

Space Human Factors Engineering Research Benefits to Programs

Anthropometry & Biomechanics

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Provided by
Anthropometry & Biomechanics Facility

Selected Projects

- Shoulder Injury Analysis
- Hatch Design Evaluation
- Treadmill With Vibration Isolation & Stabilization

Shoulder Injury Analysis

- Research:
 - Development of Analytical Tools to Process and Apply Digitally Scanned Anthropometric Data TDP (2001 - 2004).
- Application:
 - Analysis of potential shoulder injuries due to improper shoulder joint loading due to inverted suited operations during Neutral Buoyancy Laboratory (NBL) training (2003-2004).
- Result:
 - Ability to visualize the drastic surface area and volumetric changes near shoulder joint and the impingement due to Liquid Cooling Ventilation Garment (LCVG) and the suit against the suit led to clear identification of the potential sources of injury.
 - Suit engineers are interested in improving shoulder comfort and suit sizing by using CAD drawings and 3-D anthropometry.

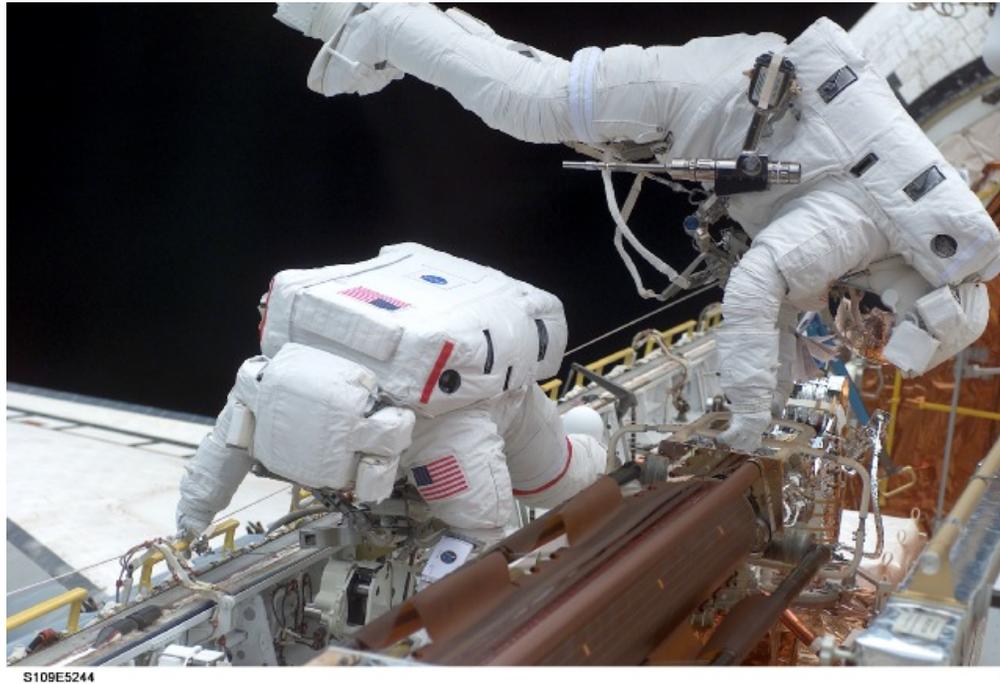
Shoulder Injury Analysis

- Medical operations identified significant incidence of reports of shoulder pain and injury as a result of Inverted EVA training in the Neutral Buoyancy Laboratory (NBL).
- A team was formed, including Anthropometry & Biomechanics Facility (ABF), to determine root cause.
- The ABF used Whole-body Laser Scanner and 3-D anthropometry extraction software developed under Anthropometric Tool Development TDP to map shoulder surface, and compare it to the Hard Upper Torso (HUT) inside dimensions from CAD drawings.
- Images showed bulges in shoulder and Liquid Cooling Ventilation Garment (LCVG) during arm extension resulting in pressure points against the HUT.

Shoulder Injury Analysis (cont.)

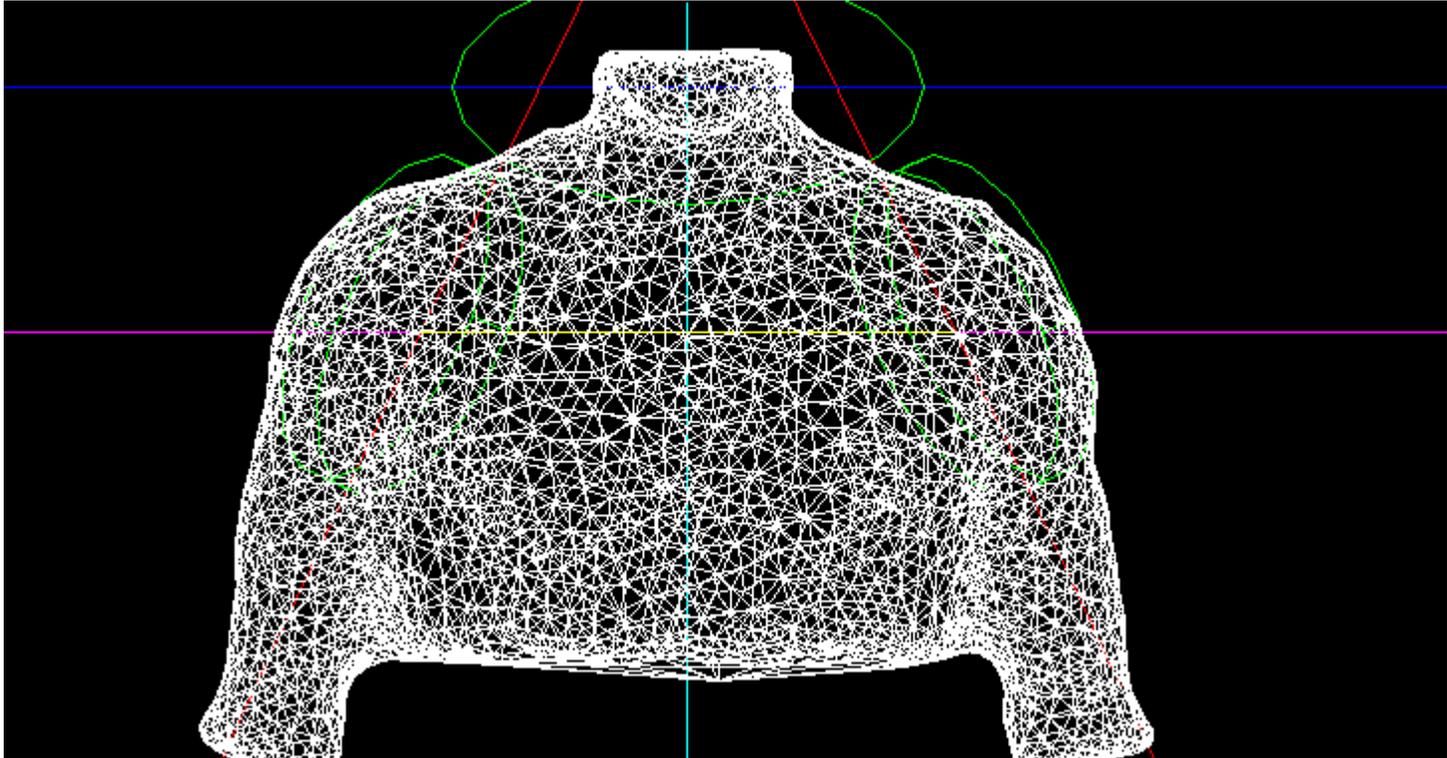
- Since the clearance between the Hard Upper Torso (HUT) and the shoulder diminishes with the arm in the upward position, the work on Laser Anthropometry resulted in the following recommendations:
 - Develop and implement a full-body laser scanning protocol for astronauts participating in EVA training. Data shall be made available for suit sizing.
 - Review and update suit sizing algorithm to reflect latest configuration of Space Suit Assembly (SSA) hardware, and use of laser scanning. Access the laser-scan database to obtain anthropometric requirements.
 - Laser anthropometric studies of male and female astronauts, biomechanical analysis of shoulder joint motion in both genders, use of CAD models of shoulder joint motion and Extravehicular Mobility Unit (EMU) shoulder joint design should all be incorporated into the development of the next generation space suit.

Shoulder Injury Analysis (cont.)



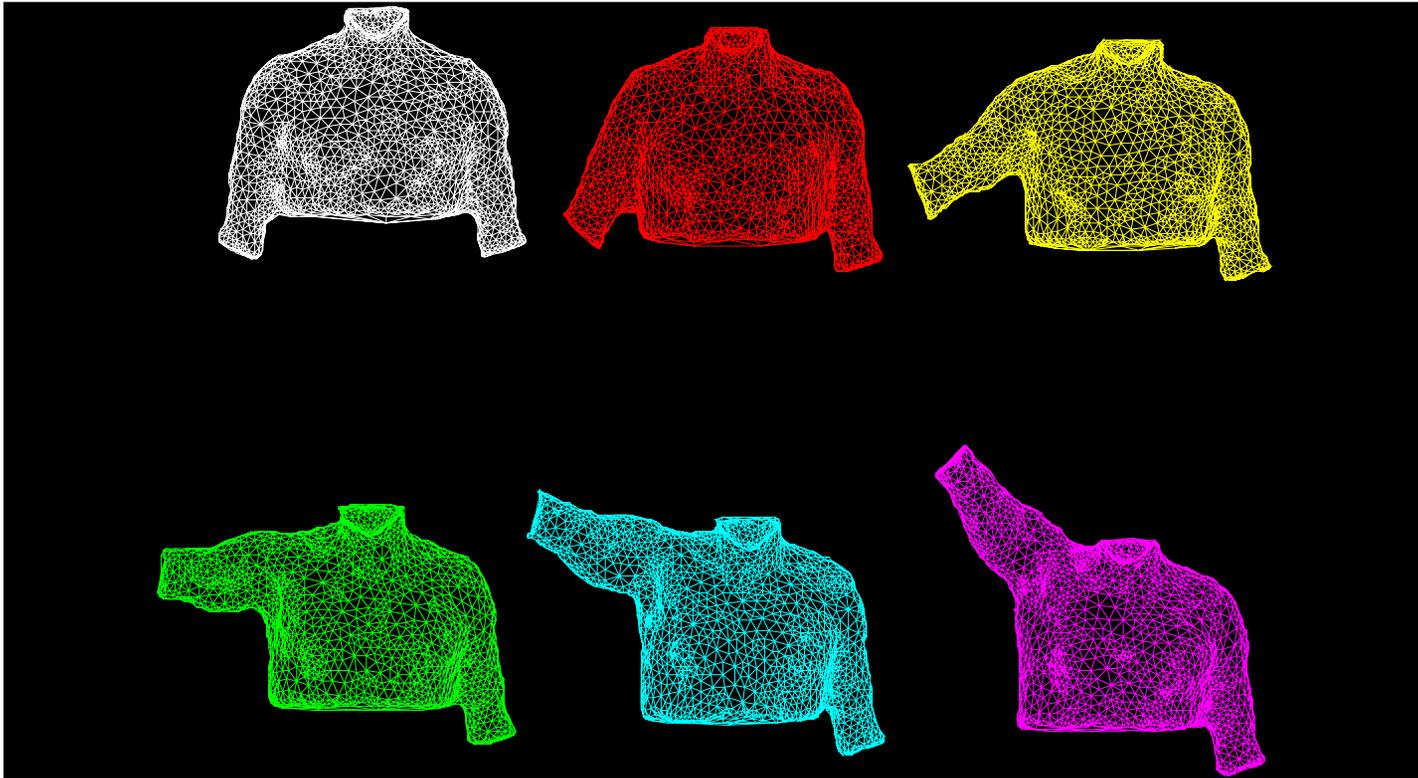
Photograph of EVA operations being performed.
Note the inverted position.

Shoulder Injury Analysis (cont.)



Wire drawing of Large Planar Hard Upper Torso (HUT) merged with laser scan of unsuited subject.

Shoulder Injury Analysis (concluded)



Changes in Shoulder Area at various Arm Positions

Hatch Design Evaluation

- **Research:**
 - Development of Analytical Tools to Process and Apply Digitally Scanned Anthropometric Data TDP (2001 - 2004).
- **Application:**
 - Assessed unassisted crew strength capabilities for ISS training to enable ground training that is virtually identical to space operations (2003) .
- **Result:**
 - Determined the maximum acceptable design weight limits for the new hatch windows so that all crewmembers are able to open and close the hatch without technician's help during ground training.

Hatch Design Evaluation

- The ABF consulted on design of hatch for emergency egress crew training on ground.
- The ISS mockup facility had several hatches with weights ranging from 10 lbs to 80 lbs necessitating the assistance of additional personnel.
- Questions were raised about the making the hatch weights the same and that would not require additional assistance to ensure the integrity of training.
- Multipurpose, Multiaxial Isokinetic Dynamometer (MMID) was used to measure comfortable exertion levels in appropriate postures by various personnel.

Hatch Design Evaluation (cont.)

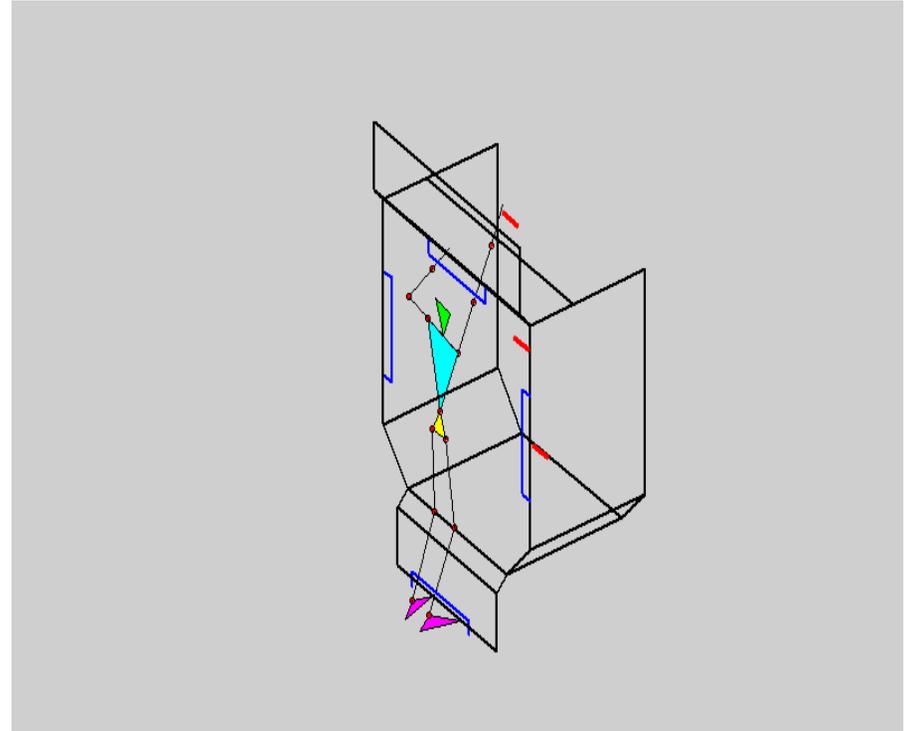
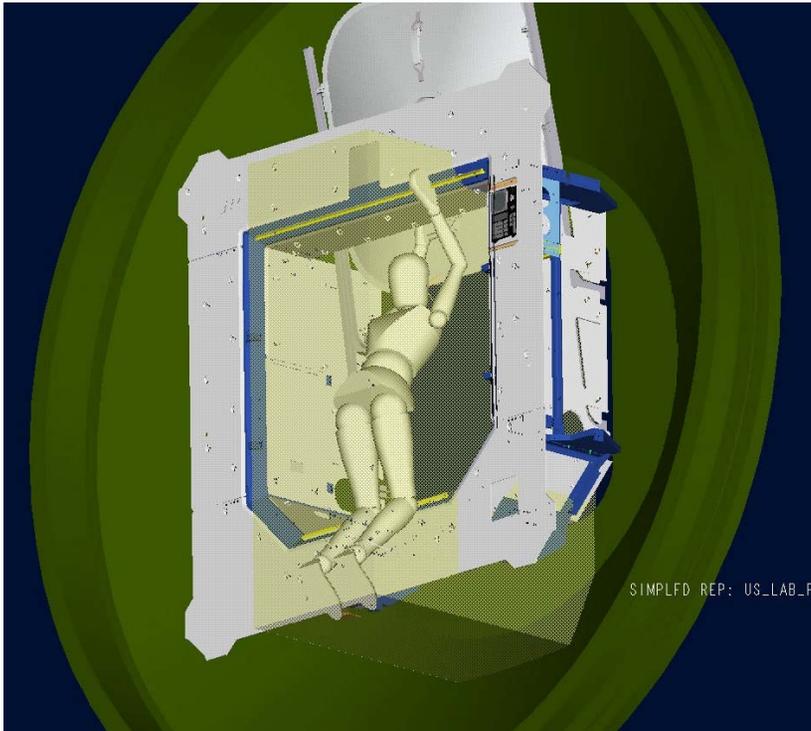
- Weight limits were determined to be much lower than the projected requirements previously set by the Safety engineers.
- Memo from the Project Lead:
 - “Considering this information, work on the Light Weight Hatch project was stopped before additional design or manufacturing activities took place and the design requirements will be revisited to address this new ergonomic information. The budget on this project was \$215,000.”

Hatch Design Evaluation (cont.)



Multipurpose Multiaxial Isokinetic Dynamometer

Hatch Design Evaluation (concluded)



Hatch Operation simulation with the Ergo model

Treadmill with Vibration Isolation & Stabilization

- Research:
 - Development of Analytical Tools to Process and Apply Digitally Scanned Anthropometric Data TDP (2001 - 2004).
- Application:
 - Evaluated the effects that mounted hardware would have on crewmember head clearance while exercising (2002).
- Result:
 - Provided hardcore biomechanical analysis results to alleviate the concerns for the engineers and program managers and eliminated the need to initiate a major overhaul of the light fixtures on-board the ISS.

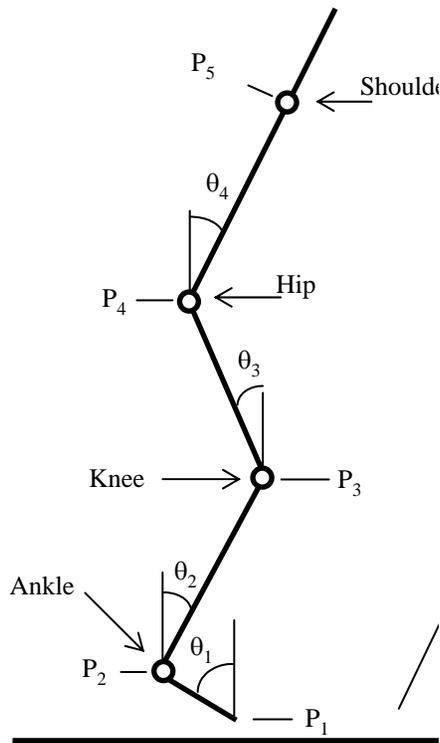
Treadmill with Vibration Isolation & Stabilization

Anthropometric Modeling

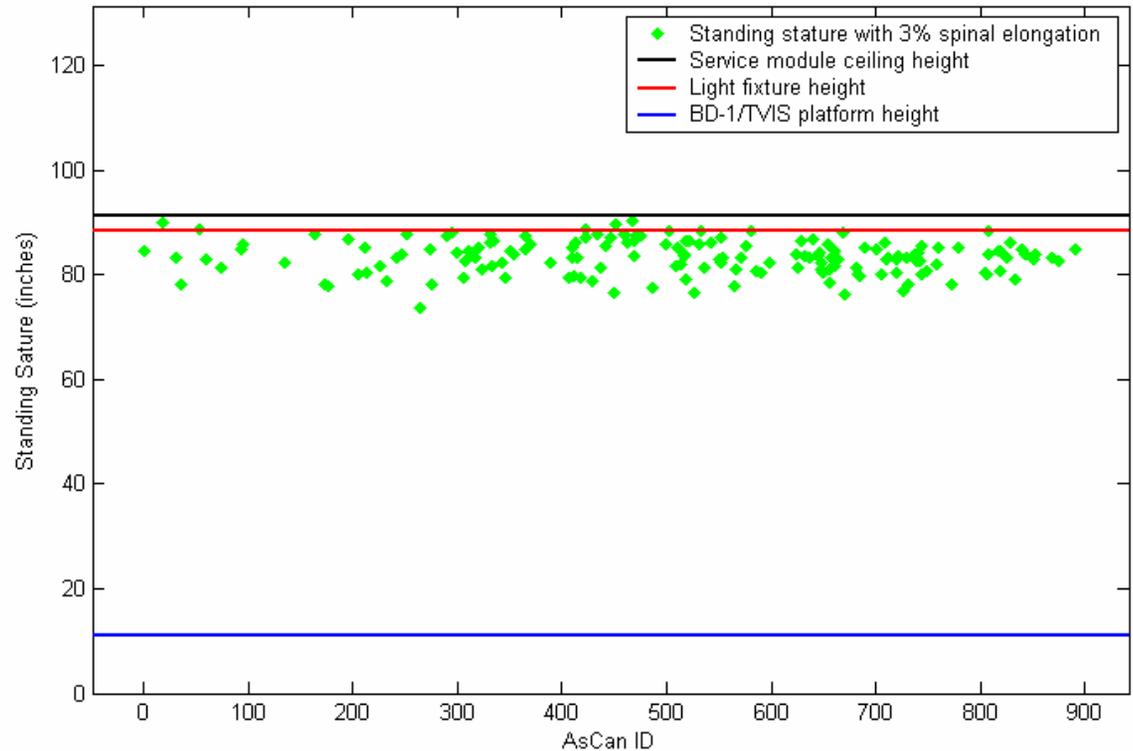
- The ISS treadmill is currently not working. NASA wanted the crew to use the Russian Treadmill (BD-1) but it does not have vibration isolation capabilities. Hence, the engineers considered placing the Russian Treadmill on the TVIS to take advantage of its isolation properties.
- The ABF conducted an anthropometric analysis to determine if any crewmembers would be affected by bumping into the ceiling light fixture.
- The analysis, which included all crewmember's anthropometric data, spinal elongation and 0-g running data, concluded that very few of the crewmembers would be coming into contact with the light fixtures.
- The results were provided to the Russian & US engineers which helped them determine if they should remove the ceiling lights.

Treadmill with Vibration Isolation & Stabilization (cont.)

Kinematic model and Results



STANDING STATURE OF 161 CURRENT ASTRONAUTS WITH 3% SPINAL ELONGATION AND 1-INCH RUNNING SHOE



Results showed that some of the crewmembers would be coming into contact with the light fixtures.