1-G Human Factors for Optimal Processing and Operability of Ground Systems up to CxP GOP PDR

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*1-G is Earth Gravity

Problem Introduction

- KSC Design Engineering had the challenge to:
  - Define the human factors Level 5 requirements from the FAA HFDS for each CxP GOP subsystems (Over 40 Subsystems)
  - Develop a process for developing these requirements and improve the design for ground operations

Examples of subsystems:

- Crew Access Arm
- Breathing Air
- Cold Gas Helium
- Crew Module Ammonia
- Environmental Control
- Electrical Ground Support Equipment
- Hypergol
- LO2
- LH2
- GHE
- Ignition Overpressure/Sound
- Vehicle Access Arms
- Umbilicals

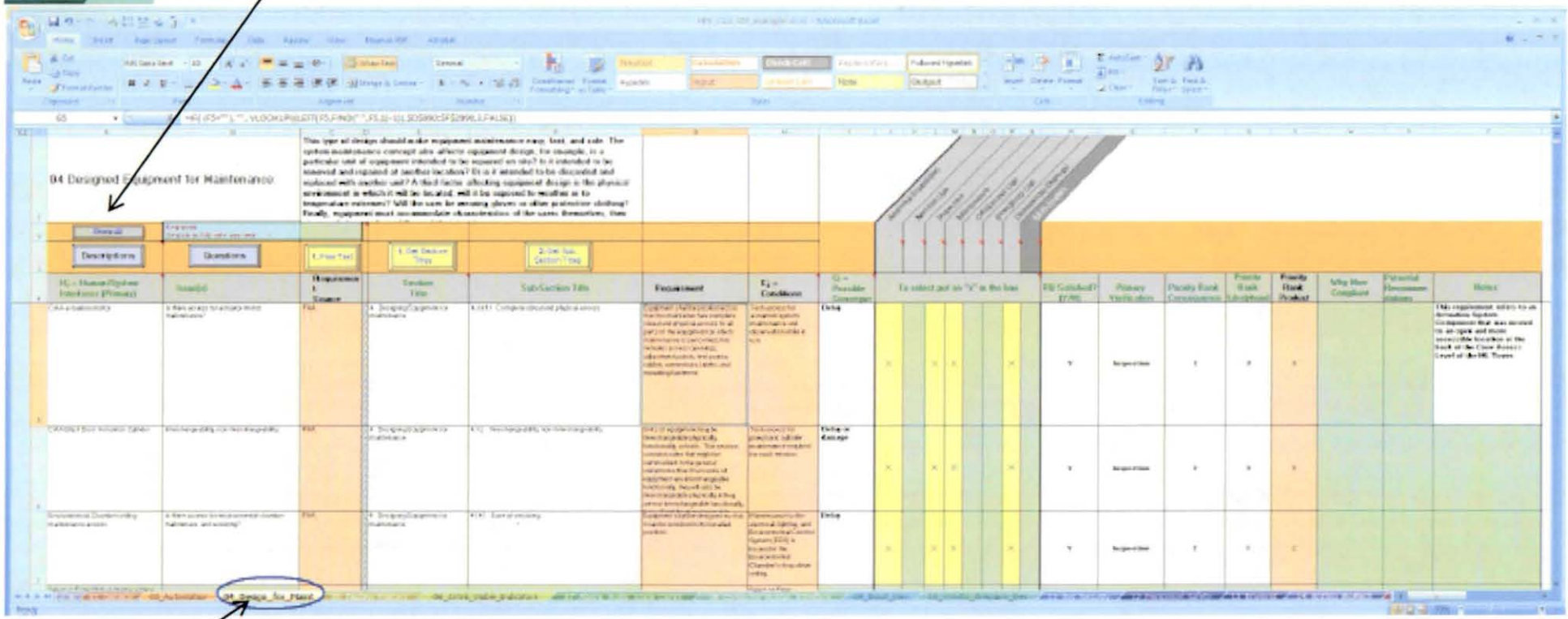
Solution

Within the Kennedy Documented Procedures a human factors engineering analysis was required to be performed by qualified human factors engineers

- Human Factors Engineering Analysis (HFEA) Tool was developed to create a dedicated subset of requirements from FAA requirements for each subsystem
- Meetings were held between the human factors engineers, lead design engineers, and systems engineers:
  - To understand the human interfaces of the subsystem
  - To understand the task at these interfaces
  - To determine the human factors considerations/issues with these task interfaces
  - To get agreement on the allocation of requirement on these task interface issues
  - And to derive human engineered design solutions for these requirements

Solution

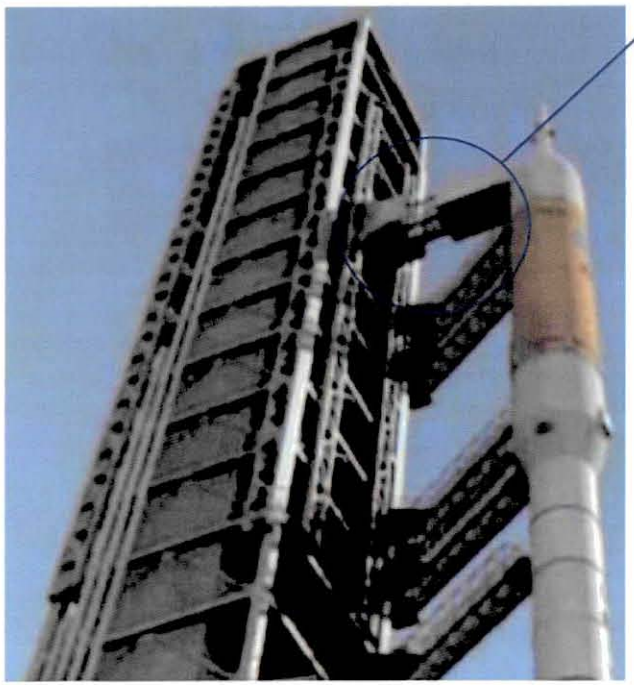
Columns: Human Interface, Issue, FAA Requirement, etc.



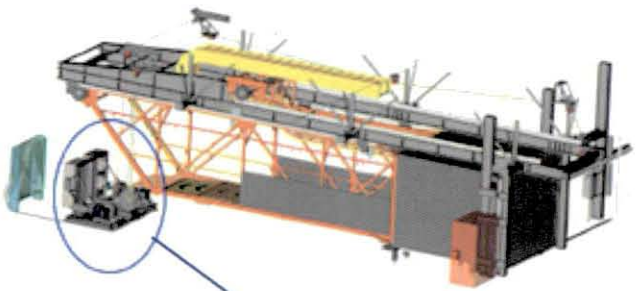
Each Tab is a FAA Chapter: Design equipment for maintenance, Controls and visual indicators, etc.

Example

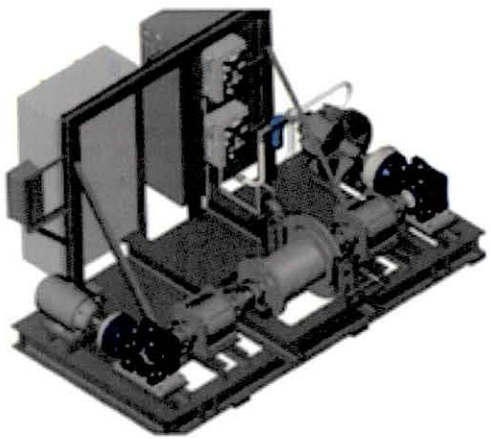
Mobile Launcher



Crew Access Arm



Actuator Motor



Example

- Human Interface - Actuator motor
- Issue/Consideration - Access for maintenance
- Requirement – FAA 4.3.4.1.1 Complete visual and physical access
  - Equipment shall be positioned so that the maintainer has complete visual and physical access to all parts of the equipment on which maintenance is performed; this includes access openings, adjustment points, test points, cables, connectors, labels, and mounting fasteners
- Consequence – Delay
- Processing phase - Inspection, Maintenance, and Disassembly
- Likelihood and Consequence was 2 and 3
- Notes: Solution was to moved the motor to an open and more accessible location at the back of the Crew Access Level of the ML Tower

Suggested Applications

- The HFEA analysis can be applied for designing in human factors for many applications
  - Since the FAA requirements are required by KSC ground systems and FAA, it is highly applicable at KSC and FAA
  - Other Government agencies may benefit from this tool, such as DoD
  - Other NASA Centers, Johnson Space Center, Marshall Space Flight Center, Etc
  - Non government companies

Advantages and Disadvantages

- Effective method to create a HFEA subsystem specific requirements report by tailoring out FAA requirements
  - Requirements were easy to select from drop down list
  - FAA sections were easy to select from tabs
- Excel sheet is easy to modify and to provide to the users; systems engineer, lead design engineer, and human factors engineer
- The process promoted identifying the human factors interface, issue, and then applicable requirements
- Determining which requirements to select from FAA was time consuming
- Determining which FAA sections applied was time consuming
- The excel sheet has limitations such as, processing time, and deletion of rows can disrupt macros
- Capturing lessons learned from design solutions was not stressed in the tool

Recommendations

For HFEA Tool improvement

- Improve selection of requirements so this is less time consuming
- Improve selection of FAA Chapter sections (tabs) so this is less time consuming
- Improve the functionality of the tool by making it a software or web-based instead of an excel spreadsheet
- Improve the tool so it promotes a operations time line way of analyzing the human factors interfaces
- Improve the tool so it will promote capturing lessons from design solution, and use of design solutions in future use
- Improve the tool and related database through collaborations with other NASA Centers, FAA, DoD, and commercial uses

Summary

- Continue to use and improve thee HFEA process and tool
- Have kickoff human factors meetings with the systems engineer and lead design engineer earlier in the design process at 30%
- Include the Human Factors Engineer as a member of the deign team
- During verification, the HFEA report should be used as a verification checklist