Creation of the Driver Fixed Heel Point (FHP) CAD Accommodation Model for Military Ground Vehicles

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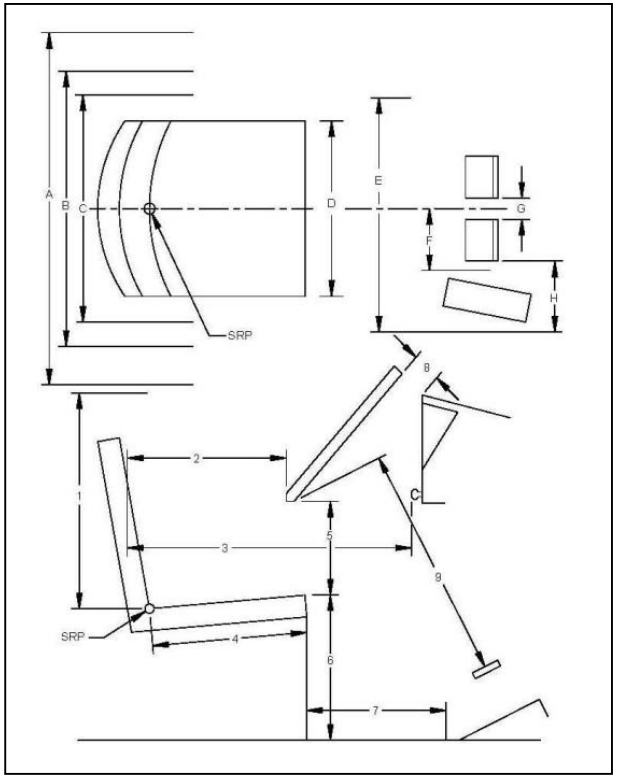
Background

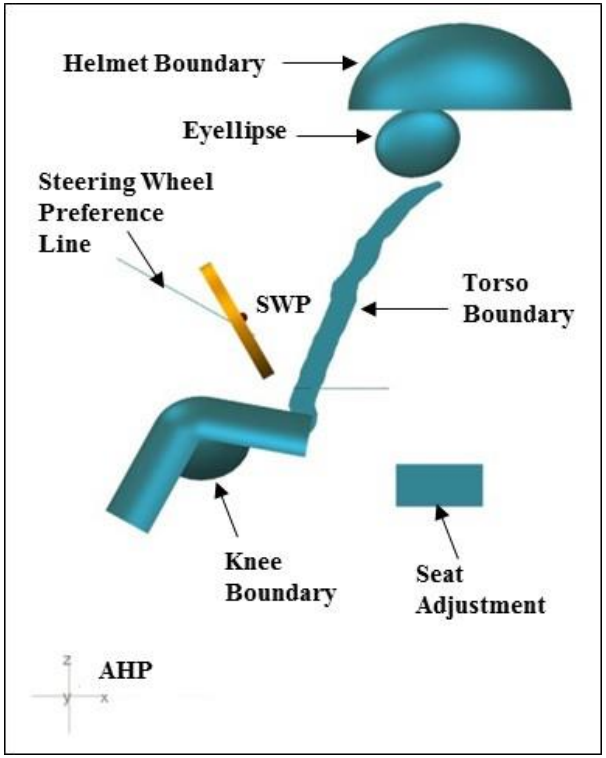
- MIL-STD-1472G, the *Department of Defense Design Criteria Standard: Human Engineering* (2012), defines basic vehicle workstation design using clearances, as shown at right
- Drawbacks of using this approach:
  - MIL-STD-1472G is open to interpretation
  - Dimensions do not relate directly to the Soldier
  - Soldier posture is not taken into account
  - Assumptions regarding clearances are not well documented



MIL-STD-1472
Clearances around equipment

Planned Approach

- Support the intent of MIL-STD-1472G with parametric Computer Aided Design (CAD) models
- Predict posture using Soldier-specific statistical population accommodation models that parallel long-standing Society of Automotive Engineers (SAE) recommended practices
- Demonstrate approach on the Fixed Heel Point (FHP) driving position, shown at right



FHP Accommodation Boundaries
Vehicle controlled via conventional steering wheel and accelerator pedal

Methods – *Seated Soldier Study*

- The *Seated Soldier Study* (2013) was completed by UMTRI to capture Soldier preferred posture and position data in a driving position while considering the following:
  - Unique environment found in military ground vehicles
  - Soldier clothing and equipment kits
- Data gathered on 145 enlisted men and women at three army posts
- Soldiers wore three levels of clothing and equipment
  - Advanced Combat Uniform (ACU)
  - Personal Protective Equipment (PPE)
    - PPE = ACU + (Improved Outer Tactical Vest (IOTV) and plates)
  - Encumbered (ENC)
    - ENC = ACU + PPE + (hydration pack, tactical assault panel (TAP) and Rifleman equipment kit)

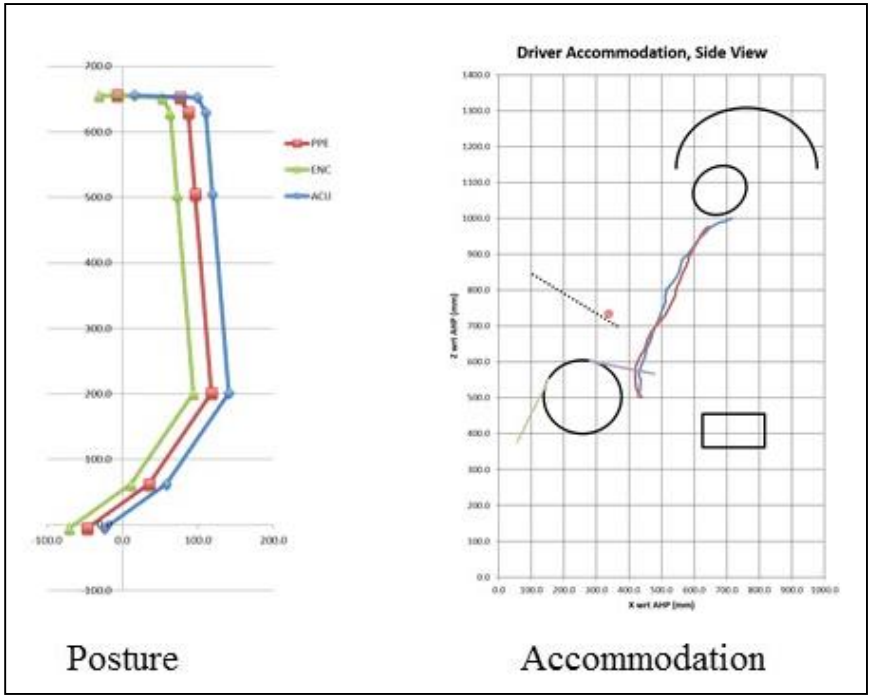
Methods – Seated Soldier Study

- Driver mockup simulates a Fixed Heel Point (FHP) driver workstation
  - Accelerator Pedal
  - Steering Wheel
  - Adjustable Seat
- Soldier's entered mockup and found their preferred driving position by adjusting the seat
  - Vertical and horizontal position
  - Seat back angle
- Each subject's posture and seat position was digitized

Soldier in Driver Mockup with ENC

Methods – Seated Soldier Study

- Data analysis was used to produce the following output:
  - Average postures for individuals as a function of body size and equipment level
  - Accommodation boundaries capturing posture variability for everyone across the target population
- Working models provided by UMTRI in the form of Microsoft Excel spreadsheets



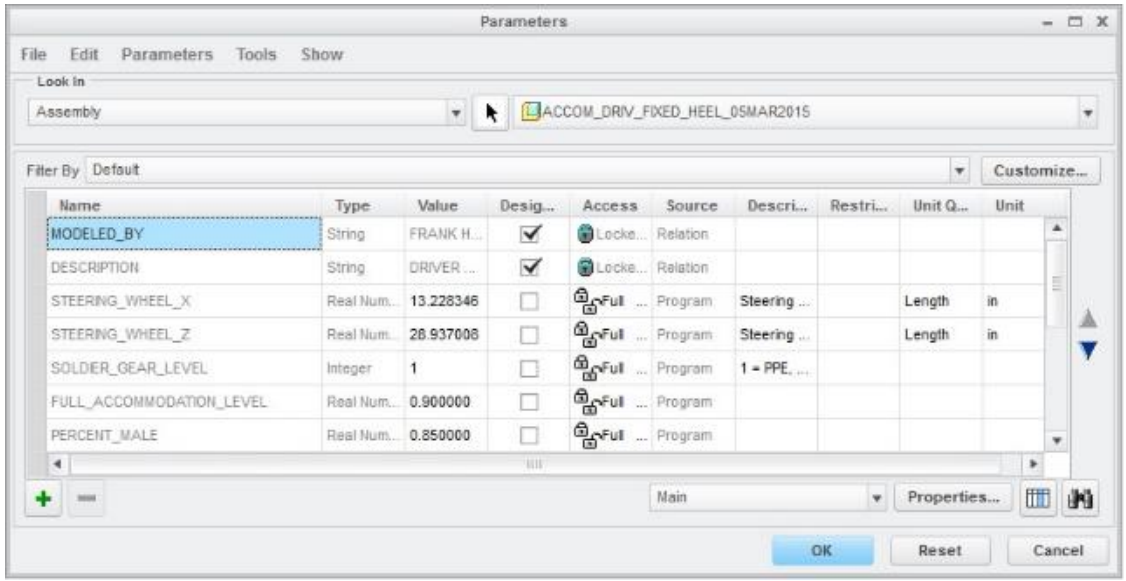
Microsoft EXCEL Workbook Output

Methods – CAD Development

- TARDEC Advanced Concepts Team (ACT) is creating a CAD version of the FHP accommodation model in PTC Creo® software
- Model is a stand-alone geometric reproduction of UMTRI's Microsoft Excel spreadsheet
- Minimum clearances were added to the model to the surrounding interior vehicle surfaces based on MIL-STD-1472G
- Direct vision zones are being created incorporating concepts from both MIL-STD-1472G and SAE Recommended Practice J1050, *Describing and Measuring the Driver's Field of View* (2009)
- Boundary manikins representing anthropometric extremes will be positioned to provide yet another reference for design and aid visualization

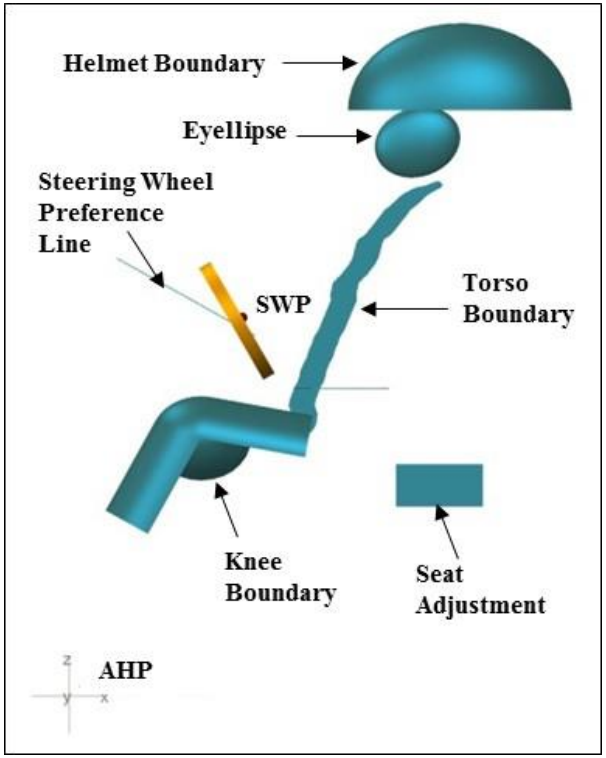
Results – CAD User Interface

- User interface created in the top assembly of the CAD model
- Logic built into model prevents need to manipulate geometry directly
- Inputs fall into three categories:
  - Soldier population
  - Accommodation level
  - Vehicle environment



Results – CAD Accommodation Boundaries

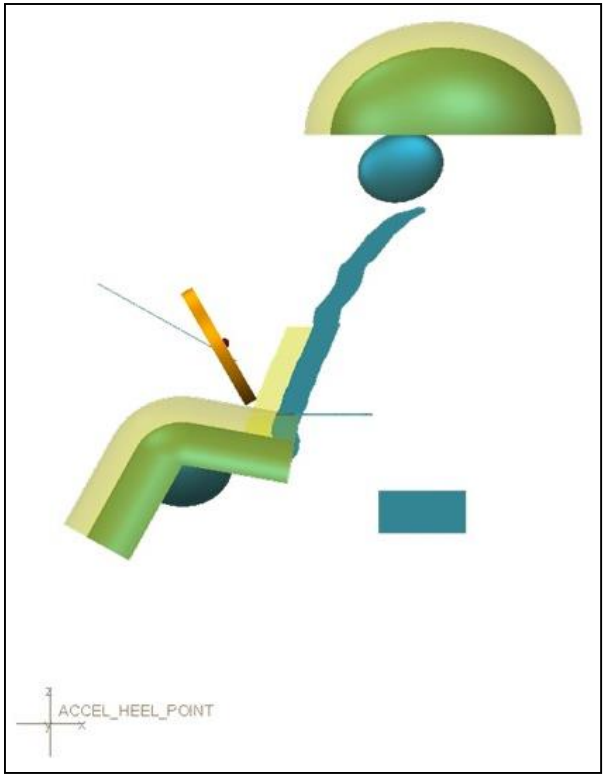
- Steering wheel placement
  - Surrogate wheel in user specified location
  - Preference line based on population data
- Seat track travel window
  - Size and location indicate adjustment needed to reach vehicle controls
  - Relates back to the occupant through the design H-point of the seat, as in SAE Recommended Practices
- Resulting Soldier population boundaries
  - Eyes
  - Helmet
  - Torso
  - Knees



Accommodation boundaries from the *Seated Soldier Study* are the foundation upon which the rest of the model is built

Results – CAD Clearance Zones

- 2.0 inch standard minimum clearance derived from MIL-STD-1472G
- Clearances, shown in yellow, were applied to the following portions of the model:
  - Helmet
  - Torso
  - Thighs
  - Knees
  - Shins



Clearance zones aid in the development of vehicle interior features such as instrument panel knee bolsters and overhead systems

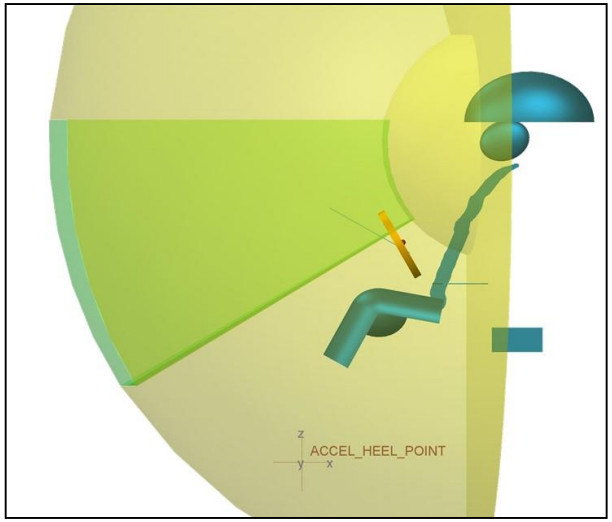
Results – CAD Direct Field of View

- Developed from a combination of MIL-STD-1472G and SAE J1050
- There are three zones, defined as follows for ambinocular vision:
  - **Primary**

    Space viewable by all occupants using “easy” eye movement only
  - **Secondary**

    Space viewable by all occupants using a combination of “easy” eye and “easy” head rotation
  - **Tertiary**

    Space viewable by all occupants using a combination of “max” eye and “max” head rotation



Direct Field of View (FOV) is used to prioritize placement of controls and displays

Results – CAD Boundary Manikins

- Seven boundary manikins representing anthropometric extremes for workstation design are automatically placed in their average postures
- Aid visualization for those unfamiliar with accommodation boundaries
- Allow for study of how specific individuals may interact with the vehicle environment

Average Male Boundary Manikin

Positioned boundary manikins add definition and aid visualization

Discussion

- The FHP accommodation model allows a population of Soldiers to be placed in a vehicle environment per the intent of MIL-STD-1472G
  - Postures are derived from multivariate analysis of empirical Soldier data
  - Effects of Soldier worn equipment are taken into account
  - Minimum adjustments and clearances needed to perform tasks are provided
  - Direct Field of View zones guide placement of controls and displays
- Building an automated model in PTC Creo® software increases efficiency
  - Eliminates much of the ambiguity found in written requirements
  - Becomes the foundation for workstation design
  - Allows for swift analysis of design tradeoffs
  - Results are consistent

Next Steps

- Complete Verification and Validation of the FHP CAD model
- Complete User Guide for FHP CAD model
- Release FHP CAD model for use by Government partners and industry
- Continue to develop accommodation models for other positions:
  - Squad
  - Driver, Fixed Eye Point
  - Driver, Out-of-Hatch
  - Driver, Highly Reclined Seating
  - Commander
  - Gunner
- Incorporate (dis)accommodation into models to understand how occupant space restrictions affect accommodation (e.g. ceiling height and seat adjustment)