

# Human Factors Analysis to Improve the Processing of Ares-1 Launch Vehicle

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# Problem Introduction

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- Flight vehicle engineering designers for Ares-1 launch vehicle:
  - had the challenge to design the flight vehicle for effective, efficient and safe ground operations
    - needed to comply with the Human Systems Interface Requirements for ground processing of flight hardware

# Solution

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- Solution was to build a physical mockup of the areas where ground operations take place
- Determine the human interfaces and associated tasks performed
- Determine the applicable requirements for these interfaces and tasks
- Used the mockup to practice modifications to the design to meet the human factors requirements





## Solution - Requirements

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- The ground maintenance and assembly requirements in the HSIR included human factors major concerns for:
  - hardware access
  - work envelopes volumes
  - reach envelope volumes
  - visual access
  - LRU weight limit
  - tool clearances
  - appropriate clothing and equipment
  - emergency egress
  - maintenance without damage





# Solution - Requirements

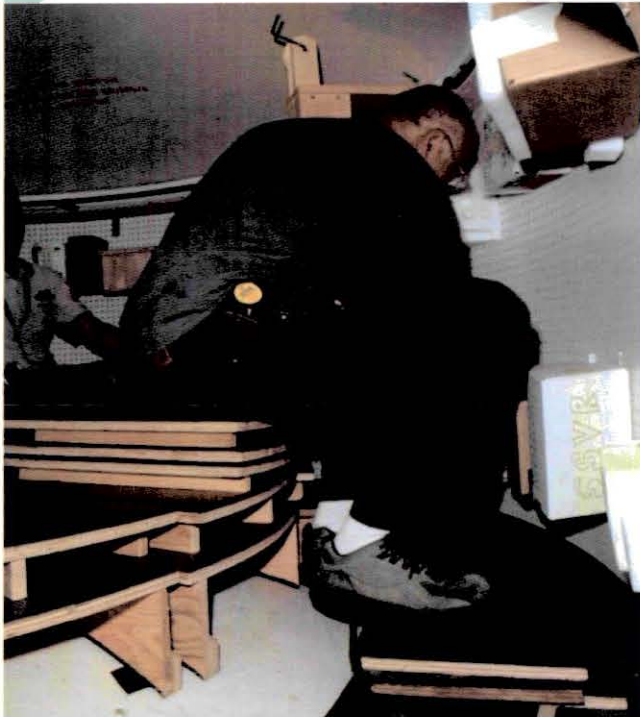
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- The Ares key human operations:
  - Ground handling and access platforms for all areas needed for access to the flight components
  - Avionics box installation/removal inside vehicle
  - Translation of avionics boxes from inside vehicle through hatch
  - Work volume inside skirt with multiple technicians
  - Installation/Removal of ground support equipment in vehicle
  - Normal and Emergency Egress operations through hatch and inside skirt

# Example – Ground Support Equipment

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- There is little that can be done to change these cramped dimensions in rocket design, so adjustments were made to:
  - the ground support equipment
  - box placement locations and heights
- The ground support equipment acts as a seat, and foot rest.
- Ground support equipment installed to:
  - protect the technician from injury
  - protect the flight hardware from damage



# Example – Avionics Boxes

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- There were several avionics boxes.
- The analysis determined the best locations based on the technicians location capabilities and:
  - Box weight
  - Tool access
  - Hand volumes
  - Cable routes





# Example – Hatch







# Advantages and Disadvantages

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- The physical mockup is very close to the real working environment
- Allow for the differences in human movement
- Promotes collaboration between designers and operators
- Different ways to perform a task can be analyzed and can be videotaped for further analysis
- Takes longer to build, and are more expensive than computer models
- Take up space, not easy to transport
- There is a chance of someone getting injured
- Operators may need to travel to the physical mockup location
- Finding the best solution takes time. Videos do not capture the 3D perspective



# Suggested Applications

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## Use physical mockups

- To improve communication between designers and users
- Where there are multiple activities taking place in the same area
- Where there are more than one person working in the same area
- Where there are awkward positions that cannot be understood well in computer models
- Where there are many human factors scenarios. To make the most of the cost and time spent to build the mockup

# Recommendations

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- Promote more standardized and integrated mockup processes and designs between KSC, MSFC, and JSC
- Promote sharing of mockups across Centers and projects
- Embed mockup analysis as part of the Engineering processes, as one option to choose from for the appropriate human factors engineering analysis
- Future mockups should also include more collaboration with the ground support equipment
- Introduce motion capture analysis capabilities into mockup activities. Motion capture allows for quicker and simpler physical mockups







# Summary

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- Mockup analysis proved very effective to promote collaboration between Ares -1 designers and ground operations personal to improve the flight hardware design
- Continue using mockups analysis to promote human factor design collaborations and solutions