Integrating Human Factors into Space Vehicle Processing for Risk Management

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What is Human Factors Engineering?

**Human Factors**

- Human Capabilities
- Ergonomics
- Usability
- Human-system integration
- Cognition
- Physiology
- Human Limitations
- Product Optimization
- Human-computer Interaction
- Psychology
The Reality of Space Vehicle Processing

Design for Usability...
Our Goal? Proactive, not Reactive!

• Consideration of human capabilities and limitations before designing products is the #1 way to manage risk to our most valuable resources: PEOPLE!

  ![Happy Face]

• Designing products that are intuitive and user-friendly will minimize frustration and human error, resulting in less $$ spent for redesigns and repairs!

  ![Piggy Bank]

A Step in the Right Direction

• USA’s implementation of the Human Engineering Modeling and Performance (HEMAP) Lab
  – Utilizes COTS motion capture system to capture motions of humans and objects, then displays data in a real-time 3D environment
  – Utilizes COTS HF modeling software that provides ergonomic analyses of high-risk operations involving heavy lifting, awkward postures, repetitive motions, and difficult reach positions, and process flow operations.

  ![Cameras]
  Cameras capture sensors strategically placed on human body

  ![USA Logo]
**How it's Done: Flow of Activities**

- **Real-time Task**
- **Simulated Task**
- **Motion Capture Simulation**
- **HF Software Model**

**Project: ET Foam Application**

**Objectives:**

- To ensure that techs can endure the foam spray operation safely
  - Factors involved: repetitive motion and fatigue
- To ensure that technicians fit safely in the environment
  - Factors involved: head clearance, tripping hazards, uneven platforms

**Goal:** To help flight certify the foam spray task on the ET for Mission STS-117
**Project: ET Foam Application**

Tools used:

**Static Strength Prediction Tool**

- 100% of the population is expected to have the static strength to perform the ET foam task for 60 minutes, based on the following:
  - Elbow, shoulder, hip, knee, and ankle; and the trunk angles for flexion, rotation, and lateral bending and torque on the limbs and trunk.

![Static Strength Prediction Tool Graph]

**Lower Back Compression Analysis**

- Based on 60 minutes of foam spray time, compression and shear forces at the L4/L5 vertebral disc are within acceptable limits for this task, due to minimal bending and twisting.
- Compression forces are within NIOSH/OSHA recommended and permissible lifting and force limits.
  - Results are within the acceptable limits due to the optimal range of motion the task is performed (waist to shoulder height).

![Lower Back Compression Analysis Graph]
**Project: ET Foam Application**

**Tools Used:**

Metabolic Energy Expenditure

- Based on 60 minutes of foam spray time, energy expended for foam spray task is within the acceptable limits.

Work rest cycle

- Based on a foam spray time of 60 minutes, a rest time of 4.74 minutes is recommended.
  - Based on this information, this task is assumed to provide sufficient recovery time to avoid fatigue in the upper body.

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**Project: ET Foam Application**

The fix: platform reconfiguration
Project: Crawler Plywood

The problem: Repetitive lifting and bending to place 400 sheets of plywood on launch pad for crawler transporter, and hammering wedges into place to secure plywood on crawler path

Project: Crawler Plywood

The fix: Cable system and forklift attachments to drop plywood into place
Project: Window Polycarbonate Cover Installation

The problem: Difficulty installing polycarbonate shields over orbiter windows. This is a static body position that requires the person to reach overhead for up to 20-30 minutes.

The fix: Back and shield support

- Back pad will extend 7 inches out from the panel and will run the length of the panel.
- Shield support will attach to bottom of panel and extend upward to hold the shield in place during build-up, eliminating the need for a human to manually hold the shield in place.
Project: Ingress/Egress through Orion Crew Hatch

- A proactive approach to evaluate how employees will access and transport items through the crew hatch.

So we are identifying potential risks before they become a problem!!!

Problem:
- Access issues while entering/exiting Orion Crew Module

Plan:
- To mitigate the excessive bending and twisting during ingress/egress
- Simulated a worst case and best case scenario
Project: Ingress/Egress through Orion Crew Hatch

Worst Case:
- Identified increased lower back compression forces while entering through the crew hatch when platform is flush with hatch entry

Best Case:
- Design a step/seat that is 18" above the platform for the technician to use for ingress/egress.
  - Reduces the low back compression forces, i.e., bending and twisting

Beyond Shuttle: Oh, the Possibilities...

- What can YOU do to reduce risk to employees AND flight hardware in your environment?
  - Take the time to identify risks FIRST...down to the smallest tasks
  - Think PROACTIVE when designing new products OR processes—it's easier to change the design on paper than after it's been implemented!
  - Talk to the people who actually perform the work. Their input is invaluable.
  - RUN TESTS to identify optimal designs and configurations
  - WALK THROUGH the ENTIRE process, from start to finish, and remember to have a reaction plan for off-nominal situations

- During the design phase, interview the users and develop requirements to ensure a user friendly product....
  But remember it is the DESIGNER'S responsibility to identify the risk, minimize it, and provide an intuitive, error-free product!
Questions