Soldier Modeling for Improved Accommodation and Safety

Quad Members
Faculty: Matthew P. Reed, Jingwen Hu, Han Kim, Jonathan D. Rupp, Judy Jin
         U. of Michigan
         Zissimos Mourelatos, Dorin Drignei
         Oakland U.
Student: Yaser Zerehsaz (GSRA), Daniel Park (post-doc), many undergrads
         U. of Michigan
Industry: Jeff Mayhugh, Navistar
         Ulrich Raschke, Siemens
Motivation

• Current and future vehicle programs face major challenges in providing adequate accommodation for soldiers while ensuring performance and safety

• Current MIL-STD 1472g lacks detailed information on soldier posture and body shape, including the effects of personal protective equipment (PPE) for seat and vehicle interior layout

• Current design guidance is based on outdated anthropometry and tools that do not adequately represent soldier attributes

• Design standards for seats, restraints, and vehicle interior layout do not take into account PPE and gear
The Seated Soldier Study

Methods:

- Measured 310 soldiers at 3 Army posts
- Driver and squad postures
- Whole-body laser scanning

Standard Anthropometry

Driver Postures

Laser Scans

Squad Postures
S³: Major Outcomes

Statistical Models of Body Shape

Clearance Requirements

Data on Harness Fit
Driver Posture Prediction

**Goal:** Predict driving posture

**Inputs:**
- steering wheel location re accelerator pedal
- driver stature, erect sitting height, body weight, and gear level (ACU, PPE, ENC)

**Outputs:**
- Seat position
- Seat back angle
- Hip location
- Eye location
- Body segment angles
**Goal:** Predict squad posture

**Inputs:**
- seat height and back angle
- stature, erect sitting height, body weight, and gear level (ACU, PPE, ENC)

**Outputs:**
- Hip location
- Eye location
- Body segment angles
**Background:** Design tools embodying human accommodation requirements are needed for vehicle interior layout

**Objective:** Create soldier-specific design tools using methods developed at U-M

**Method:** Analyze driver and squad posture and space-claim information from Seated Soldier Study

**Status:** Driver and squad models completed; preparing documentation and assisting TARDEC in implementation
**Seat Index Point Tool**

**Background:** The current standard tool for measuring seats is not practicable for many squad seating conditions.

**Objective:** Evaluate and adapt the ISO 5353 Seat Index Point Tool for military seating applications.

**Method:** Add back angle probe; Comparative measurements of military seats.

**Status:** Completing initial testing; finalizing back angle probe; preparing documentation.
New Driver Configurations

**Background:** New vehicle designs may include driver workstations markedly different from typical trucks

**Objective:** Quantify driver posture and component-location preferences for 3 configurations

**Method:** Field study using soldiers in mockups

**Status:** Constructing mockups for pilot testing; full-scale testing on an Army post Fall 2014
**Background:** Soldiers wearing heavy gear must perform a wide range of in-vehicle tasks; current data with light clothing are not applicable.

**Objective:** Quantify the effects of body armor and body borne gear on seated reach capability and difficulty.

**Method:** Laboratory motion-capture study using volunteers with a wide range of body size.

**Status:** Full-scale testing underway (targeting 36 subjects)
Equipped Reach
Background: Many soldier injuries in vehicles are due to crashes, including rollovers

Objective: Optimize airbag/restraint system designs for occupant protection in tactical vehicles in frontal and rollover crashes using sled tests, finite element simulations, and a hybrid optimization process

Method:

• Baseline sled tests
• Develop and validated occupant and compartment FE models
• Parametric simulations and hybrid design-space exploration optimization*
• Airbag/restraint optimizations
• Additional sled tests to verify optimized solutions

* Collaboration with Oakland University
Crash Protection
Crash Protection

Baseline Sled Tests: Body Armor

3-Point Belt

5-Point Harness
Crash Protection

Baseline Sled Tests: Added Gear

3-Point Belt

5-Point Harness
Finite Element Models

Midsize Male HIII ATD with ACU, IOTV, and TAP
5-Point Baseline – No Gear
WIAMan Activities at U-M

- UMTRI is one of several sites conducting biomechanics testing in support of the Warrior Injury Assessment Manikin program.

- The U-M role includes anthropometric specifications for WIAMan and subject positioning guidelines using ARC Seated Soldier Study data.
• Driver posture data collection at an Army post (summer 2014)
• Optimizing vehicle layout taking into account multiple design constraints
• Seat design guidelines, methods, and technology to account for current body dimensions and gear
• Advanced manikin generation, including realistic effects of encumbrance (with NSRDEC)
• HMMWV frontal crash and rollover testing, restraint system optimization using FE models
• FS^3: Extending seated soldier with more female participants?
Research Team and Collaborators

**TARDEC**
Risa Scherer  
Katrina Harris  
Holly Howard  
Harry Zywiol  
Stacy Budzik  
Jennifer Ammori  
Mike Megiveron  
Hollie Pietsch  
Gale Zielinkski  
Frank Huston  
Rebekah Gruber  
John Tesluk

**Anthrotech**
Bruce Bradtmiller  
Belva Hodge  
Lisa Ann Piercy  
Mike Mucher  
Mark Breza  
Travis Hotaling  
Tatiana Lurie  
Christina Smith

**U-M**
Sheila Ebert  
Jingwen Hu  
Jon Rupp  
Carl Miller  
Nathaniel Madura  
Brian Eby  
Quentin Weir  
Charlie Bradley  
Laura Malik  
Judy Jin  
Yaser Zerehsaz

**Industry**
Jeff Mayhugh  
Pete Kempf  
Ulrich Raschke

**Other US Army**
Brian Corner  
Steve Paquette  
Todd Garlie  
Joe McEntire  
Rick Kosycki

**Oakland U**
Zissimos Mourelatos  
Dorin Drignei

**US Army Site POCs**
John MacArthur (JBLM)  
Fred Corbin (Ft Hood)  
Jim Parks (Ft Campbell)
This work was supported by the Automotive Research Center, a U.S. Army Center of Excellence for Modeling and Simulation of Ground Vehicles led by the University of Michigan

For more information:

mreed@umich.edu

mreed.umtri.umich.edu