

ELBOW_WEIGHTED_CENT_X	2.274	in
ELBOW_WEIGHTED_CENT_Y	11.139	in
ELBOW_WEIGHTED_CENT_Z	19.842	in
ELBOW_X_AXIS_LENGTH	5.009	in
ELBOW_Y_AXIS_LENGTH	3.857	in
ELBOW_Z_AXIS_LENGTH	5.845	in

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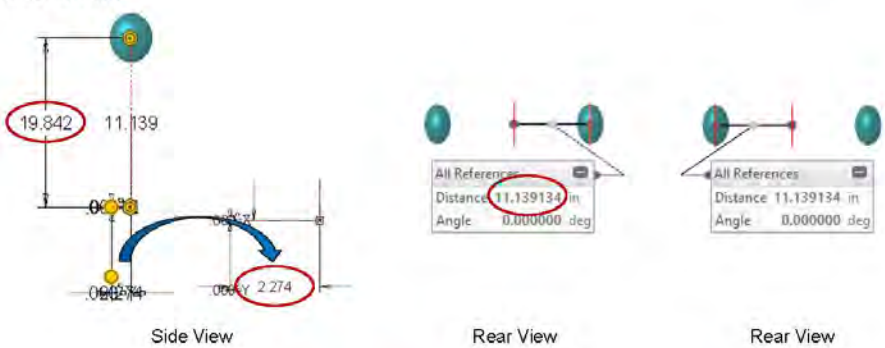
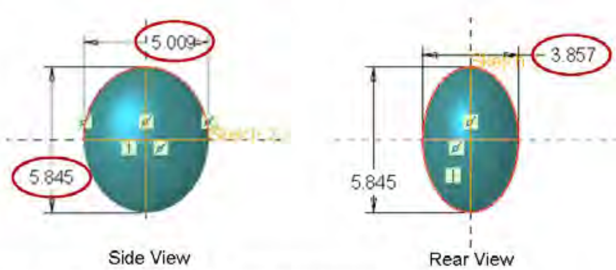
TEST #9: ELBOW CONTOUR (CONT.)

GVSC CAD Model Result

Centroids



Axis Lengths



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TEST #9: BOOT CONTOUR

UMTRI Spreadsheet Calculations

Boot Centroids	X (in)	Y (in)	Z (in)
Right	-24.160	7.135	0.000
Left	-24.160	-7.135	0.000

Side View of Boot Contours (X, Z)		
Axis Length (X)	2.988	in
Axis Length (Z)	4.921	in

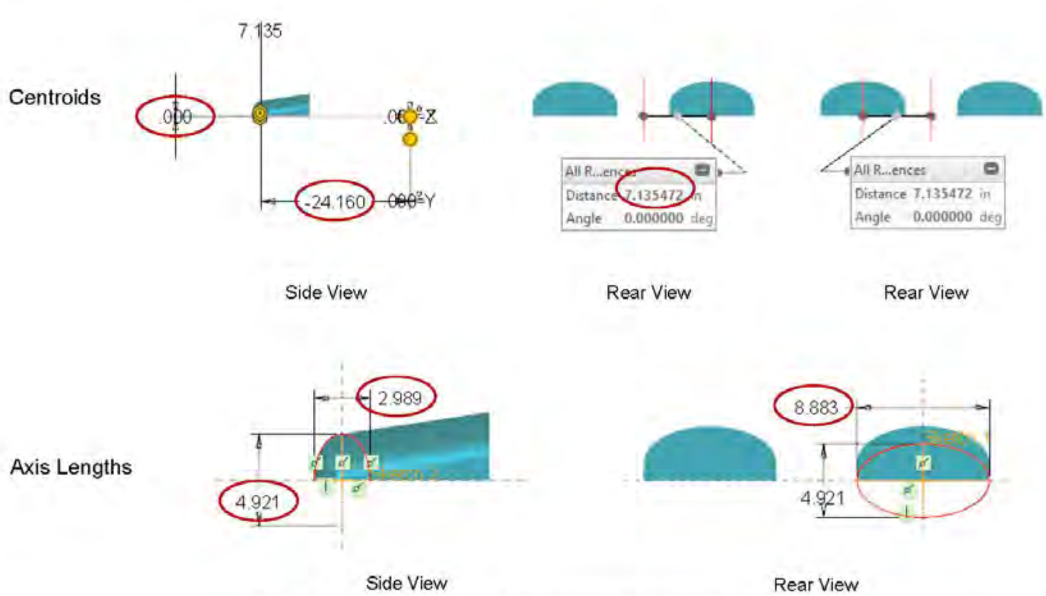
Rear View of Boot Contours (Y, Z)		
Axis Length (Y)	8.882	in
Axis Length (Z)	4.921	in

GVSC CAD Model Calculations

BOOT_TOE_WEIGHTED_CENT_X	-24.160	in
BOOT_TOE_WEIGHTED_CENT_Y	7.135	in
BOOT_TOE_WEIGHTED_CENT_Z	0.000	in
BOOT_TOE_X_AXIS_LENGTH	2.989	in
BOOT_TOE_Y_AXIS_LENGTH	8.883	in
BOOT_TOE_Z_AXIS_LENGTH	4.921	in

TEST #9: BOOT CONTOUR (CONT.)

GVSC CAD Model Result



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Test #9: Vary Ensemble

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	50%	ACU	15.0	10.0	SAE J826	No

Clearance (2.0 inches), Shown in Yellow

GVSC CAD Model

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 325

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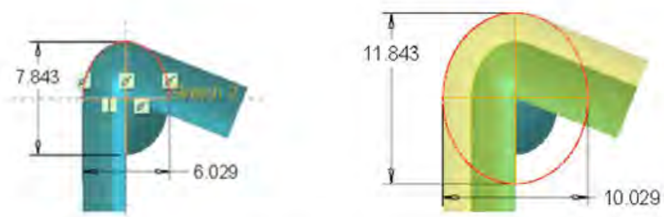
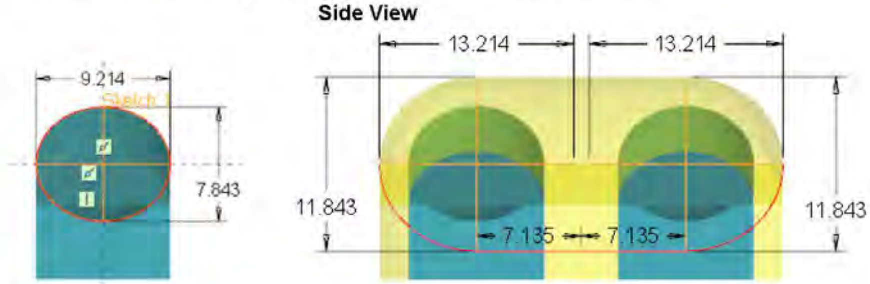
Test #9: Clearance, Knee Contour



$$Sample\ Calculation:\ \frac{1}{2}\,(11.843\ in. - 7.843\ in.) = 2.000\ in.\ clearance$$

Side View



Rear View

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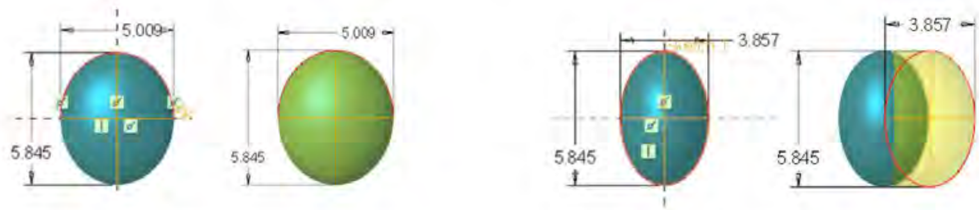
TEST #9: CLEARANCE, ELBOW CONTOUR

$Sample\ Calculation: 13.139\ in. - 11.139\ in. = \ 2.000\ in.clearance$

Rear View



Side View **Rear View**

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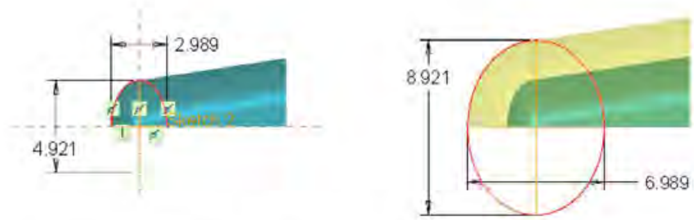
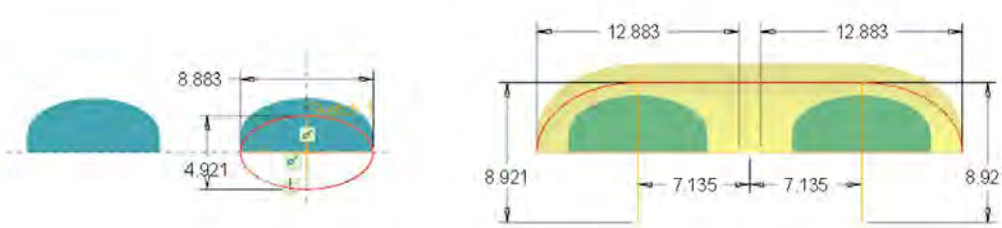
TEST #9: CLEARANCE, BOOT CONTOUR



$Sample\ Calculation: \frac{1}{2}\ (8.921\ in. - 4.921\ in.) = \ 2.000\ in.clearance$

Side View



Rear View

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 328

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TEST #9: VARY GENDER MIX

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	50%	ACU	15.0	10.0	SAE J826	No

Vision Zones

Vison zones are constructed geometrically; no calculations are involved.

Primary Zone Secondary Zone Tertiary Zone

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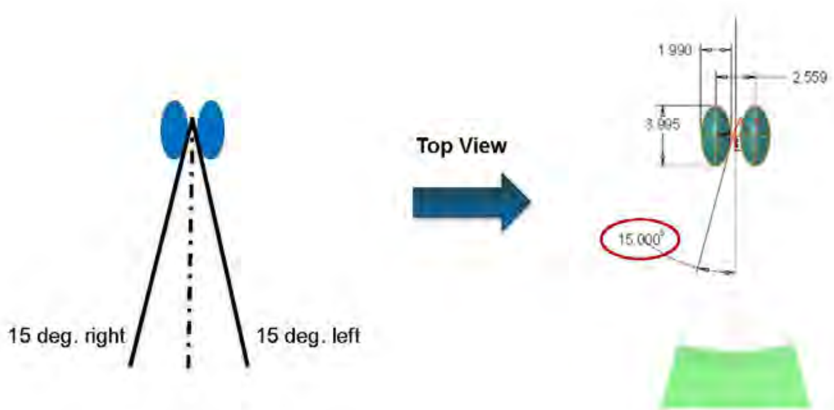
TEST #9: PRIMARY VISION ZONE



Intent CAD Implementation

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY

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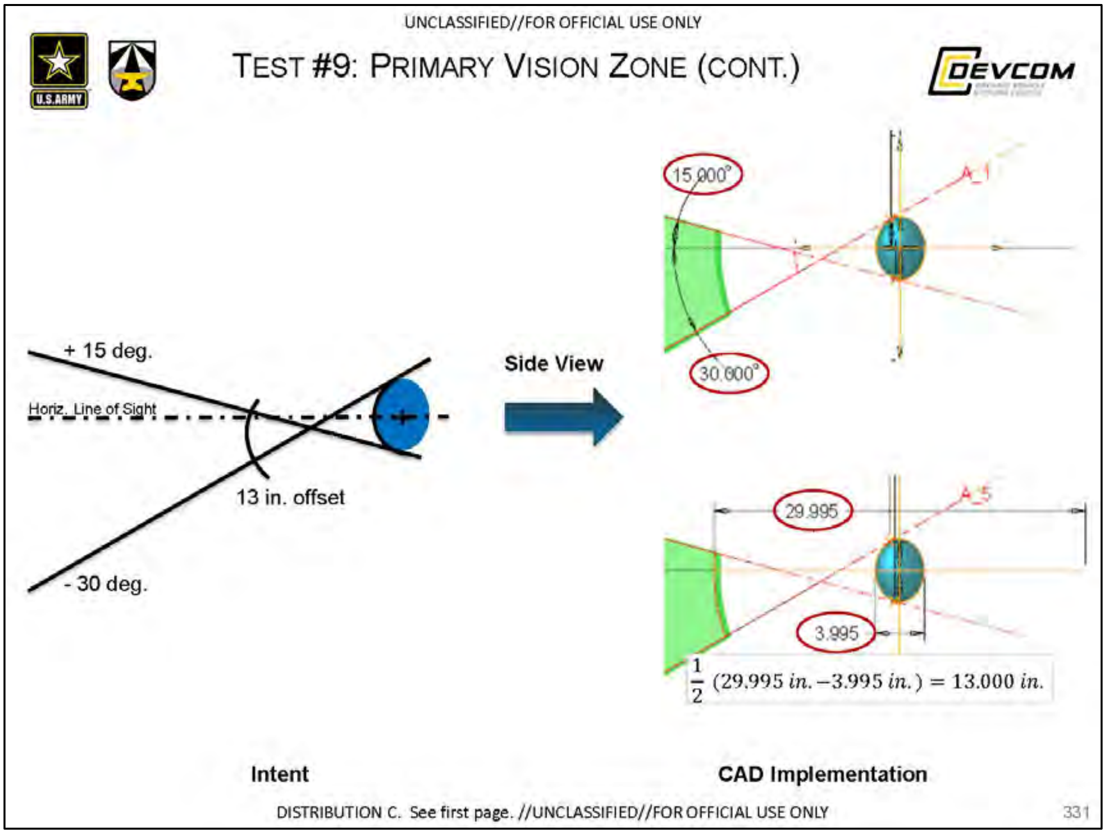

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TEST #9: PRIMARY VISION ZONE (CONT.)
DEVCOM
+ 15 deg.
Horiz. Line of Sight
13 in. offset
- 30 deg.
Side View
15.000°
A_1
30.000°
29.995
A_5
3.995
$\frac{1}{2}$ (29.995 in. −3.995 in.) = 13.000 in.
Intent
CAD Implementation
DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY
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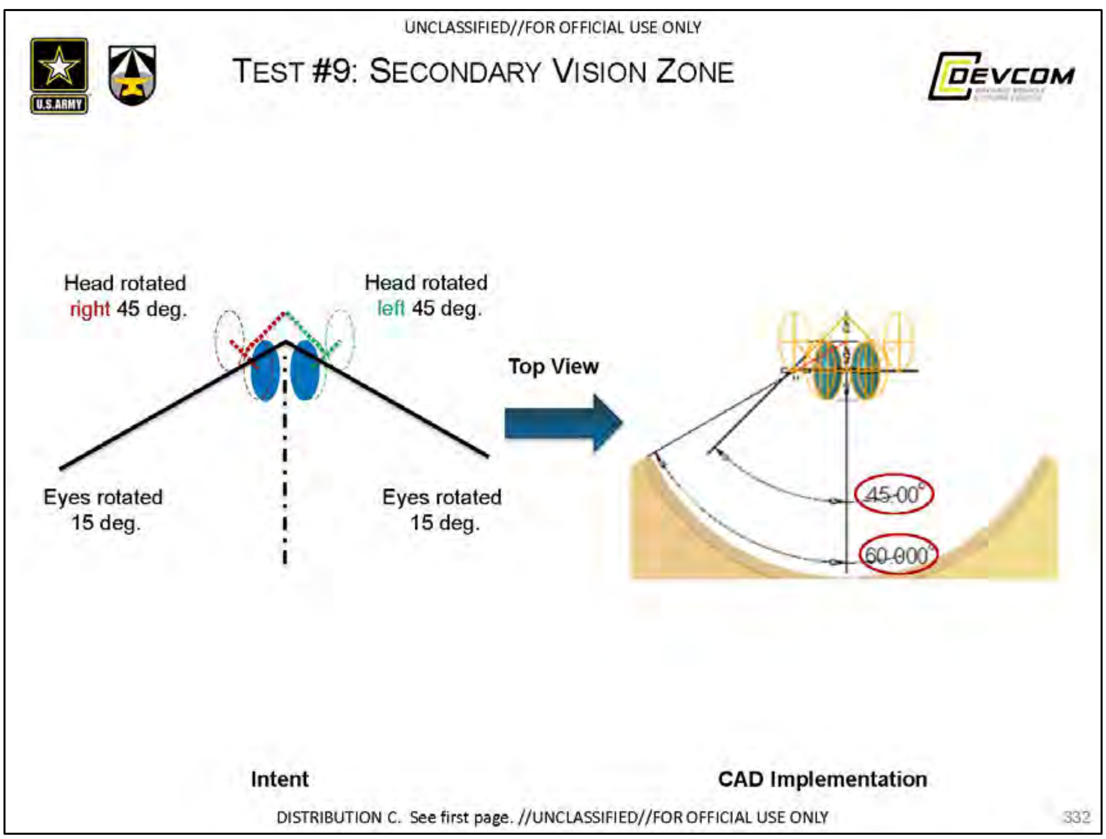

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TEST #9: SECONDARY VISION ZONE
DEVCOM
Head rotated right 45 deg.
Head rotated left 45 deg.
Eyes rotated 15 deg.
Eyes rotated 15 deg.
Top View
45.00°
60.000°
Intent
CAD Implementation
DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY
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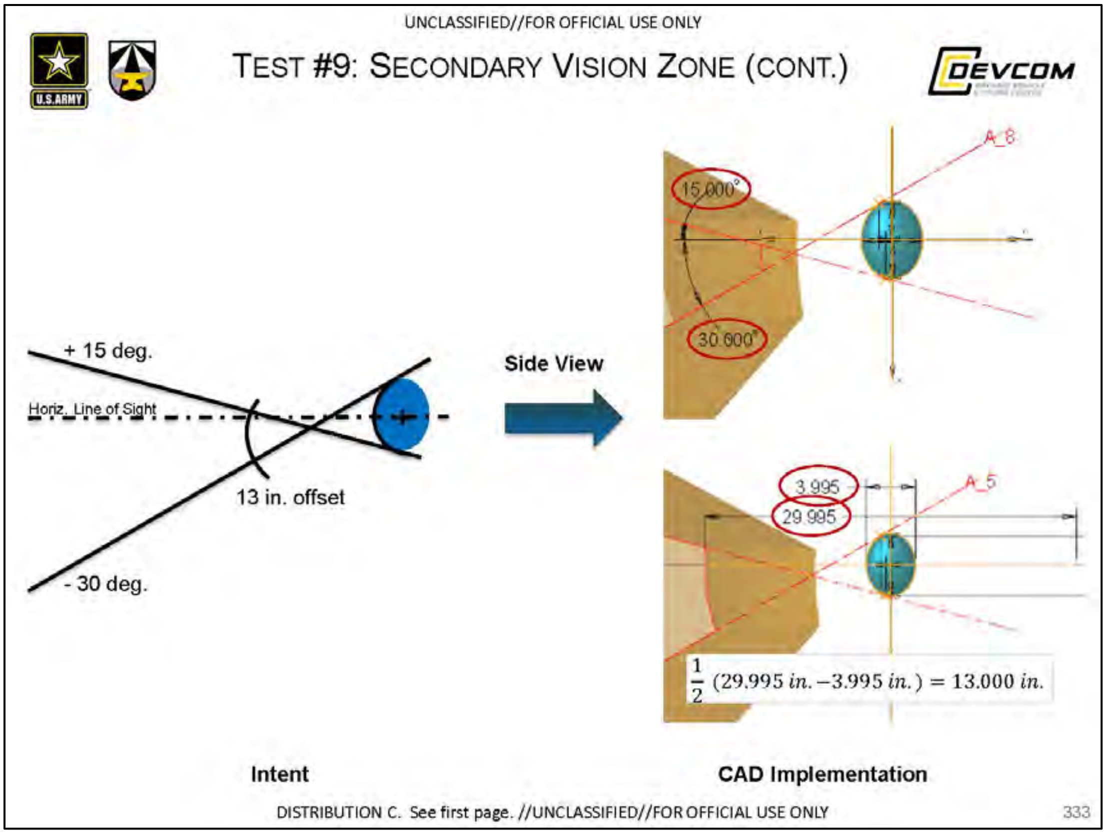

UNCLASSIFIED//FOR OFFICIAL USE ONLY
TEST #9: SECONDARY VISION ZONE (CONT.)
DEVCOM
+ 15 deg.
Horiz. Line of Sight
13 in. offset
- 30 deg.
Side View
A_8
15.000°
30.000°
3.995
29.995
A_5
$\frac{1}{2}(29.995\ in. - 3.995\ in.) = 13.000\ in.$
Intent
CAD Implementation
DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY
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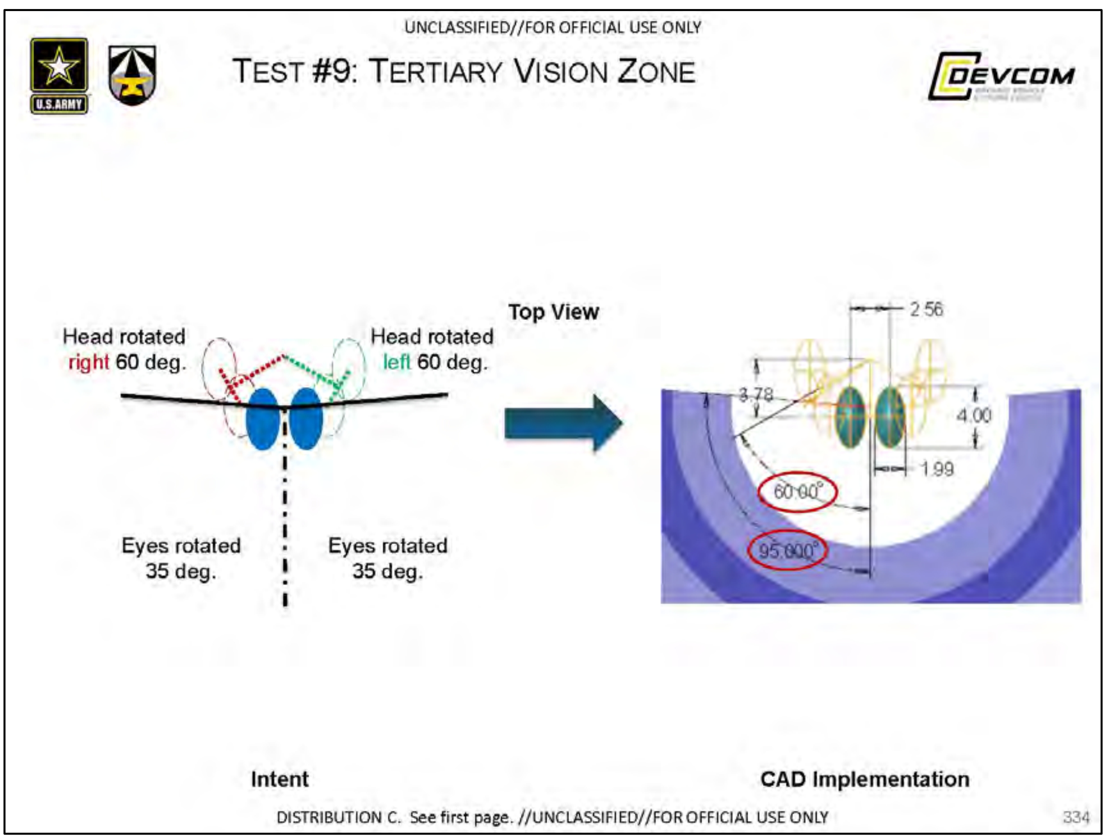

UNCLASSIFIED//FOR OFFICIAL USE ONLY
TEST #9: TERTIARY VISION ZONE
DEVCOM
Head rotated right 60 deg.
Head rotated left 60 deg.
Eyes rotated 35 deg.
Eyes rotated 35 deg.
Top View
2.56
3.78
4.00
1.99
60.00°
95.000°
Intent
CAD Implementation
DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY
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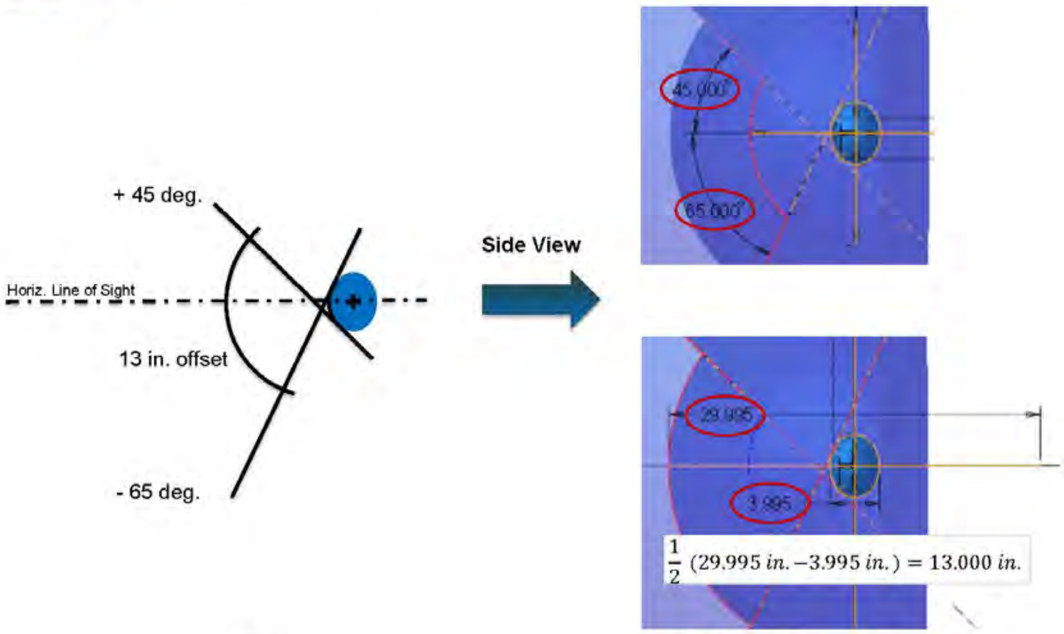
TEST #9: TERTIARY VISION ZONE (CONT.)



Intent **CAD Implementation**

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 335

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TEST #9: VARY GENDER MIX

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	50%	ACU	15.0	10.0	SAE J826	No

Boundary Manikin Posture and Position

GVSC CAD Model

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 336

Test #9: Results, Manikin Positioning

Small Overall Female						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM1_HIP_X	-0.092	in	-0.092	in	0.000	in
POSTURE_DHM1_HIP_Z	14.384	in	14.384	in	0.000	in
POSTURE_DHM1_EYE_X	0.504	in	0.504	in	0.000	in
POSTURE_DHM1_EYE_Z	36.577	in	36.577	in	0.000	in
Small Overall Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM2_HIP_X	-0.354	in	-0.354	in	0.000	in
POSTURE_DHM2_HIP_Z	14.489	in	14.489	in	0.000	in
POSTURE_DHM2_EYE_X	-0.206	in	-0.206	in	0.000	in
POSTURE_DHM2_EYE_Z	38.474	in	38.474	in	0.000	in
Average Size Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM3_HIP_X	-0.352	in	-0.352	in	0.000	in
POSTURE_DHM3_HIP_Z	14.488	in	14.488	in	0.000	in
POSTURE_DHM3_EYE_X	-0.946	in	-0.946	in	0.000	in
POSTURE_DHM3_EYE_Z	40.824	in	40.824	in	0.000	in
Widest Shoulders Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM4_HIP_X	-0.325	in	-0.325	in	0.000	in
POSTURE_DHM4_HIP_Z	14.478	in	14.478	in	0.000	in
POSTURE_DHM4_EYE_X	-1.320	in	-1.320	in	0.000	in
POSTURE_DHM4_EYE_Z	42.179	in	42.179	in	0.000	in
Longest Torso Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM5_HIP_X	-0.311	in	-0.311	in	0.000	in
POSTURE_DHM5_HIP_Z	14.472	in	14.472	in	0.000	in
POSTURE_DHM5_EYE_X	-1.330	in	-1.330	in	0.000	in
POSTURE_DHM5_EYE_Z	43.354	in	43.354	in	0.000	in
Longest Legs Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM6_HIP_X	-0.480	in	-0.480	in	0.000	in
POSTURE_DHM6_HIP_Z	14.540	in	14.540	in	0.000	in
POSTURE_DHM6_EYE_X	-1.512	in	-1.512	in	0.000	in
POSTURE_DHM6_EYE_Z	41.185	in	41.185	in	0.000	in
Large Overall Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM7_HIP_X	-0.712	in	-0.712	in	0.000	in
POSTURE_DHM7_HIP_Z	14.633	in	14.633	in	0.000	in
POSTURE_DHM7_EYE_X	-1.788	in	-1.788	in	0.000	in
POSTURE_DHM7_EYE_Z	43.173	in	43.173	in	0.000	in

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

Largest Observed Differences:
0.000 inches

Values in agreement

Test #9: Small Overall Female

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-2.3	-31.3	-74.3	→	-0.092	in
Hip re H-point Z	-15.7	-15.7	-15.7	→	14.384	in
Eye re H-point X	12.8	-39.2	-100.2	→	0.504	in
Eye re H-point Z	548.1	548.1	548.1	→	36.577	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM1_HIP_X	-0.092	in
POSTURE_DHM1_HIP_Z	14.384	in
POSTURE_DHM1_EYE_X	0.504	in
POSTURE_DHM1_EYE_Z	36.577	in

GVSC CAD Model Geometry

Side View

Front View

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TEST #9: SMALL OVERALL MALE

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-9.0	-38.0	-81.0	→	-0.354	in
Hip re H-point Z	-13.0	-13.0	-13.0	→	14.489	in
Eye re H-point X	-5.2	-57.2	-118.2	→	-0.206	in
Eye re H-point Z	596.3	596.3	596.3	→	38.474	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM2_HIP_X	-0.354	in
POSTURE_DHM2_HIP_Z	14.489	in
POSTURE_DHM2_EYE_X	-0.206	in
POSTURE_DHM2_EYE_Z	38.474	in

GVSC CAD Model Geometry

Side View

Front View

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TEST #9: AVERAGE SIZE MALE

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-8.9	-37.9	-80.9	→	-0.352	in
Hip re H-point Z	-13.0	-13.0	-13.0	→	14.488	in
Eye re H-point X	-24.0	-76.0	-137.0	→	-0.946	in
Eye re H-point Z	655.9	655.9	655.9	→	40.824	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM3_HIP_X	-0.352	in
POSTURE_DHM3_HIP_Z	14.488	in
POSTURE_DHM3_EYE_X	-0.946	in
POSTURE_DHM3_EYE_Z	40.824	in

GVSC CAD Model Geometry

Side View

Front View

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TEST #9: WIDEST SHOULDERS MALE

UMTRI Spreadsheet Calculations*

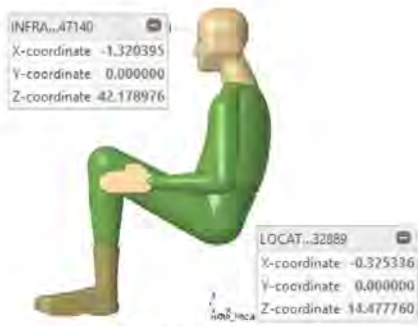
	ACU	PPE	ENC			
Hip re H-point X	-8.3	-37.3	-80.3	→	-0.325	in
Hip re H-point Z	-13.3	-13.3	-13.3	→	14.478	in
Eye re H-point X	-33.5	-85.5	-146.5	→	-1.320	in
Eye re H-point Z	690.3	690.3	690.3	→	42.179	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM4_HIP_X	-0.325	in
POSTURE_DHM4_HIP_Z	14.478	in
POSTURE_DHM4_EYE_X	-1.320	in
POSTURE_DHM4_EYE_Z	42.179	in

GVSC CAD Model Geometry



Side View

Front View

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TEST #9: LONGEST TORSO MALE

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-7.9	-36.9	-79.9	→	-0.311	in
Hip re H-point Z	-13.4	-13.4	-13.4	→	14.472	in
Eye re H-point X	-33.8	-85.8	-146.8	→	-1.330	in
Eye re H-point Z	720.2	720.2	720.2	→	43.354	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM5_HIP_X	-0.311	in
POSTURE_DHM5_HIP_Z	14.472	in
POSTURE_DHM5_EYE_X	-1.330	in
POSTURE_DHM5_EYE_Z	43.354	in

GVSC CAD Model Geometry

Side View

Front View

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Test #9: Longest Legs Male

DEVCOM

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-12.2	-41.2	-84.2	→	-0.480	in
Hip re H-point Z	-11.7	-11.7	-11.7	→	14.540	in
Eye re H-point X	-38.4	-90.4	-151.4	→	-1.512	in
Eye re H-point Z	665.1	665.1	665.1	→	41.185	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM6_HIP_X	-0.480	in
POSTURE_DHM6_HIP_Z	14.540	in
POSTURE_DHM6_EYE_X	-1.512	in
POSTURE_DHM6_EYE_Z	41.185	in

GVSC CAD Model Geometry

Side View

Front View

Test #9: Large Overall Male

DEVCOM

UMTRI Spreadsheet Calculations*

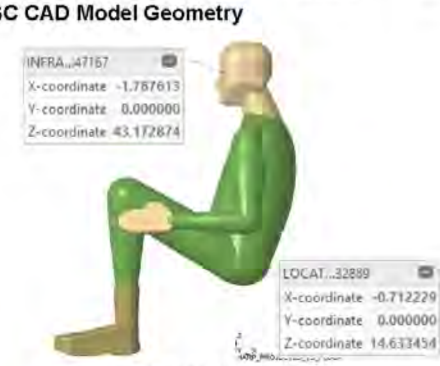
	ACU	PPE	ENC			
Hip re H-point X	-18.1	-47.1	-90.1	→	-0.712	in
Hip re H-point Z	-9.3	-9.3	-9.3	→	14.633	in
Eye re H-point X	-45.4	-97.4	-158.4	→	-1.788	in
Eye re H-point Z	715.6	715.6	715.6	→	43.173	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM7_HIP_X	-0.712	in
POSTURE_DHM7_HIP_Z	14.633	in
POSTURE_DHM7_EYE_X	-1.788	in
POSTURE_DHM7_EYE_Z	43.173	in

GVSC CAD Model Geometry



Side View

Front View

10.7.10 TEST #10 – PROVIDE HYDRATION PACK RELIEF

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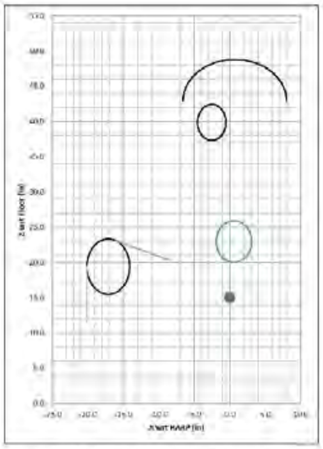
TEST #10: PROVIDE HYDRATION PACK RELIEF

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	50%	ENC	15.0	10.0	SAE J826	Yes

Basic Accommodation



UMTRI Spreadsheet

GVSC CAD Model

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TEST #10: HYDRATION PACK RELIEF EFFECTS

Test #	Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
8	90%	50%	PPE	15.0	10.0	SAE J826	No
10	90%	50%	ENC	15.0	10.0	SAE J826	Yes

Note: Highlighted values differ from comparison test.

Observations/Notes

- The model assumes that providing Hydration Pack Relief completely negates the fore/aft offset that otherwise exists between the PPE and ENC ensembles.

Side View

— Test #8
Test #10

Front View

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TEST #10: RESULTS, ACCOMMODATION

HARP	UMTRI Value		GVSC Value		Difference	
HARP_X	0.000	in	0.000	in	0.000	in
HARP_Z	15.000	in	15.000	in	0.000	in

Eyellipse	UMTRI Value		GVSC Value		Difference	
EYELLIPSE_CENTROID_X	-2.540	in	-2.540	in	0.000	in
EYELLIPSE_CENTROID_Y (+/-)	1.280	in	1.280	in	0.000	in
EYELLIPSE_CENTROID_Z	39.880	in	39.880	in	0.000	in
EYELLIPSE_X_AXIS_LENGTH	3.993	in	3.995	in	0.002	in
EYELLIPSE_Y_AXIS_LENGTH	1.988	in	1.990	in	0.001	in
EYELLIPSE_Z_AXIS_LENGTH	5.098	in	5.097	in	0.000	in

Helmet Contour	UMTRI Value		GVSC Value		Difference	
HELMET_CONTOUR_CENTROID_X	0.708	in	0.708	in	0.000	in
HELMET_CONTOUR_CENTROID_Y (+/-)	2.185	in	2.185	in	0.000	in
HELMET_CONTOUR_CENTROID_Z	42.865	in	42.865	in	0.000	in
HELMET_CONTOUR_X_AXIS_LENGTH	14.596	in	14.597	in	0.002	in
HELMET_CONTOUR_Y_AXIS_LENGTH	9.657	in	9.659	in	0.001	in
HELMET_CONTOUR_Z_AXIS_LENGTH	11.869	in	11.869	in	0.000	in

Knee Contour	UMTRI Value		GVSC Value		Difference	
KNEE_CONTOUR_WEIGHTED_CENT_X	-17.097	in	-17.097	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Y (+/-)	7.135	in	7.135	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Z	19.425	in	19.425	in	0.000	in
KNEE_CONTOUR_X_AXIS_LENGTH	6.029	in	6.029	in	0.000	in
KNEE_CONTOUR_Y_AXIS_LENGTH	9.212	in	9.214	in	0.001	in
KNEE_CONTOUR_Z_AXIS_LENGTH	7.843	in	7.843	in	0.000	in
KNEE_SHIN_ANGLE	0.000	deg	0.000	deg	0.000	deg
KNEE_THIGH_ANGLE	20.167	deg	20.167	deg	0.000	deg

Elbow Contour	UMTRI Value		GVSC Value		Difference	
ELBOW_WEIGHTED_CENT_X	0.582	in	0.582	in	0.000	in
ELBOW_WEIGHTED_CENT_Y	14.084	in	14.084	in	0.000	in
ELBOW_WEIGHTED_CENT_Z	22.998	in	22.998	in	0.000	in
ELBOW_X_AXIS_LENGTH	5.006	in	5.009	in	0.003	in
ELBOW_Y_AXIS_LENGTH	3.857	in	3.857	in	0.000	in
ELBOW_Z_AXIS_LENGTH	5.843	in	5.845	in	0.002	in

Boot Contour	UMTRI Value		GVSC Value		Difference	
BOOT_TOE_WEIGHTED_CENT_X	-25.302	in	-25.302	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Y	7.135	in	7.135	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Z	0.000	in	0.000	in	0.000	in
BOOT_TOE_X_AXIS_LENGTH	2.988	in	2.989	in	0.001	in
BOOT_TOE_Y_AXIS_LENGTH	8.882	in	8.883	in	0.001	in
BOOT_TOE_Z_AXIS_LENGTH	4.321	in	4.321	in	0.000	in

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

Largest Observed Differences:
0.003 inches
0.000 degrees

Values in agreement

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TEST #10: SEAT HARP

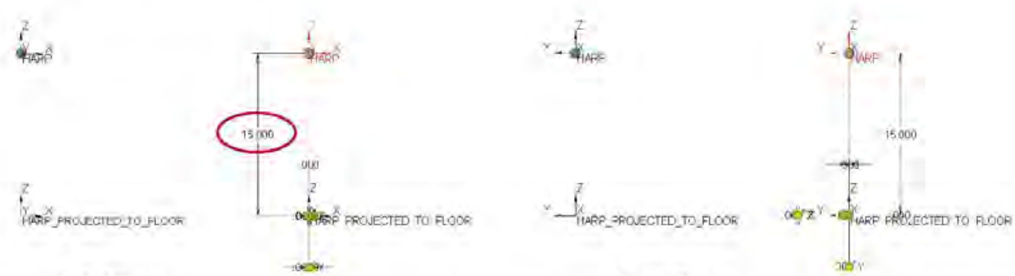
UMTRI Spreadsheet Calculations

	X (in)	Z (in)
HARP	0.000	15.000

GVSC CAD Model Calculations

HARP_X	0.000	in
HARP_Z	15.000	in

GVSC CAD Model Geometry



Side View **Front View**

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TEST #10: EYELLIPSE

UMTRI Spreadsheet Calculations

Eyellipse Centroids	X (in)	Y (in)	Z (in)
Right	-2.540	1.280*	39.880
Left	-2.540	-1.280*	39.880

Side View of Eyellipses (X, Z)		
Axis Length (X)	3.993	in
Axis Length (Z)	5.098	in

Rear View of Eyellipses (Y, Z)		
Axis Length (Y)	1.988	in
Axis Length (Z)	5.098	in

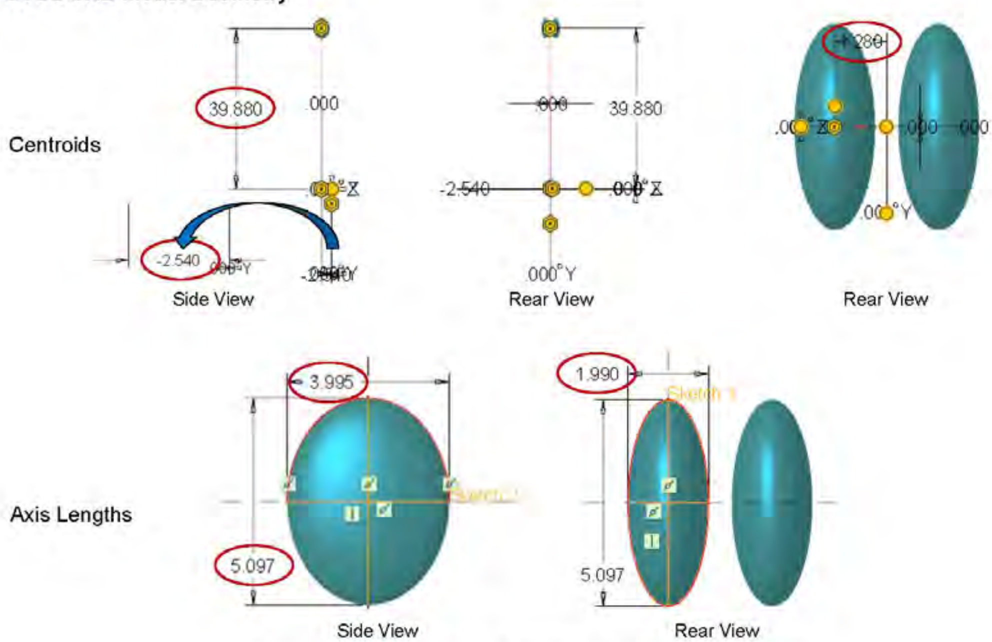
GVSC CAD Model Calculations

EYELLIPSE_CENTROID_X	-2.540	in
EYELLIPSE_CENTROID_Y	1.280*	in
EYELLIPSE_CENTROID_Z	39.880	in
EYELLIPSE_X_AXIS_LENGTH	3.995	in
EYELLIPSE_Y_AXIS_LENGTH	1.990	in
EYELLIPSE_Z_AXIS_LENGTH	5.097	in

*Given value, not calculated

TEST #10: EYELLIPSE (CONT.)

GVSC CAD Model Geometry



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TEST #10: HELMET CONTOUR

UMTRI Spreadsheet Calculations

Construction Centroids	X (in)	Y (in)	Z (in)
Right	0.708	2.185*	42.865
Left	0.708	-2.185*	42.865

Side View of Helmet Contour (X, Z)		
Axis Length (X)	14.596	in
Axis Length (Z)	11.869	in

Rear View of Helmet Contour (Y, Z)		
Axis Length (Y)	9.657	in
Axis Length (Z)	11.869	in

GVSC CAD Model Calculations

HELMET_CONTOUR_CENTROID_X	0.708	in
HELMET_CONTOUR_CENTROID_Y	2.185*	in
HELMET_CONTOUR_CENTROID_Z	42.865	in
HELMET_CONTOUR_X_AXIS_LENGTH	14.597	in
HELMET_CONTOUR_Y_AXIS_LENGTH	9.659	in
HELMET_CONTOUR_Z_AXIS_LENGTH	11.869	in

*Given value, not calculated

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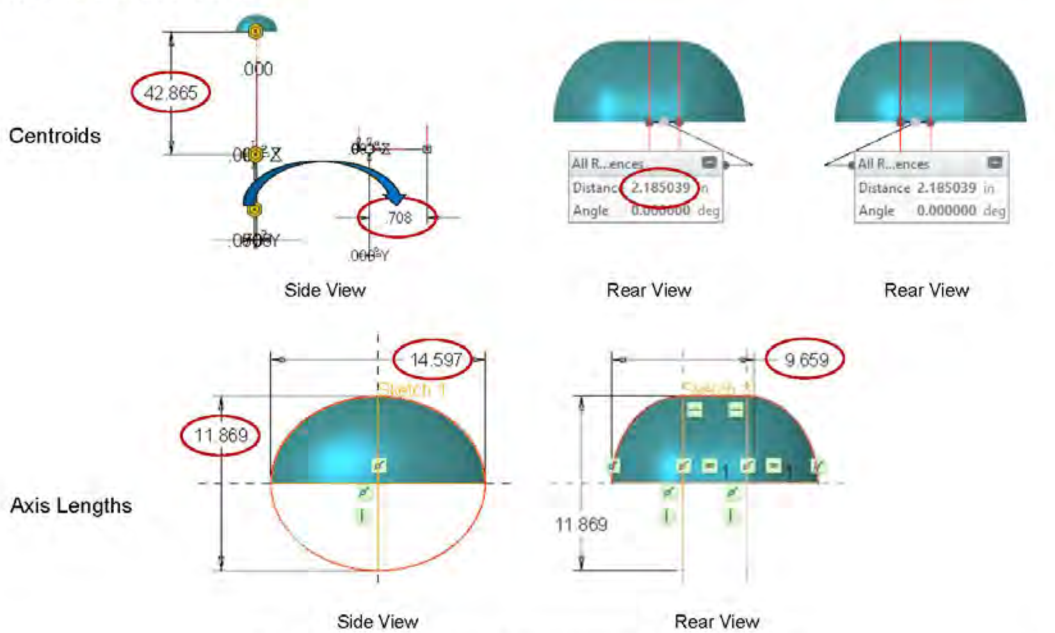
TEST #10: HELMET CONTOUR (CONT.)

GVSC CAD Model Result



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TEST #10: KNEE CONTOUR

UMTRI Spreadsheet Calculations

Knee Centroids	X (in)	Y (in)	Z (in)
Right	-17.097	7.135	19.425
Left	-17.097	-7.135	19.425

Side View of Knee Contours (X, Z)		
Axis Length (X)	6.029	in
Axis Length (Z)	7.843	in

Rear View of Knee Contours (Y, Z)		
Axis Length (Y)	9.212	in
Axis Length (Z)	7.843	in

Leg Segment Angle wrt Vertical	0.000*	deg
Thigh Segment Angle wrt Horizontal	20.167	deg

GVSC CAD Model Calculations

KNEE_CONTOUR_WEIGHTED_CENT_X	-17.097	in
KNEE_CONTOUR_WEIGHTED_CENT_Y	7.135	in
KNEE_CONTOUR_WEIGHTED_CENT_Z	19.425	in
KNEE_CONTOUR_X_AXIS_LENGTH	6.029	in
KNEE_CONTOUR_Y_AXIS_LENGTH	9.214	in
KNEE_CONTOUR_Z_AXIS_LENGTH	7.843	in
KNEE_SHIN_ANGLE	0.000*	deg
KNEE_THIGH_ANGLE	20.167	deg

*Given value, not calculated

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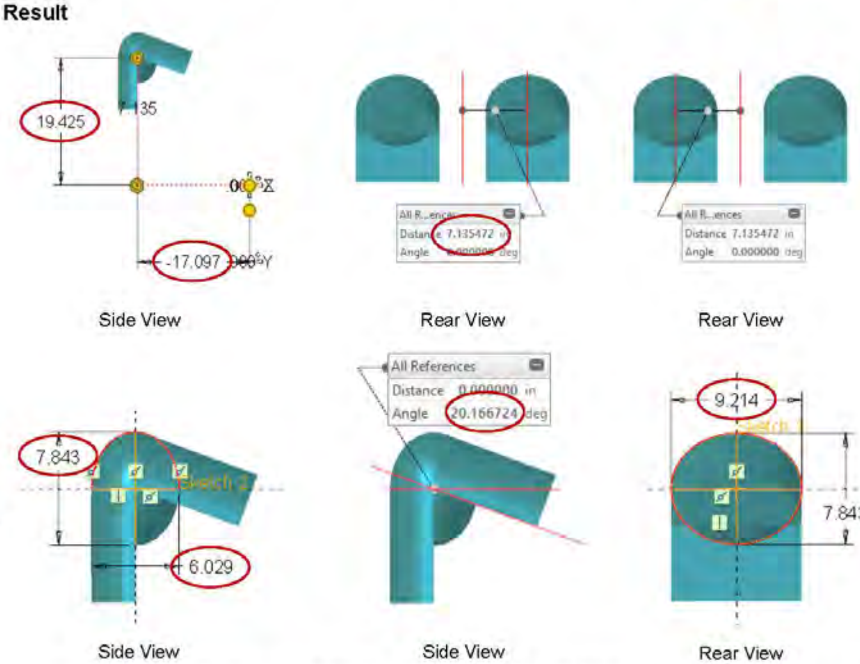
TEST #10: KNEE CONTOUR (CONT.)

GVSC CAD Model Result

Centroids

Axis Lengths
Shin/Thigh Angles



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TEST #10: ELBOW CONTOUR

UMTRI Spreadsheet Calculations

Elbow Centroids	X (in)	Y (in)	Z (in)
Right	0.582	14.084	22.988
Left	0.582	-14.084	22.988

Side View of Elbow Contours (X, Z)		
Axis Length (X)	5.006	in
Axis Length (Z)	5.843	in

Rear View of Elbow Contours (Y, Z)		
Axis Length (Y)	3.857	in
Axis Length (Z)	5.843	in

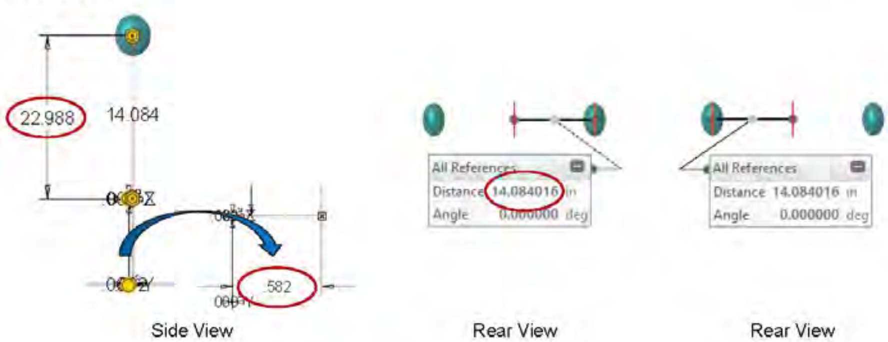
GVSC CAD Model Calculations

ELBOW_WEIGHTED_CENT_X	0.582	in
ELBOW_WEIGHTED_CENT_Y	14.084	in
ELBOW_WEIGHTED_CENT_Z	22.988	in
ELBOW_X_AXIS_LENGTH	5.009	in
ELBOW_Y_AXIS_LENGTH	3.857	in
ELBOW_Z_AXIS_LENGTH	5.845	in

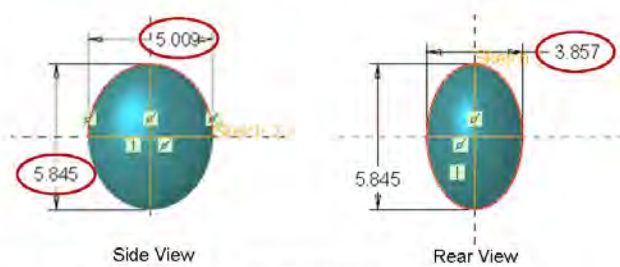
TEST #10: ELBOW CONTOUR (CONT.)

GVSC CAD Model Result

Centroids



Axis Lengths



TEST #10: BOOT CONTOUR

UMTRI Spreadsheet Calculations

Boot Centroids	X (in)	Y (in)	Z (in)
Right	-25.302	7.135	0.000
Left	-25.302	-7.135	0.000

Side View of Boot Contours (X, Z)		
Axis Length (X)	2.988	in
Axis Length (Z)	4.921	in

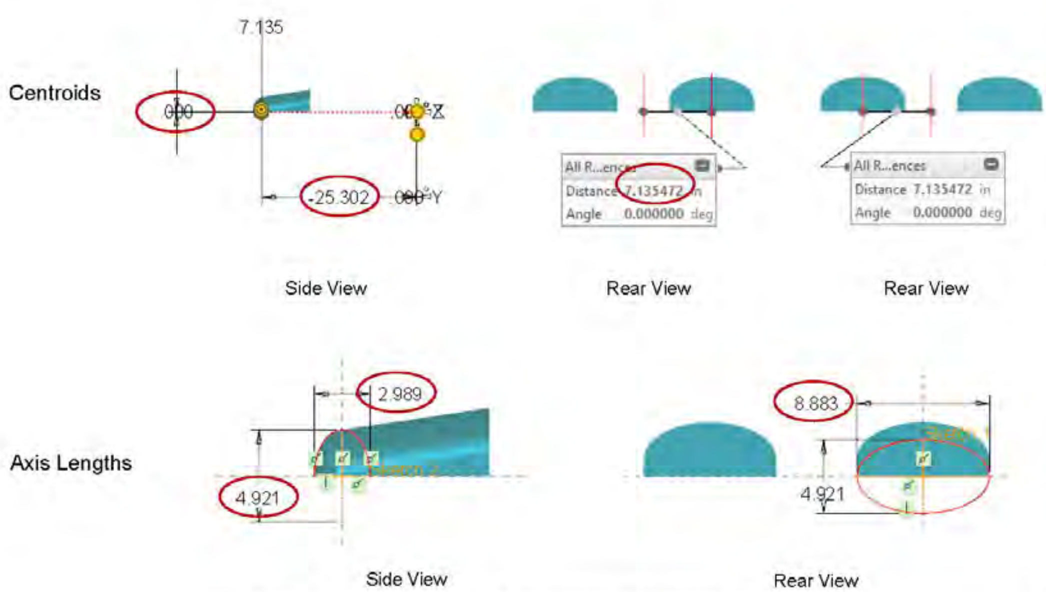
Rear View of Boot Contours (Y, Z)		
Axis Length (Y)	8.882	in
Axis Length (Z)	4.921	in

GVSC CAD Model Calculations

BOOT_TOE_WEIGHTED_CENT_X	-25.302	in
BOOT_TOE_WEIGHTED_CENT_Y	7.135	in
BOOT_TOE_WEIGHTED_CENT_Z	0.000	in
BOOT_TOE_X_AXIS_LENGTH	2.989	in
BOOT_TOE_Y_AXIS_LENGTH	8.883	in
BOOT_TOE_Z_AXIS_LENGTH	4.921	in

TEST #10: BOOT CONTOUR (CONT.)

GVSC CAD Model Result



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TEST #10: PROVIDE HYDRATION PACK RELIEF

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	50%	ENC	15.0	10.0	SAE J826	Yes

Clearance (2.0 inches), Shown in Yellow

GVSC CAD Model

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 359

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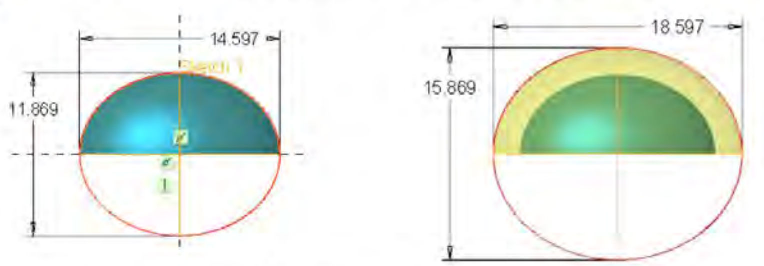
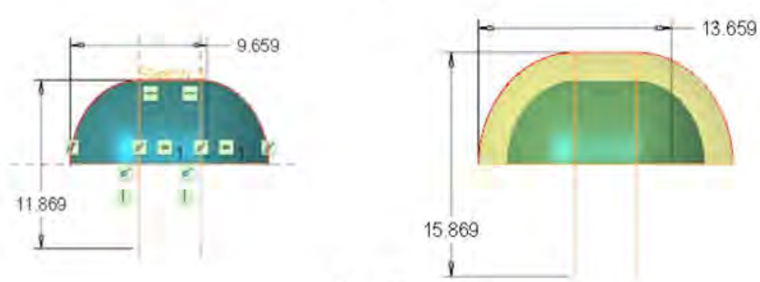
TEST #10: CLEARANCE, HELMET CONTOUR



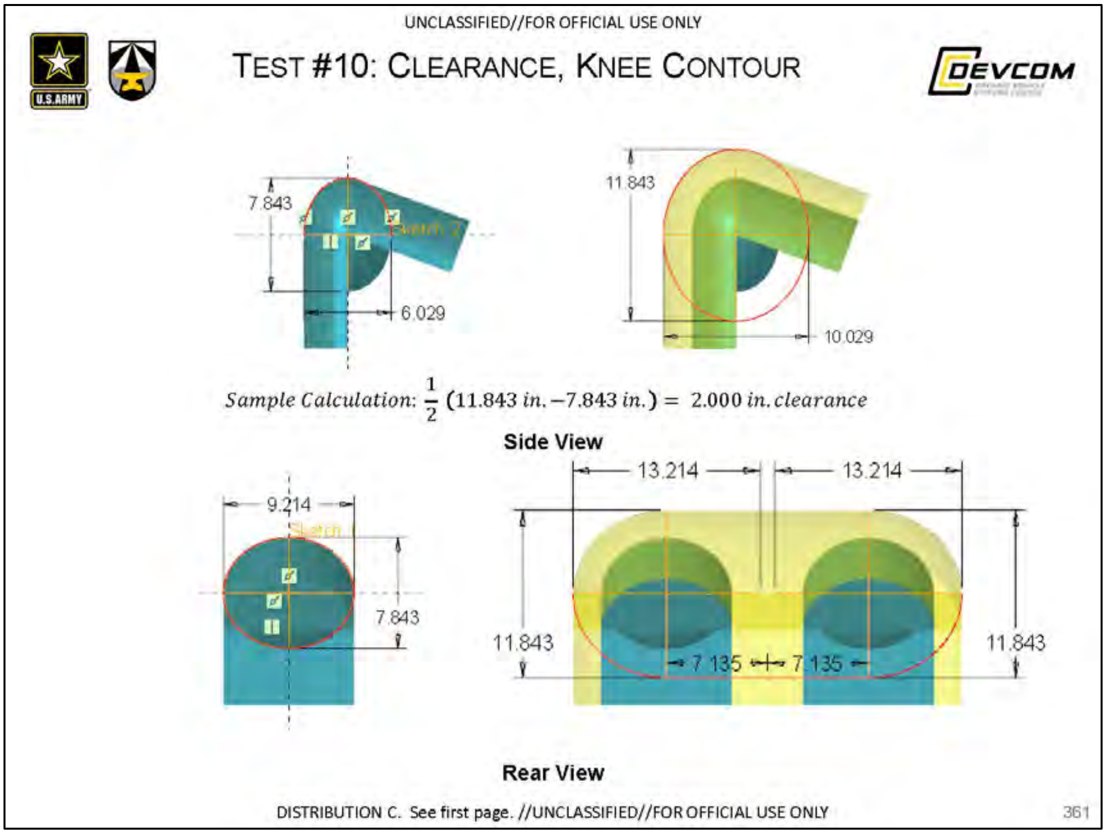
$$Sample\ Calculation:\ \frac{1}{2}\,(18.597\ in. - 14.597\ in.) = \ 2.000\ in.\ clearance$$

Side View



Rear View

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 360


UNCLASSIFIED//FOR OFFICIAL USE ONLY
TEST #10: CLEARANCE, KNEE CONTOUR
DEVCOM
7.843
6.029
11.843
10.029
Sample Calculation: $\frac{1}{2}$ (11.843 in. − 7.843 in.) = 2.000 in. clearance
Side View
9.214
7.843
13.214
13.214
11.843
7.135
7.135
11.843
Rear View
DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY
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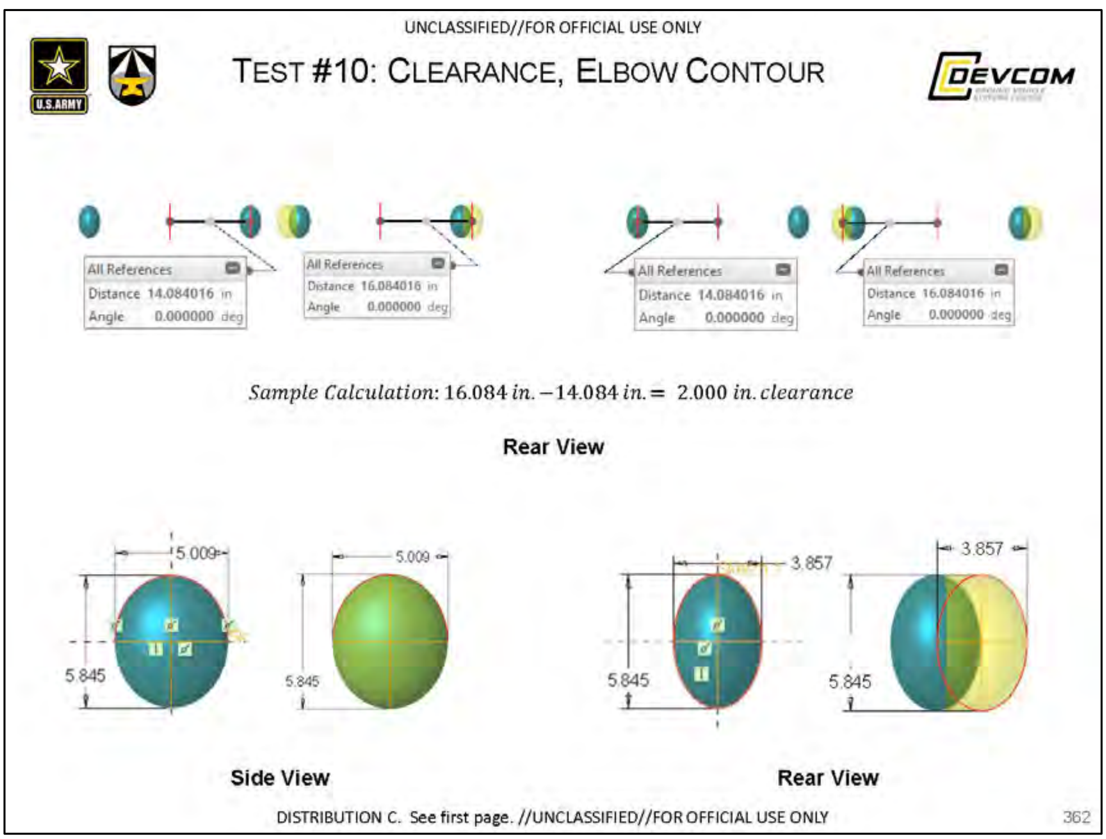
UNCLASSIFIED//FOR OFFICIAL USE ONLY
TEST #10: CLEARANCE, ELBOW CONTOUR
DEVCOM
All References
Distance 14.084016 in
Angle 0.000000 deg
All References
Distance 16.084016 in
Angle 0.000000 deg
All References
Distance 14.084016 in
Angle 0.000000 deg
All References
Distance 16.084016 in
Angle 0.000000 deg
Sample Calculation: 16.084 in. − 14.084 in. = 2.000 in. clearance
Rear View
5.009
5.845
5.009
5.845
3.857
5.845
3.857
5.845
Side View
Rear View
DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY
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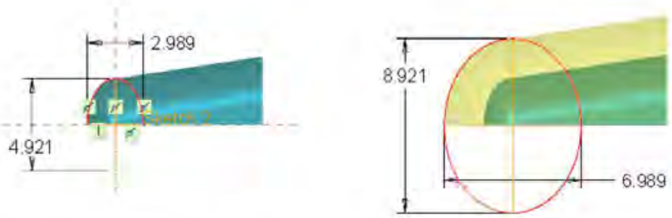
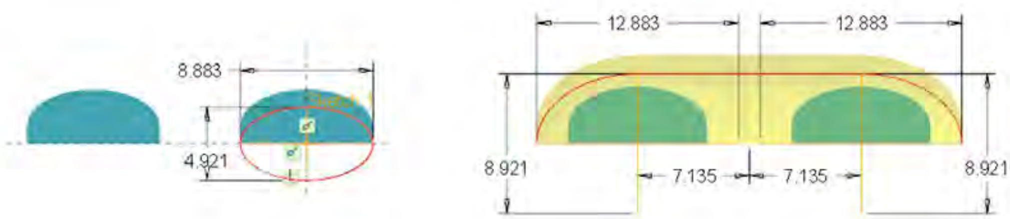
TEST #10: CLEARANCE, BOOT CONTOUR



$$Sample\ Calculation: \frac{1}{2}(8.921\ in. - 4.921\ in.) = 2.000\ in.\ clearance$$

Side View



Rear View

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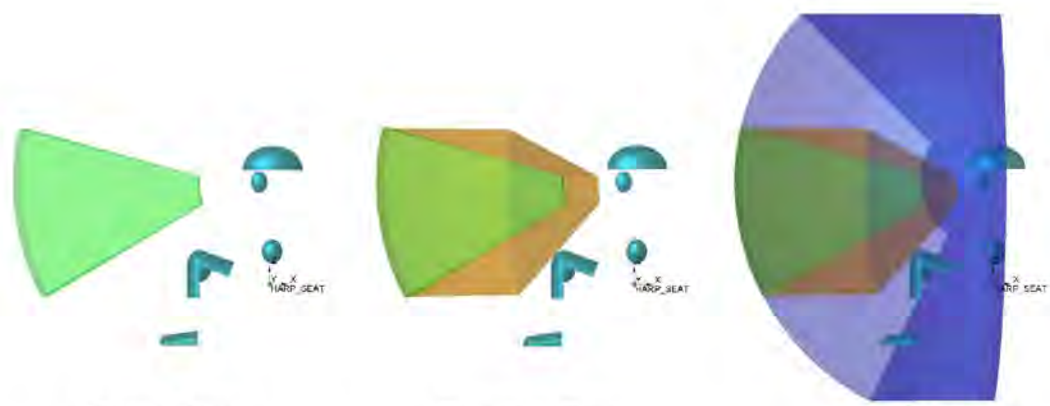
TEST #10: PROVIDE HYDRATION PACK RELIEF

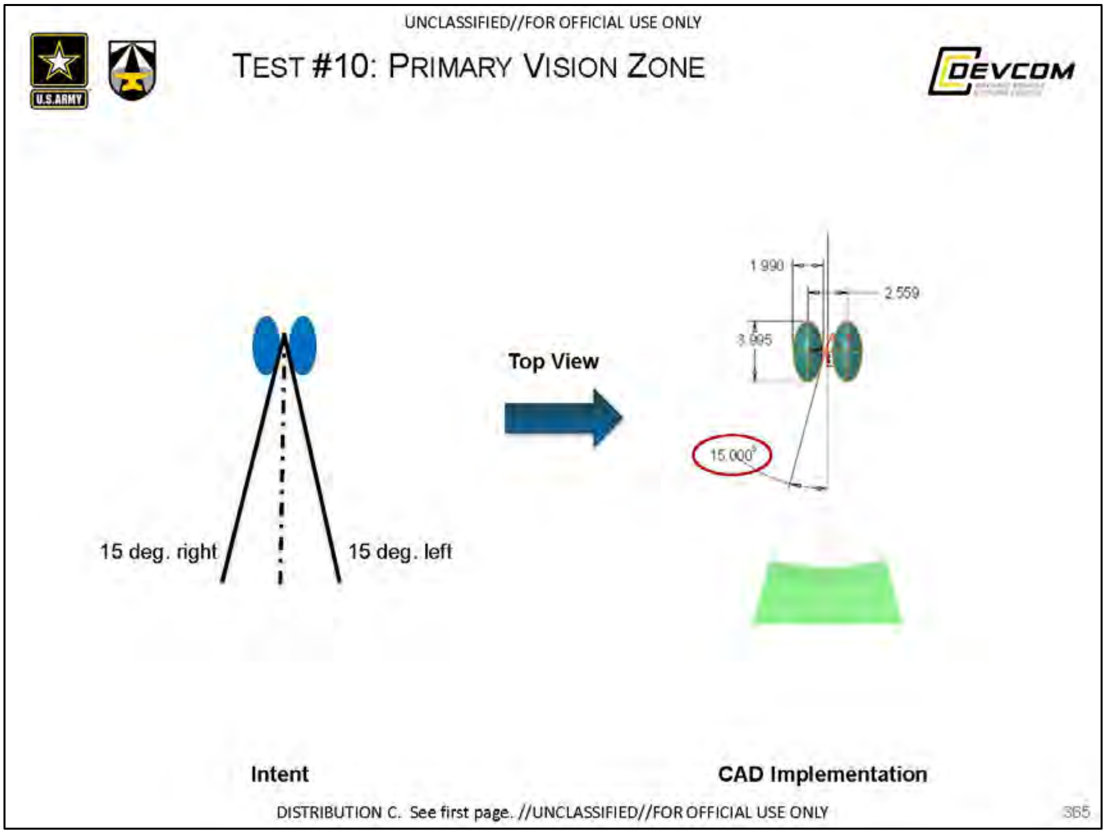
Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	50%	ENC	15.0	10.0	SAE J826	Yes

Vision Zones

Vison zones are constructed geometrically; no calculations are involved.



Primary Zone Secondary Zone Tertiary Zone


UNCLASSIFIED//FOR OFFICIAL USE ONLY
TEST #10: PRIMARY VISION ZONE
Top View
15 deg. right
15 deg. left
1.990
2.559
3.995
15.000°
Intent
CAD Implementation
DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY
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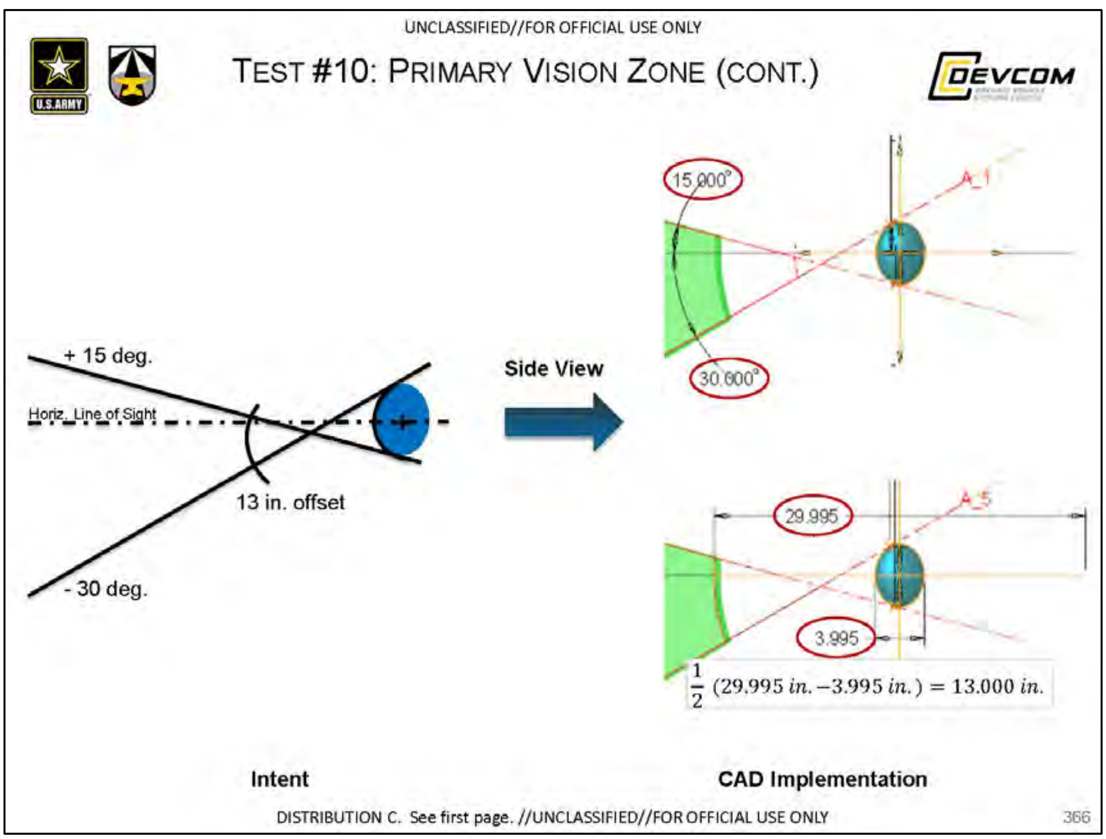
UNCLASSIFIED//FOR OFFICIAL USE ONLY
TEST #10: PRIMARY VISION ZONE (CONT.)
Side View
+ 15 deg.
Horiz. Line of Sight
13 in. offset
- 30 deg.
15.000°
30.000°
A_1
29.995
3.995
A_5
$\frac{1}{2}$ (29.995 in. −3.995 in.) = 13.000 in.
Intent
CAD Implementation
DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY
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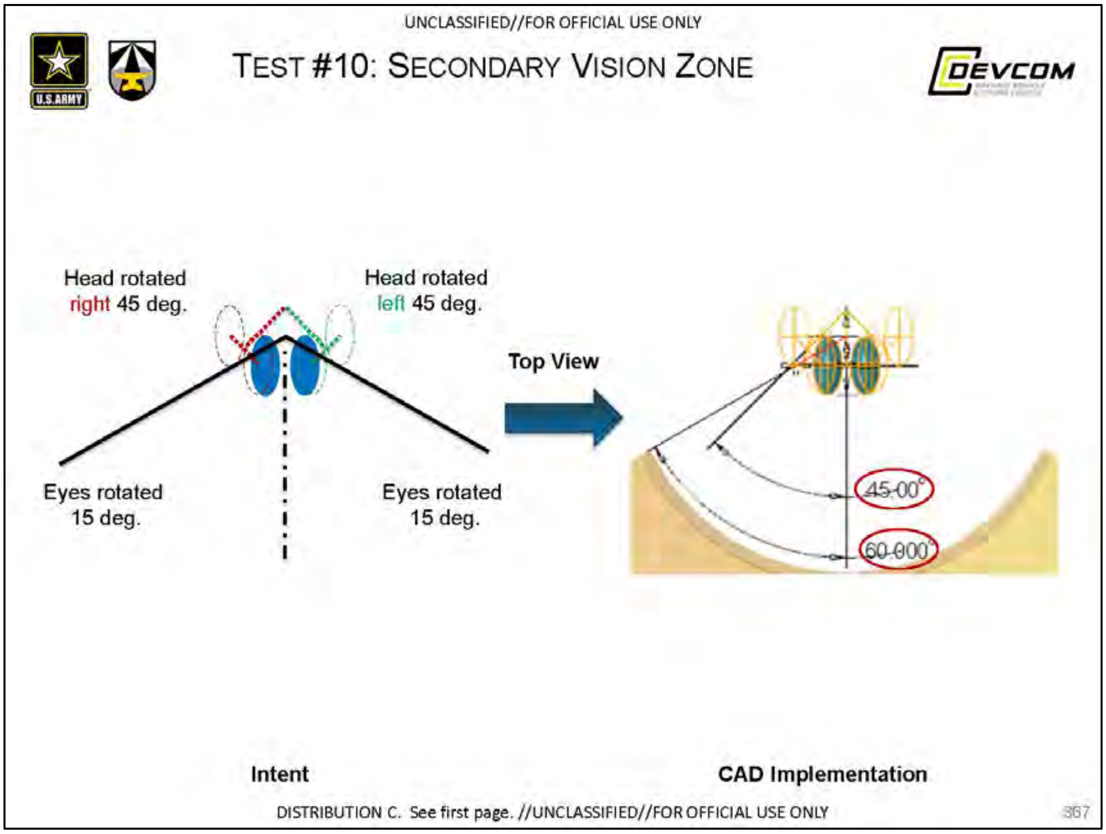
UNCLASSIFIED//FOR OFFICIAL USE ONLY
TEST #10: SECONDARY VISION ZONE
DEVCOM
Head rotated right 45 deg.
Head rotated left 45 deg.
Eyes rotated 15 deg.
Eyes rotated 15 deg.
Top View
45.00°
60.000°
Intent
CAD Implementation
DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY
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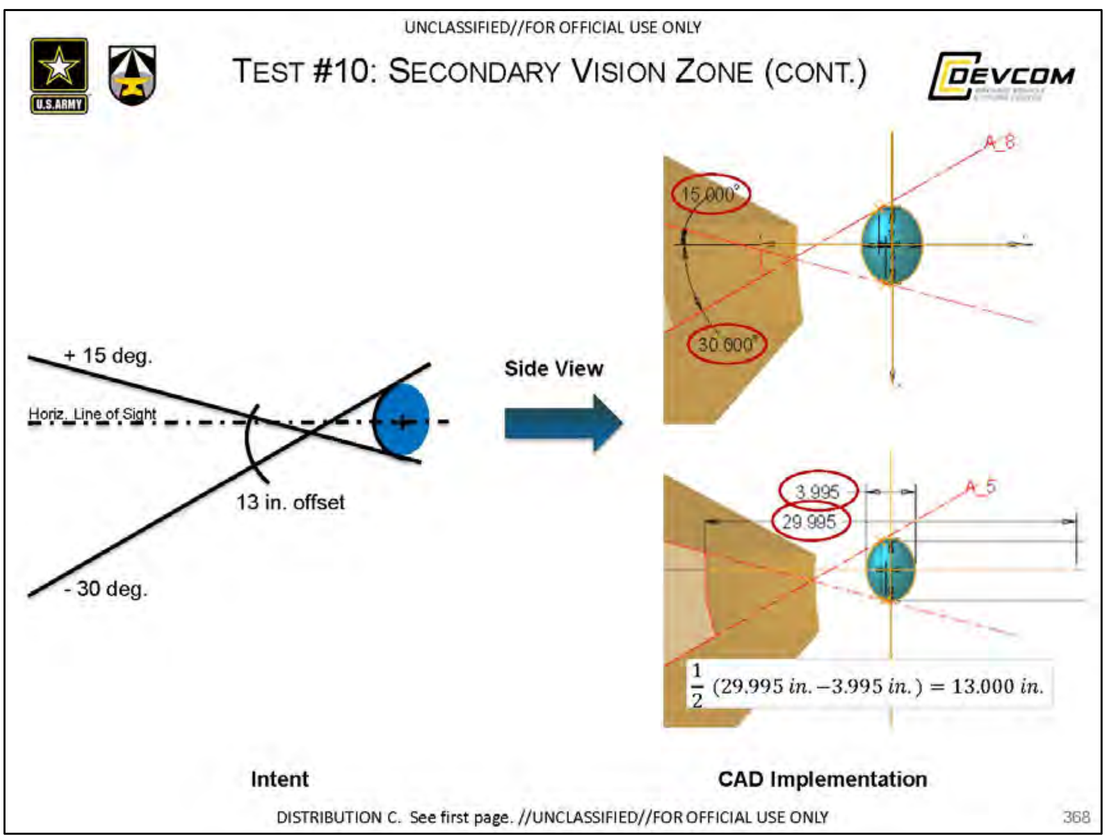
UNCLASSIFIED//FOR OFFICIAL USE ONLY
TEST #10: SECONDARY VISION ZONE (CONT.)
DEVCOM
+ 15 deg.
Horiz. Line of Sight
13 in. offset
- 30 deg.
Side View
A_8
15.000°
30.000°
3.995
29.995
A_5
1/2 (29.995 in. −3.995 in.) = 13.000 in.
Intent
CAD Implementation
DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY
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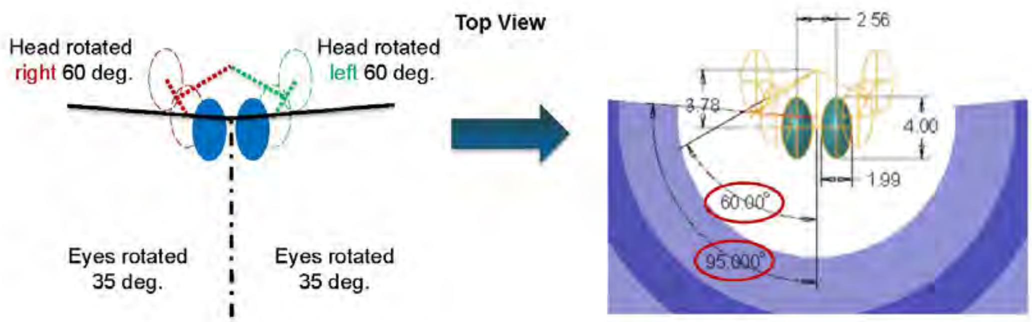
TEST #10: TERTIARY VISION ZONE



Intent **CAD Implementation**

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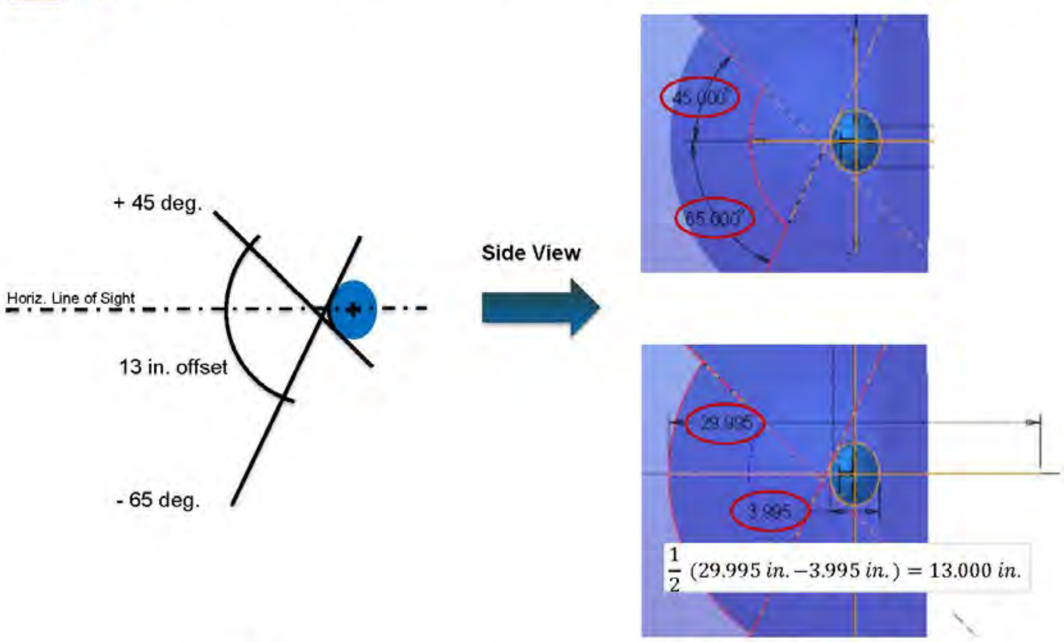
TEST #10: TERTIARY VISION ZONE (CONT.)



Intent **CAD Implementation**

DISTRIBUTION C. See first page. //UNCLASSIFIED//FOR OFFICIAL USE ONLY 370

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Test #10: Provide Hydration Pack Relief

Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	Seat Back Angle (deg.) (A40)	HARP Measurement Tool	Hydration Pack Relief Availability
90%	50%	ENC	15.0	10.0	SAE J826	Yes

Boundary Manikin Posture and Position

GVSC CAD Model

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Test #10: Results, Manikin Positioning

	UMTRI Value		GVSC Value		Difference	
Small Overall Female						
POSTURE_DHM1_HIP_X	-1.233	in	-1.233	in	0.000	in
POSTURE_DHM1_HIP_Z	14.384	in	14.384	in	0.000	in
POSTURE_DHM1_EYE_X	-1.544	in	-1.544	in	0.000	in
POSTURE_DHM1_EYE_Z	36.577	in	36.577	in	0.000	in
Small Overall Male						
POSTURE_DHM2_HIP_X	-1.496	in	-1.496	in	0.000	in
POSTURE_DHM2_HIP_Z	14.489	in	14.489	in	0.000	in
POSTURE_DHM2_EYE_X	-2.253	in	-2.253	in	0.000	in
POSTURE_DHM2_EYE_Z	38.474	in	38.474	in	0.000	in
Average Size Male						
POSTURE_DHM3_HIP_X	-1.494	in	-1.494	in	0.000	in
POSTURE_DHM3_HIP_Z	14.488	in	14.488	in	0.000	in
POSTURE_DHM3_EYE_X	-2.994	in	-2.994	in	0.000	in
POSTURE_DHM3_EYE_Z	40.824	in	40.824	in	0.000	in
Widest Shoulders Male						
POSTURE_DHM4_HIP_X	-1.467	in	-1.467	in	0.000	in
POSTURE_DHM4_HIP_Z	14.478	in	14.478	in	0.000	in
POSTURE_DHM4_EYE_X	-3.368	in	-3.368	in	0.000	in
POSTURE_DHM4_EYE_Z	42.179	in	42.179	in	0.000	in
Longest Torso Male						
POSTURE_DHM5_HIP_X	-1.453	in	-1.453	in	0.000	in
POSTURE_DHM5_HIP_Z	14.472	in	14.472	in	0.000	in
POSTURE_DHM5_EYE_X	-3.377	in	-3.377	in	0.000	in
POSTURE_DHM5_EYE_Z	43.354	in	43.354	in	0.000	in
Longest Legs Male						
POSTURE_DHM6_HIP_X	-1.622	in	-1.622	in	0.000	in
POSTURE_DHM6_HIP_Z	14.540	in	14.540	in	0.000	in
POSTURE_DHM6_EYE_X	-3.559	in	-3.559	in	0.000	in
POSTURE_DHM6_EYE_Z	41.185	in	41.185	in	0.000	in
Large Overall Male						
POSTURE_DHM7_HIP_X	-1.654	in	-1.654	in	0.000	in
POSTURE_DHM7_HIP_Z	14.633	in	14.633	in	0.000	in
POSTURE_DHM7_EYE_X	-3.835	in	-3.835	in	0.000	in
POSTURE_DHM7_EYE_Z	43.173	in	43.173	in	0.000	in

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

Largest Observed Differences:
0.000 inches

Values in agreement

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TEST #10: SMALL OVERALL FEMALE

DEVCOM

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-2.3	-31.3	-74.3	→	-1.233	in
Hip re H-point Z	-15.7	-15.7	-15.7	→	14.384	in
Eye re H-point X	12.8	-39.2	-100.2	→	-1.544	in
Eye re H-point Z	548.1	548.1	548.1	→	36.577	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM1_HIP_X	-1.233	in
POSTURE_DHM1_HIP_Z	14.384	in
POSTURE_DHM1_EYE_X	-1.544	in
POSTURE_DHM1_EYE_Z	36.577	in

GVSC CAD Model Geometry

Side View

Front View

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TEST #10: SMALL OVERALL MALE

DEVCOM

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-9.0	-38.0	-81.0	→	-1.496	in
Hip re H-point Z	-13.0	-13.0	-13.0	→	14.489	in
Eye re H-point X	-5.2	-57.2	-118.2	→	-2.253	in
Eye re H-point Z	596.3	596.3	596.3	→	38.474	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM2_HIP_X	-1.496	in
POSTURE_DHM2_HIP_Z	14.489	in
POSTURE_DHM2_EYE_X	-2.253	in
POSTURE_DHM2_EYE_Z	38.474	in

GVSC CAD Model Geometry

Side View

Front View

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TEST #10: AVERAGE SIZE MALE

DEVCOM

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-8.9	-37.9	-80.9	→	-1.494	in
Hip re H-point Z	-13.0	-13.0	-13.0	→	14.488	in
Eye re H-point X	-24.0	-76.0	-137.0	→	-2.994	in
Eye re H-point Z	655.9	655.9	655.9	→	40.824	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM3_HIP_X	-1.494	in
POSTURE_DHM3_HIP_Z	14.488	in
POSTURE_DHM3_EYE_X	-2.994	in
POSTURE_DHM3_EYE_Z	40.824	in

GVSC CAD Model Geometry

Side View Front View

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TEST #10: WIDEST SHOULDERS MALE

DEVCOM

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-8.3	-37.3	-80.3	→	-1.467	in
Hip re H-point Z	-13.3	-13.3	-13.3	→	14.478	in
Eye re H-point X	-33.5	-85.5	-146.5	→	-3.368	in
Eye re H-point Z	690.3	690.3	690.3	→	42.179	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM4_HIP_X	-1.467	in
POSTURE_DHM4_HIP_Z	14.478	in
POSTURE_DHM4_EYE_X	-3.368	in
POSTURE_DHM4_EYE_Z	42.179	in

GVSC CAD Model Geometry

Side View Front View

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TEST #10: LONGEST TORSO MALE

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-7.9	-36.9	-79.9	→	-1.453	in
Hip re H-point Z	-13.4	-13.4	-13.4	→	14.472	in
Eye re H-point X	-33.8	-85.8	-146.8	→	-3.377	in
Eye re H-point Z	720.2	720.2	720.2	→	43.354	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM5_HIP_X	-1.453	in
POSTURE_DHM5_HIP_Z	14.472	in
POSTURE_DHM5_EYE_X	-3.377	in
POSTURE_DHM5_EYE_Z	43.354	in

GVSC CAD Model Geometry

Side View

Front View

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TEST #10: LONGEST LEGS MALE

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-12.2	-41.2	-84.2	→	-1.622	in
Hip re H-point Z	-11.7	-11.7	-11.7	→	14.540	in
Eye re H-point X	-38.4	-90.4	-151.4	→	-3.559	in
Eye re H-point Z	665.1	665.1	665.1	→	41.185	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM6_HIP_X	-1.622	in
POSTURE_DHM6_HIP_Z	14.540	in
POSTURE_DHM6_EYE_X	-3.559	in
POSTURE_DHM6_EYE_Z	41.185	in

GVSC CAD Model Geometry

Side View

Front View

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TEST #10: LARGE OVERALL MALE

UMTRI Spreadsheet Calculations*

	ACU	PPE	ENC			
Hip re H-point X	-18.1	-47.1	-90.1	→	-1.854	in
Hip re H-point Z	-9.3	-9.3	-9.3	→	14.633	in
Eye re H-point X	-45.4	-97.4	-158.4	→	-3.835	in
Eye re H-point Z	715.6	715.6	715.6	→	43.173	in

*Relevant values (highlighted) have been converted from millimeters to inches

GVSC CAD Model Calculations

POSTURE_DHM7_HIP_X	-1.854	in
POSTURE_DHM7_HIP_Z	14.633	in
POSTURE_DHM7_EYE_X	-3.835	in
POSTURE_DHM7_EYE_Z	43.173	in

GVSC CAD Model Geometry

Side View

Front View