Measurement and Modeling of Seated Soldier Posture and Body Shape

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Background

• 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• Current design guidance is based on outdated anthropometry.

• Previous studies of seated anthropometry have not included the effects of PPE on posture and body shape.

• Warrior Injury Assessment Manikin (WIAMan) blast dummy program needs detailed seated anthropometry data.
Objectives

1. Gather detailed data on the **postures of soldiers with a wide range of body sizes sitting in military vehicle seats** as drivers and passengers with and without protective equipment and with and without protective footrests.

2. Gather detailed data on the **position and space requirements for body armor and other gear** in both standing and seated postures.

3. Gather quantitative data on the **locations of protective equipment relative to the soldier and vehicle seat** for use in human modeling and blast event simulation.

4. Develop data-based **tools to represent the postures, positions, and body size** (space claim) for soldiers as drivers and passengers in tactical vehicles as a function of occupant and vehicle characteristics.
Test Plan

- Data collection January – April 2012 at three Army posts: Joint Base Lewis-McChord, Ft Hood, Ft Campbell
- Goal was to measure 300 soldiers with a wide range of body size, including as many women as possible
- Data collection conducted by subcontractor Anthrotech, Inc., which is providing six trained staff
- Substantial additional coordination by TARDEC and the data collection sites
Methods - Overview

Standard Anthropometry

Whole-Body Scanning

Hardseat Body Landmarks

Driving Postures

Crew Postures

Four Garb Levels: minimal, ACU, armor, encumbered
Standard Anthropometry

- Using ANSUR II methods*
- 36 dimensions
- Focus on characterizing subjects relative to ANSUR II
- Minimal garb only

*ANSUR II is a large-scale Army anthropometry study currently underway.
Hardseat Body Landmarks

- Laboratory seat that allows access to posterior torso landmarks
- Body landmark locations measured using FARO Arm coordinate digitizer
- Data are used to accurately quantify torso skeleton geometry (pelvis, spine, ribcage)
- Minimal garb only
Driver Mockup

- Steering wheel, pedals, adjustable seat (fore-aft, up-down, back angle)
- Range of vehicle packages (steering wheel-to-pedal relationships) representing different vehicle types
- Driver adjusts seat to obtain comfortable posture
- Body landmarks defining posture measured using FARO Arm coordinate digitizer
- Garb: ACU, armor, encumbered (not all configurations at all garb conditions)
Crew Mockup

- Fixed seat (no sitter adjustments)
- Range of seat height, seat cushion angle, seat back angle, and foot position (including representation of protective footrest)
- Body landmarks defining posture measured using FARO Arm coordinate digitizer
- Garb: ACU, armor, encumbered (not all configurations at all garb conditions)
Laser Scanning

- Standing and erect sitting postures for reference to other datasets
- Supported sitting postures spanning the range of driver and crew postures
- Garb: minimal, BDU, armor, encumbered (not all postures in all garb conditions)
Body Shape Modeling

- Whole-Body Scan Data
- Manually Measured Body Landmarks
- Standard Anthropometry
- Manual Landmark Extraction

流程图:

1. Whole-Body Scan Data
2. Manually Measured Body Landmarks
3. Standard Anthropometry
5. Clean and Fit Polygon Mesh
6. Model Integration
7. Mesh with Landmarks
8. PCA+Regression Analysis
9. Fit Homologous Mesh
10. Statistical Model to Predict Body Shape from Body Dimensions, Posture, or Landmark Locations
Current Status

Data collection completed:
309 soldiers measured
257 men (83%)
52 women (17%)
Data processing underway

Male Summary (preliminary)

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Outcomes

1. Statistical models of seated soldier posture as driver and crew
   • ~40 surface landmarks
   • major body joints
   • eye location, hip location
   • seat H-point location and back angle
   • including effects of PPE
Outcomes

2. Statistical models of soldier body shape in seated postures

Statistical body shape models from a previous studies
(new model will include whole body in seated postures)

Overlaid scans from current study
Outcomes

3. 3D space claim for encumbered soldiers

Overlaid scans without posture adjustment
Outcomes

4. Anthropometric specifications for WIAMan (new Army blast dummy):
   - external body contours
   - external body landmarks
   - internal joint estimates, include hips and spine
Outcomes

5. Guidance for vehicle and seat design based on current soldier anthropometry including effects of encumbrance, providing input for a revision of the sections of MIL-STD 1472 dealing with seat and vehicle design
TARDEC Applications

Blast Dummy Development

Human Body Models for Blast Simulation

Ergonomics (Erika Baker, TARDEC)

Vehicle Interior Layout (Packaging)
# Study Team and Collaborators

## TARDEC
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- Jennifer Ammori

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- John MacArhur (JBLM)
- Fred Corbin (Ft Hood)
- Jim Parks (Ft Campbell)
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