

# Human Factors Operability Timeline Analysis to Improve the Processing Flow of the Orion Spacecraft

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# Problem Introduction

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- Orion vehicle goes through several areas and stages of processing before its launched at the Kennedy Space Center
  - In order to have efficient and effective processing, all of the activities need have a human factors engineering analysis
  - Corresponding Human factors requirements and design solutions needed to be defined
- Areas of Processing
  - MPPF (Crew module and Service module)
  - Vehicle Integration Building (VAB) (Crew module/Service module to Launch Vehicle and Ground Support Equipment
  - Launch Pad



# Solution

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- Developing a written timeline of events that included each activity within each functional flow block
- For each activity, develop computer animation videos and pictures of the human and hardware
- The HFEAT was improved by modifying it to include the timeline of events.
  - See IEEE paper 1-G Human Factors for Optimal Processing and Operability of Ground Systems up to CxP GOP PDR
- Each activity was analyzed by operability experts and human factors experts with spacecraft processing experience
- The HFEAT was used to define the human factors requirements
- Design solutions were developed for these requirements



# Solution

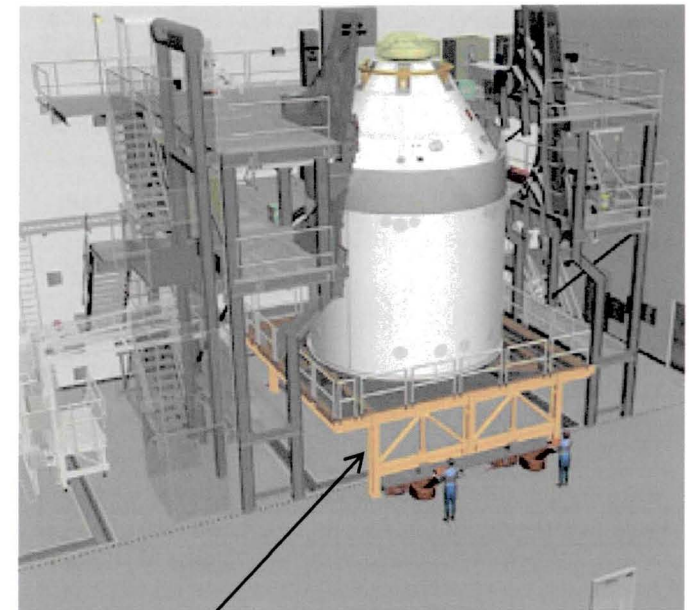
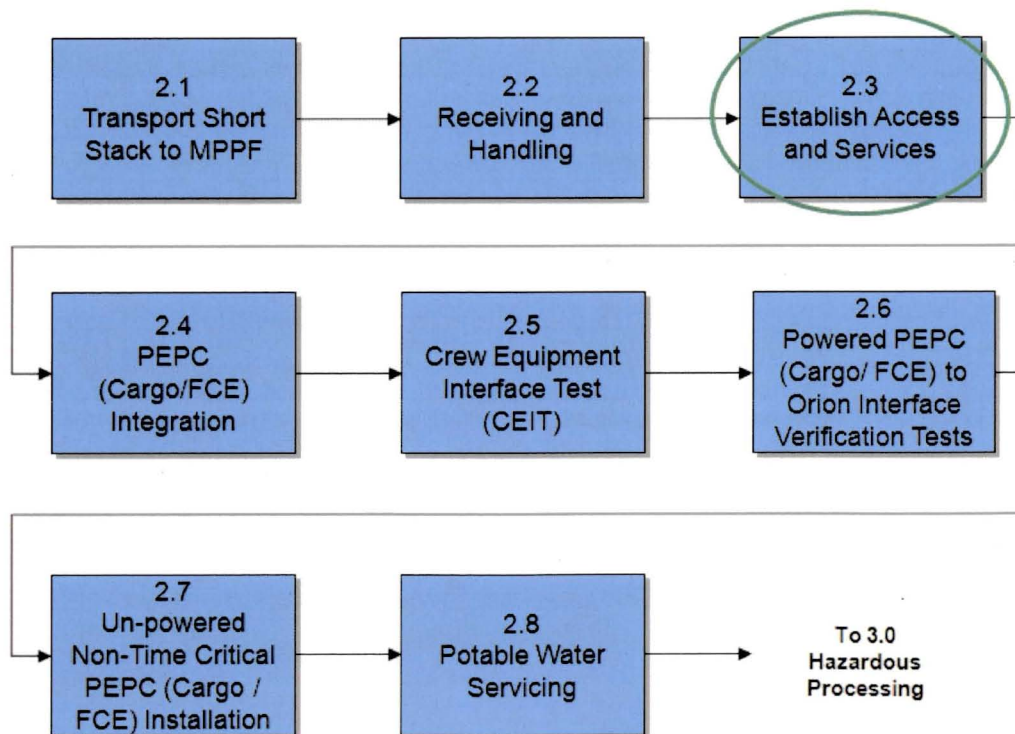
- The HFEAT was modified to include column inputs for:
  - Location
  - Human Interface
  - Task
  - FFBD Event and Number
  - Task Issues and Actions
  - Team Actions
  - Comment for Video

Orion Timeline\_Human\_Factors\_Analysis\_Rev 5 (5-8-9) (3L for paper) [Compatibility Mode] - Microsoft Excel

Location	Human/Syst em Interfaces (Primary)	Human Interface	Task	FFBD Event and Number	Tasks and Issues and Actions	Req Source	Section Title	Sub- Section Title	Requirement	Conditions	Possible Consequences	Assembly Nominal Use	Inspection Maintenance	Emergency Use Off/Nominal Use	Primary Verification	Priority Rank Likelihood	Priority Rank Consequence	Priority Rank Product	Why Non- Compliant	Potential Recommendations	Notes	Team Action	Comment for Video
MPP	Short stack pallet			FFBD # 2.17 and 3.83	TASK: Move short stack pallet into and out of servicing bay ISSUE: Communication, visibility by operator to pallet corner. Alignment of pallet into bay ACTION: Assume method to prevent movement and misalignment of pallet with existing bay structure during installation/removal of short stack pallet	FAA	General Design Requirements	2.1 Incorporate Safety Factors 2.2.2 F of Safe Design 2.3.3 Error Prevention 2.3.4 Error Tolerance	Users shall be protected from making errors to the maximum possible extent.	LOCATION: Inside MPP	GSE damage, delay	X	X		N	Adapt	2	2	4 Current conceptual design does not address this issue	Install guide rails on floor	Maintenance is to address pallet storage without Orion Short Stack.	Tom Mader and Marco Flaminio to assess this human factors item and respond to team lead (Roland Bohlert)	
MPP	ECS transport purge hoses and connectors			FFBD # 2.13, 2.3.3, 3.83, 4.23	TASK: Connect, Disconnect and stow hoses (Lifting, handling - pulling). Weight, flexibility of hose. The connection is low to the ground. ACTION: Assume the hoses can be lifted by the technicians (Two person lift)	FAA	4.2.2 Weight	4.2.2.8 Maximum weight of units of equipment to be carried by more than one person.	If a unit of equipment is designed to be carried by two people, the weight carried by either one of them shall not exceed 19 kg (42 lb). Thus, if the weight of the unit is distributed uniformly, the maximum weight of the unit is 38 kg (84 lb). This limit applies to carrying distances up to 10 m (33 ft).	LOCATION: Inside MPP and YAB	Heavy GSE damage, delay	X	X	X	N	Inspection	2	2	4 Lift requires more than 44 pounds per person and awkward postures.	Consider making hoses in sections to reduce weight.	History of bail and enclosures remove from under tasks (disconnecting and stowing hoses hoses at pad). See Gap Requirement (NCR) using equation for allowed body position.	Progenio Francis to assess this human factors item and respond to team lead (Roland Bohlert)	no human shown
MPP	Short stack pallet guard rails			FFBD # 2.13, 2.3.3, 3.83, 4.23	TASK: Remove guard rails from short stack pallet ISSUE: Lifting, handling and awkward positions. Weight and size of guard rails. ACTION: Assume the guard rails can be lifted by the technicians (One or Two person lift)	FAA	4.2.2 Weight	4.2.2.8 Maximum weight of units of equipment to be carried by more than one person.	If a unit of equipment is designed to be carried by two people, the weight carried by either one of them shall not exceed 19 kg (42 lb). Thus, if the weight of the unit is distributed uniformly, the maximum weight of the unit is 38 kg (84 lb). This limit applies to carrying distances up to 10 m (33 ft).	LOCATION: Inside MPP and YAB	Heavy GSE damage, delay	X	X	X	N	Inspection	2	2	4 Current conceptual design does not address this issue	Design manageable size and weight guard rails	The guard rails are located on the short stack pallet.	Randy Eastman to forward to LM Short Stack pallet POC for disposition and respond to team lead (Roland Bohlert)	

# Example

## Functional flow block diagram



Short stack pallet



# Example

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- Location – MPPF
- Human/System Interface - Short stack pallet
- Task/Issue/Action
  - Task: Move short stack pallet into and out of servicing bay
  - Issue - (Communication, visibility by operator to pallet corners): Alignment of pallet into bay
  - Action - Assure method to prevent contact and misalignment of pallet with existing bay structure during installation/removal of short stack pallet
- FAA Requirement - Users shall be protected from making errors to the maximum possible extent
- Potential Recommendation - Install guide rails on floor
- Team Action – Team Members to assess this human factors item and respond to team lead





# Suggested Applications

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- Where ever there is a timeline of activities to operate, maintain, or assemble hardware
- Where FAA requirements are required for design engineers.
- Other NASA Centers, Johnson Space Center, Marshall Space Flight Center, Etc
- Non government companies



# Advantages and Disadvantages

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## Advantages

- Time line is logical way to analyze the human activities
- Includes the engineering FFBD approach
- Promotes collaborations with human factors engineer and operations engineers
- This method ensures the capture of sequence of tasks at each processing location
- Includes the other capabilities from the HFEAT, such as the FAA requirements
- Includes use of human visualization techniques

## Disadvantages

- Time consuming, but it is thorough.





# Recommendations

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## For Tool improvement

- Improve the method for selection of FAA requirements so this is less time consuming
- Improve the method for selecting; Location, FFBD numbers, tasks, issues and actions
- Improve the functionality of the tool by making it a software or web-based instead of an excel spreadsheet
- Improve the tool so it will promote capturing lessons from design solutions for use in future designs



## Summary

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Continue to use the timeline method to successfully map out the processes and to perform human factors operability engineering analysis, and to derive applicable human factors design requirements and design solutions