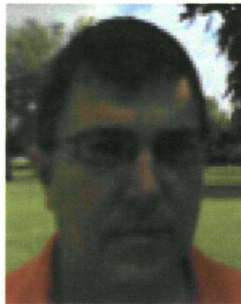


Avionics Box Cold Plate Damage Prevention



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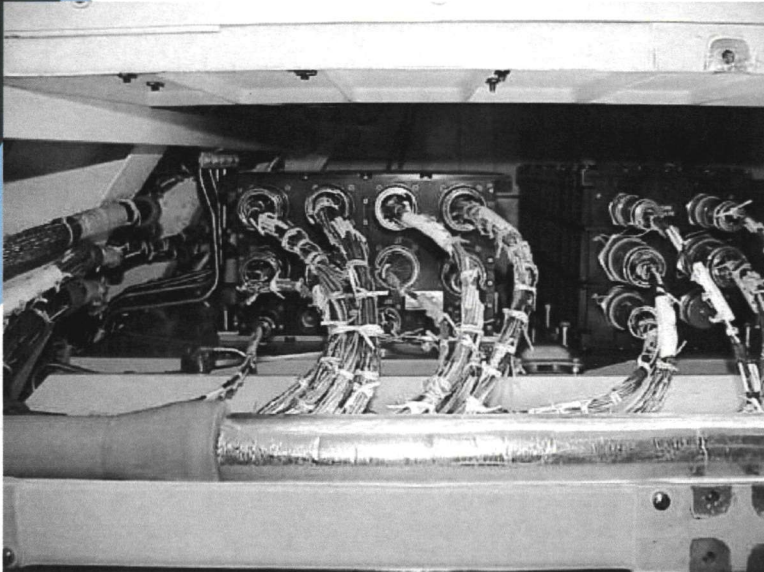
Co-Authors: Steven W. Larchar, Gena Henderson, Donald Tran, and Tim Barth



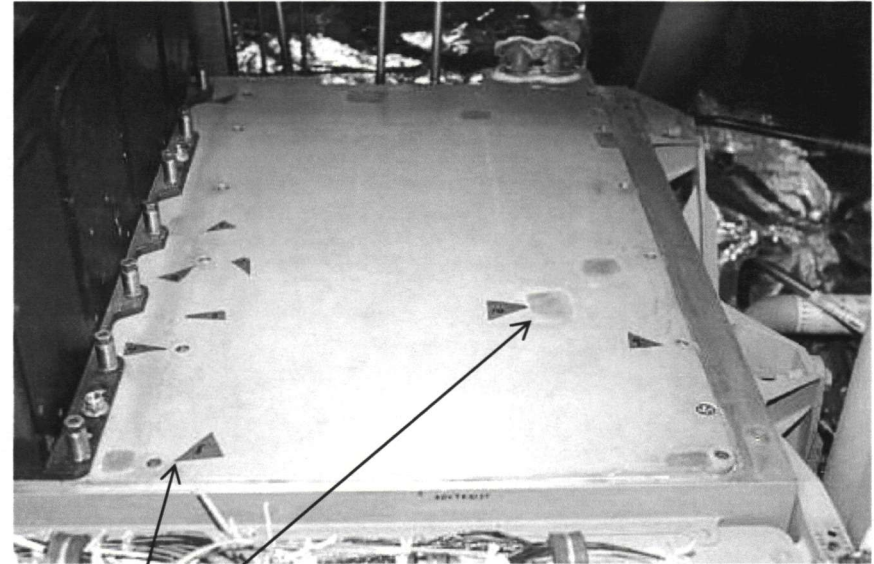
Problem Introduction

1. Prevent Cold Plate Damage in Space Shuttle.
 1. The number of cold plate problems had increased from an average of 16.5 per/year between 1990 through 2000, to an average of 39.6 per year between 2001 through 2005.
 2. Each complete set of 80 cold plates cost approximately \$29 million, an average of \$362,500 per cold plate.
 3. It takes four months to produce a single cold plate.
2. Prevent Cold Plate Damage in Future Space Vehicles.

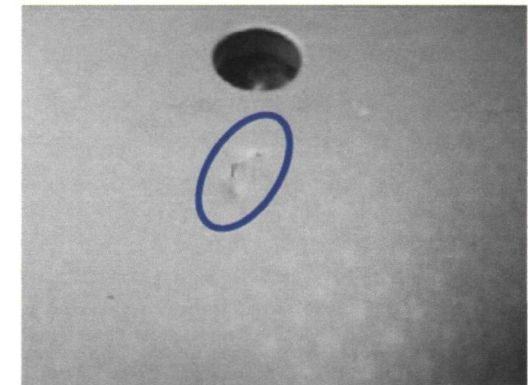
Restricted Space and Cold Plate Damage



Avionics box on top of cold plate. With restrictions to top and sides



Damages to cold plates



Close up of damage

Restricted Space and Cold Plate Damage



This is an example of the avionics boxes on shelves in the forward compartment of the Space Shuttle Orbiter.



Solution 1: Prevent Damage during Space Shuttle Processing

KSC Process Improvement Team (PIT) was formed to determine the cause of these damages, and to recommend corrective actions to mitigate future damages.

- The PIT recommended and implemented the following changes:
 - design and fabrication of cold plate covers to protect exposed surfaces,
 - standardization of cold plate mounted LRU removal and replacement (R&R) procedures across multiple engineering disciplines, and develop technician training and certification for these procedures.

Improvements

**Simulated
Cold Plate**

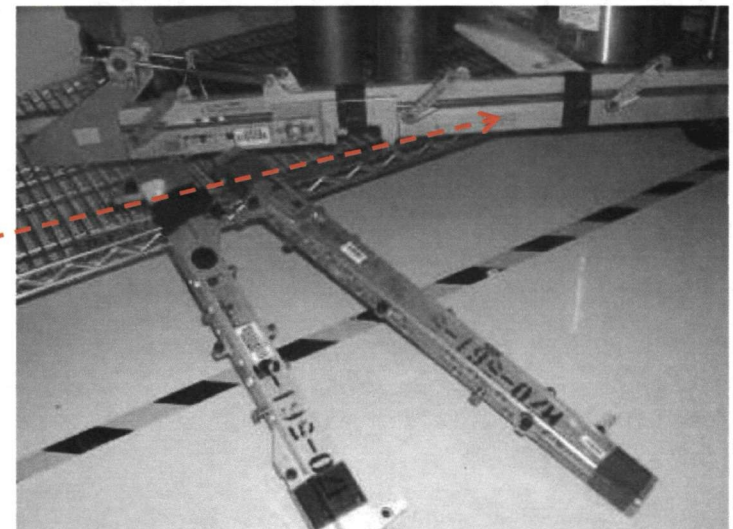
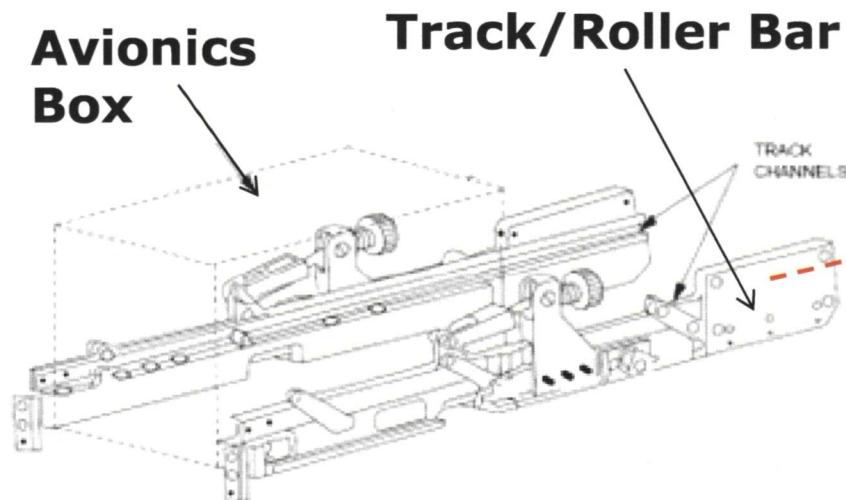
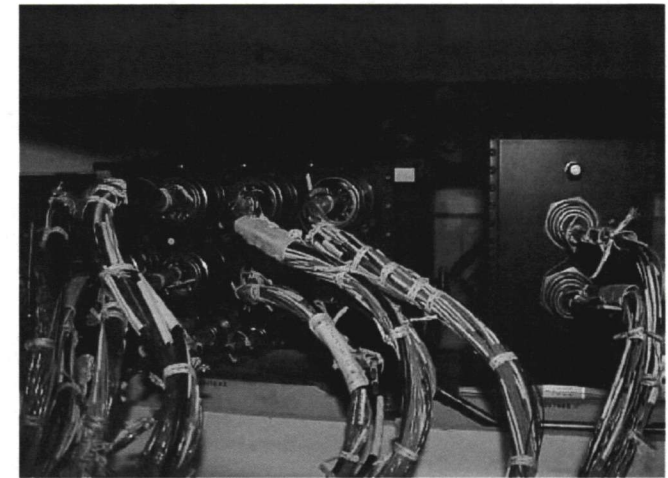
**Protective
Covers**



This cover is placed on the cold plate after the avionics box is removed to protect it so it is less likely to get damaged during other operations taking place in the same location, for example wire inspections.

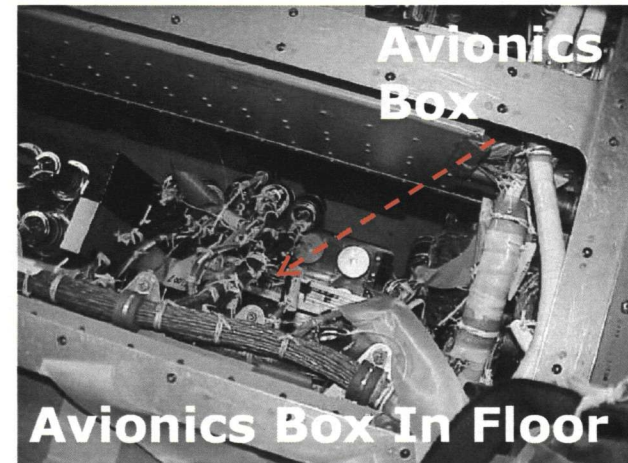
Improvements

Manual Method: This method should only be used on LRUs mounted on the top of the shelf, which there is enough room for hands to hold the box, and the boxes are not very heavy, e.g. MDMs apx. 36 pounds.



Improvements

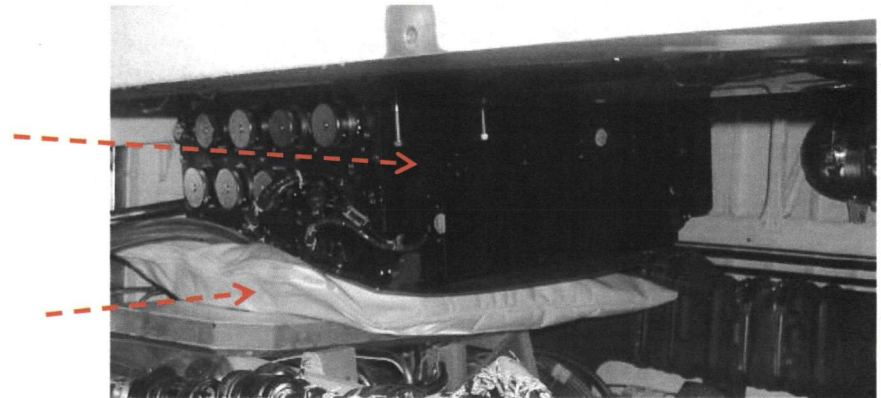
Avionics boxes installed vertically requires three people to perform the activity. One technician to lift the avionics box with the rope while the other two carefully guide the LRU to prevent damage.



The airbag method is used for boxes that mount to the bottom of the shelf instead of laying on top of the shelf.

**Avionics
box**

Air Bag



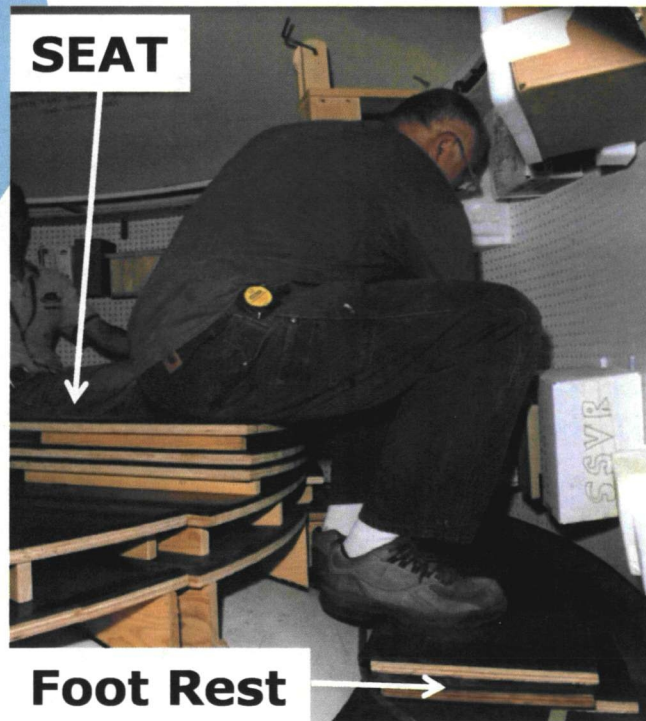


Solution #2 Prevent Damage in future Spacecraft Designs

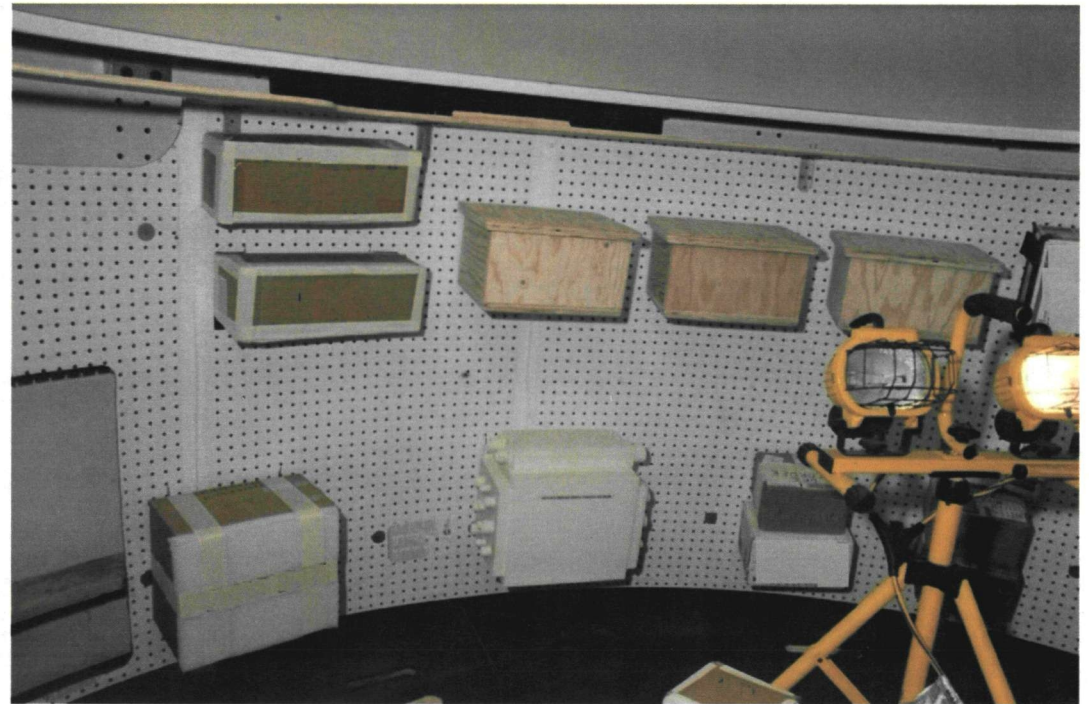
- Physical Mockups were used during Ares 1
- Motion Capture was used and is being used for Orion Development.
- Studies are being performed to determine the human capabilities for this activity.

Example:

Ares I Avionics Boxes



Improved Operator
Ergonomics

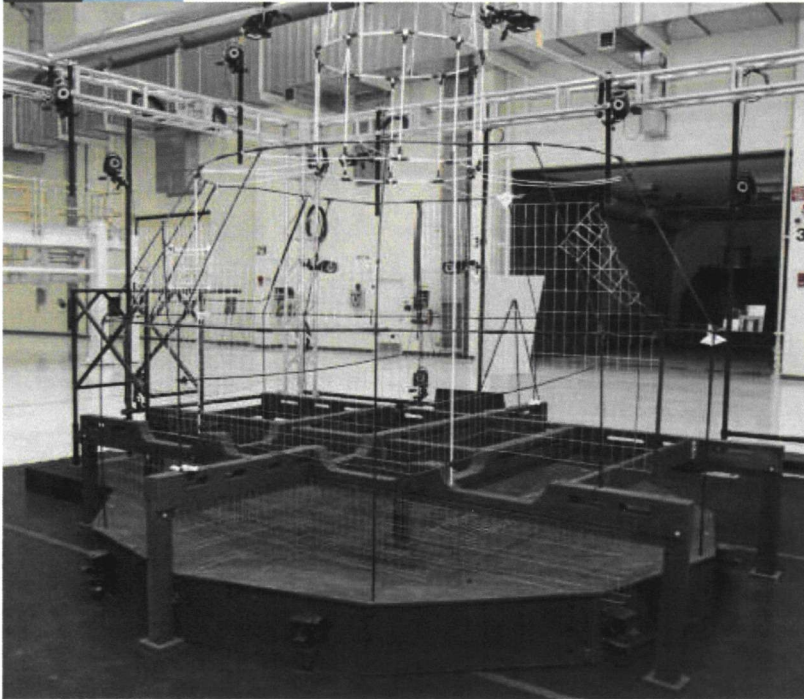


Locations of avionics boxes

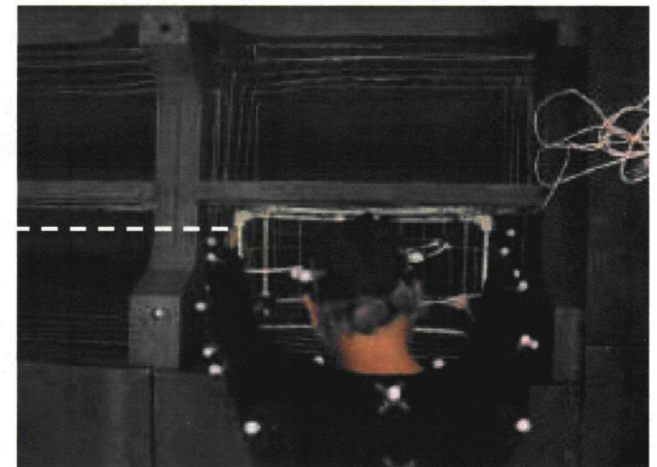
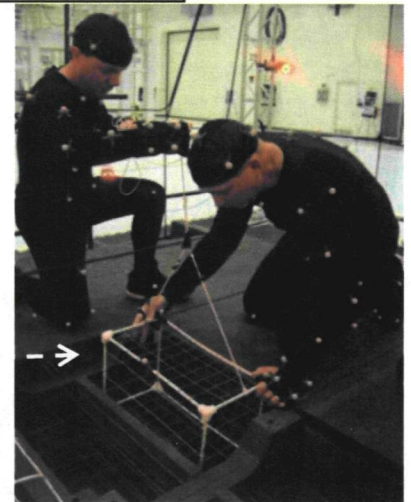
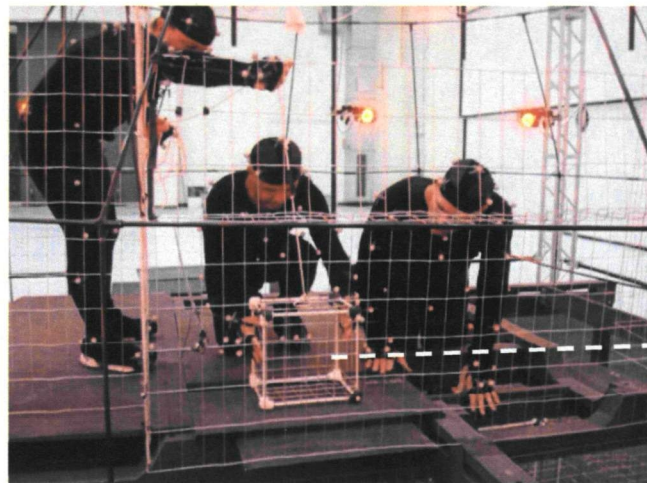
Example:

Orion Avionics Box Installation

Motion Capture Mockup



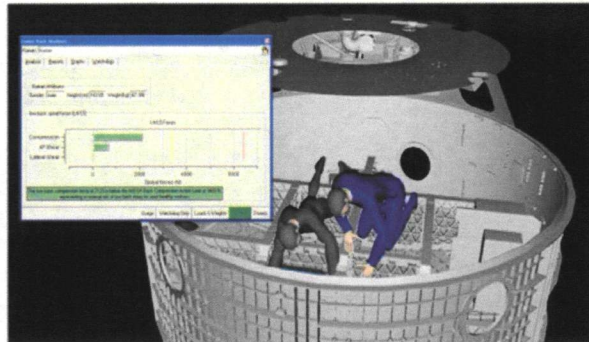
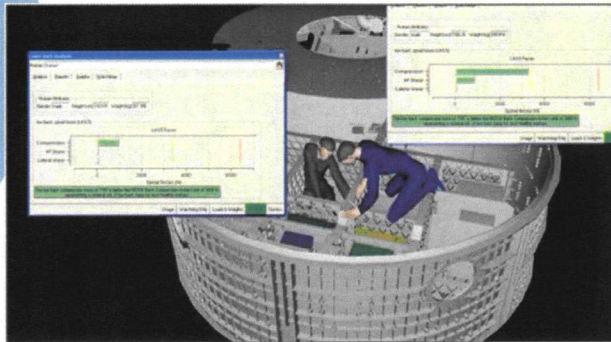
Motion Capture Activity



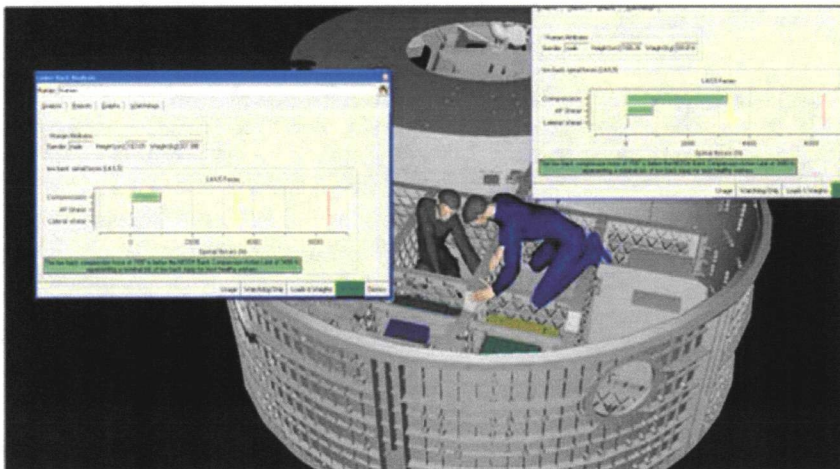
Example Accomplishment:

Orion Avionics Box Installation

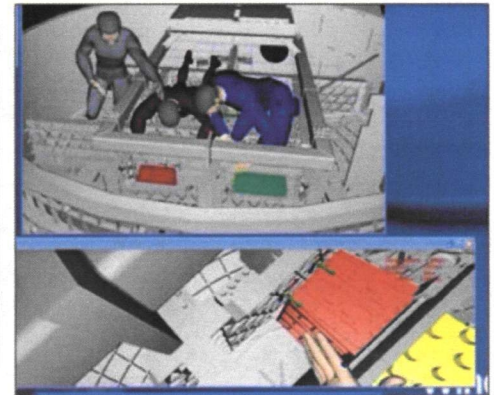
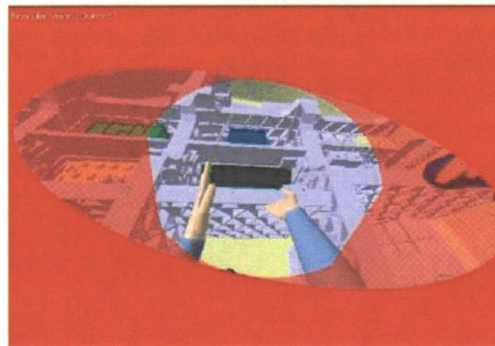
Task Position Analysis



Lower Back Analyses

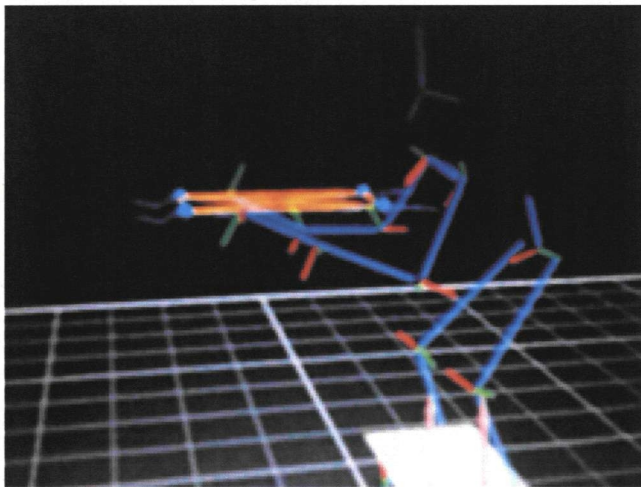


Reach and Visibility

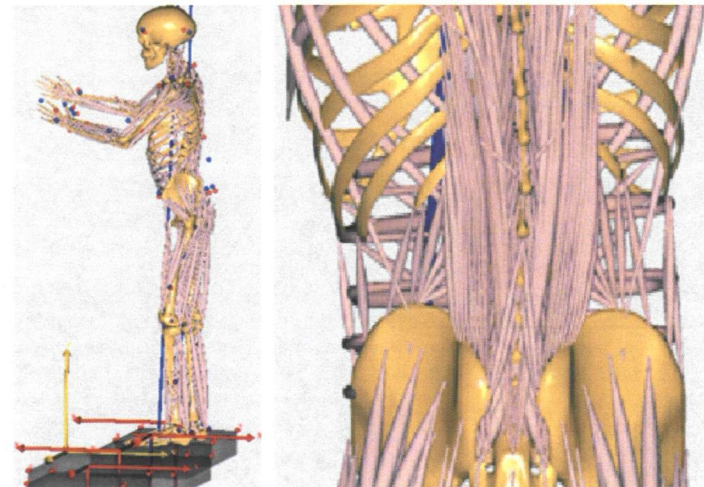


Example:

Study on Biomechanical Analysis of Careful Installation of Avionics Boxes

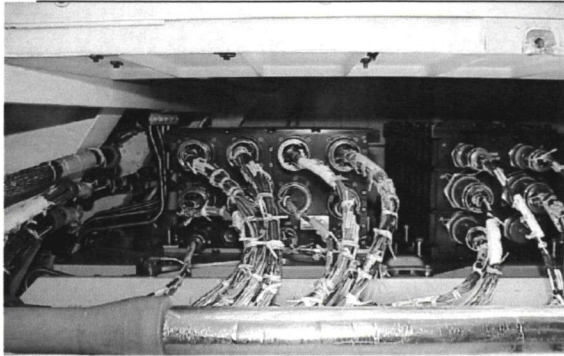


Placing Box Accurately

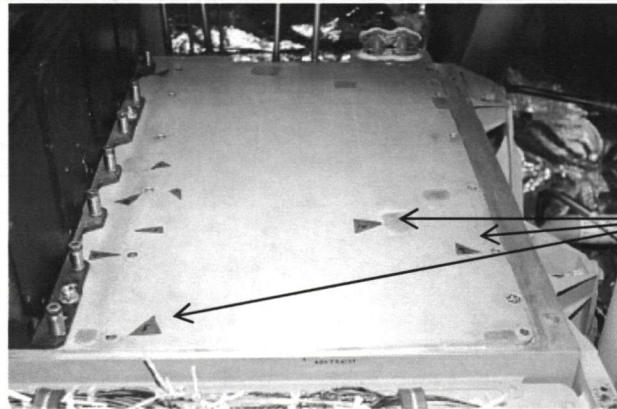


L5/S1 spinal stress

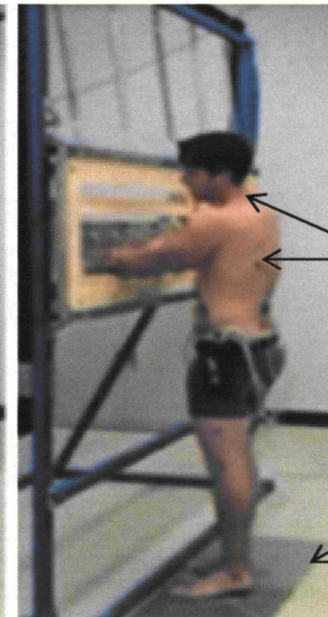
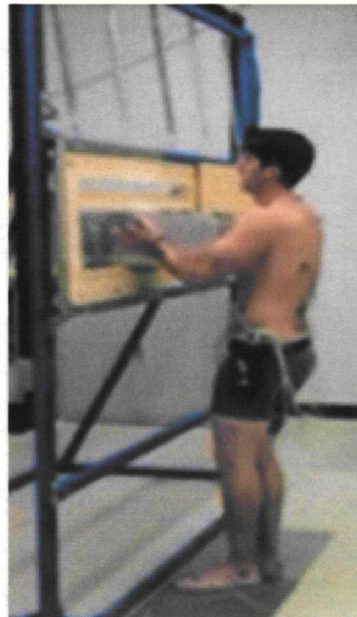
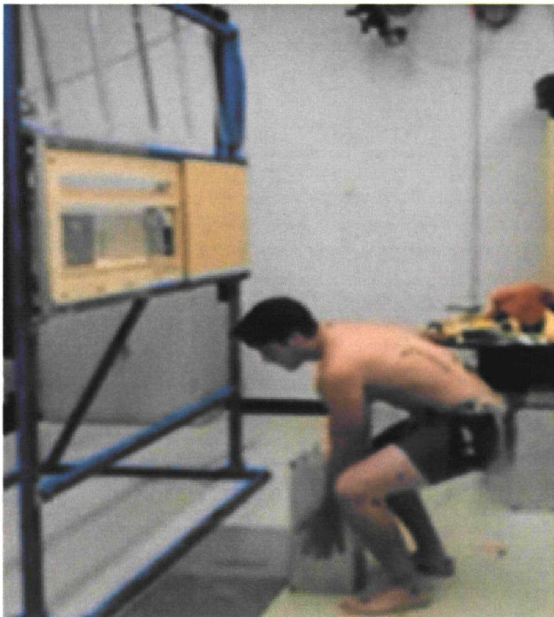
Study on Biomechanical Analysis of Careful Installation of Avionics Boxes



Box in restricted space



Cold plate damage



EMG and reflective markers

Force Plate



Summary

- Lessons Learned from Space Shuttle:
 - Were used to improve ground processes to reduce the risk of damage to avionics cold plates during the Space Shuttle Program.
 - Have been used during development of CxP Ares I
 - Are being used to improve the design of Orion's avionics boxes
 - And are leading towards studies to determine how to better design spacecraft for installing avionics boxes carefully in restricted space.



Recommendations/Conclusion

- Use motion capture and other human factors engineering analysis to improve the avionics/spacecraft designs for Orion, STS and Commercial spacecraft.
- From methods used during the physical mockups, motion capture , and using biomechanics to define the human capabilities:
 - develop avionics box installation requirements and establish these requirements in the NASA STD 3001, (NASA Space Flight Human System Standard) to ensure this is addressed during the design development of the avionics/spacecraft.
- Continue to use motion capture and biomechanics to define the human capabilities for avionics installations and other spacecraft ground processing activities.