

## HUMAN FACTORS CHECKLIST: THINK HUMAN FACTORS – FOCUS ON THE PEOPLE

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### ABSTRACT

A quick-look Human Factors (HF) Checklist condenses industry and NASA Agency standards consisting of thousands of requirements into 14 main categories.

With support from contractor HF and Safety Practitioners, NASA developed a means to share key HF messages with Design, Engineering, Safety, Project Management, and others. It is often difficult to complete timely assessments due to the large volume of HF information. The HF Checklist evolved over time into a simple way to consider the most important concepts. A wide audience can apply the checklist early in design or through planning phases, even before hardware or processes are finalized or implemented. The checklist is a good place to start to supplement formal HF evaluation.

The HF Checklist was based on many Space Shuttle processing experiences and lessons learned. It is now being applied to ground processing of new space vehicles and adjusted for new facilities and systems.

### 1. INTRODUCTION

If human factors (HF) concepts are not applied, it is often due to the complexity of understanding the large volume of requirements and information available. The sheer quantity of information can make it difficult to know where to begin. Also, with limited resources, it is often difficult to complete timely HF assessments.

To bridge the gap, a simple 14-item HF Checklist was developed to share key HF messages throughout the

Kennedy Space Center (KSC) and other NASA Centers. Originators included NASA civil servant and contractor HF Practitioners with a variety of HF training, operations experience, and work experience on different programs at various Centers.

The NASA Constellation Program Ground Operations Project developed a set of HF requirements to cover the key areas of launch processing concerns. These were high-level requirements, such as reach, envelope volume, visual access, damage prevention, lifting, and tool clearances. In 2007, a pathfinder project focused on similar HF issues related to design of ground systems and developed the initial HF checklist as a tool to help engineers identify HF areas of concern. The project applied the checklist to key tasks that would involve multiple personnel or place individuals or teams in complex configurations. [1] A 2014 pathfinder applied an updated checklist to identify and categorize HF aspects with a subset of tasks planned for the Space Launch System (SLS); entailing a multi-purpose crew vehicle atop a core stage rocket and boosters.

The HF Checklist evolved after the pathfinder projects to identify HF risks in new program designs for flight and ground systems. It was revised over time and developed into a flyer for general use within the NASA community. See Fig. 1 and 2.

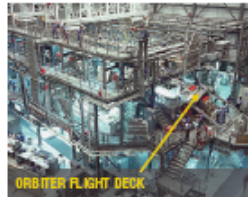


# THINK HUMAN FACTORS

Focus on the People



ORBITER FLIGHT DECK



ORBITER FLIGHT DECK

Conceptual vs. Actual

**14** Checklist Items  
address  
**1000's**  
of Human Factors Requirements

**Think Human Factors throughout lifecycles:**

- A - Concept and Technology Development,
- B - Preliminary Design and Technology Completion,
- C - Final Design and Fabrication,
- D - System Assembly, Integration and Test, Launch,
- E - Operations and Sustainment,
- F - Closeout (NPR 7123.1A)

**Define task steps and human interfaces**

**Use checklist to ID human factor issues**

## HUMAN FACTORS CHECKLIST

- Work Environment
- Personnel Workspace (Work Envelope Volume)
- Adjacent Work Areas
- Remote/Local Operations – Control Rooms
- Visual Access
- Information Displays
- Consistent Nomenclature
- Mating/Connections
- Physical Tasks – Lift/Push/Pull/Carry/Climb/Postures/Etc.
- Tools or Shop Aids
- Personal Protective Equipment (PPE): Gear/Attire
- Task Design and Training
- Consistent Work Practices and Cognitive Factors
- Damage/Error Prevention, Detection and Recovery

A simple lifting strap solution can redistribute loads to reduce risk of injury.



Assessing improvement options for Mobile Launcher Jib Hoist handling at Kennedy Space Center (KSC) – NASA Design, & Jacobs Test & Operations Support Contractor (TOSC)

Data indicators using inconsistent coloring could lead to human error

Clearer labels & actions for controls/displays reduce chances of injury, damage & errors



Space Launch System: Local and Remote Controls and Displays

### Notes

Most of these checklist items were common contributors to mishaps, close calls, process escapes, etc. at KSC.

Consider these human factors basics and, for more topics, details, and complex concerns, see References. Consult a human factors professional for more thorough human factors analyses and assessments.

Figure 1: Kennedy Space Center Human Factors Checklist, Side 1

# HUMAN FACTORS CHECKLIST

Think about these 14 checklist items  
TO IMPROVE YOUR DESIGNS, PLANNING, OPERATIONS AND MORE:



- 1. Work Environment** - ACCOUNT FOR WORK LOCATION VARIABLES.  
Consider:  Lighting  Noise  Temperature  Vibrations  
 Distractions  Material handling  Weather  Wildlife  
 Communications  Travel paths  Work surfaces  Elevations  
 Portable and fixed items. Mitigate with:  PPE  Scheduling  
 Training  Controls  Barriers.
- 2. Personnel Workspace (Work Envelope Volume)** - PROVIDE CLEAR AND ADEQUATE PHYSICAL ACCESS TO PERFORM INTENDED WORK.  
Consider space to:  Operate and stage hardware and tools  
 Interface with equipment or consoles  Work adjacent to facility, hardware, or other personnel  Work individually or in teams.
- 3. Adjacent Work Areas** - SEPARATE OR ACCOUNT FOR ACTIVITIES THAT COULD CONFLICT.  Plan for clear communications  
 Provide communication devices  Prevent conflicting functions (sanding near painting; electrical near plumbing; sensitive work near vibrations, reaching across workstations.)  Mitigate items crossing work areas (hoses, lines, etc.).
- 4. Remote/Local Operations** - Control Rooms - ALIGN DATA AND COMMUNICATIONS AMONG TASK SITES AND CONTROL AREAS.  
 Provide console or control room team with data and or camera coverage of task site team  Supply communication and safety methods for hands-on team.
- 5. Visual Access** - PROVIDE DIRECT VISIBILITY TO WORK BEING PERFORMED. Provide:  Task-specific lighting  Glare mitigation  
 Direct lines of sight  else, provide displays for viewing  Avoid visual or physical obstacles  Avoid positioning items beneath or behind others  Avoid requiring mirrors to view items.
- 6. Information Displays** - PROVIDE CLEAR, LEGIBLE, FUNCTIONAL IDENTIFICATIONS.  Account for visual variables (impairments, color-blindness, PPE, etc.)  Employ various indicators (i.e., audio, visual, tactile, movement, color, dimension, size)  Offer mixture of indicators for safety or time-sensitive systems (i.e., text or alarms accompanying color-coded indicators; categorized maps for inspection coverage, 3D views with 2D drawings).
- 7. Consistent Nomenclature** - STANDARDIZE NOMENCLATURE, FORMATS AMONG LOCATIONS, FUNCTIONS, AND COMPONENTS. Maintain consistency in:  Terminology  Interface labels  
 Signage  Color-coding  Types of labels, placards or markings for switches, circuit breakers, panels  Other human-system interfaces.
- 8. Mating/Connections** - PROMOTE STANDARDIZATION, CLEARANCES, CORRECT ALIGNMENTS.  Provide design, controls, barriers to prevent mis-mating hardware or configurations (i.e., mechanical, electrical, fluid, fasteners, cables, software). Offer clearances for:  Grasping  Carrying  Staging  Work motions  Provide checks to match intended configurations, hardware, and documentation.
- 9. Physical Tasks** - Lift/Push/Pull/Carry/Climb/Postures/Etc - ACCOUNT FOR PERSONNEL VARIABILITY AND TASK DEMANDS. Consider:  User populations  Weight loads  Workspace sizes  
 Postures,  Travel paths  Elevations  PPE  Other physiology or material handling variables. Provide:  Handles  Handholds  
 Mobility aids  Load capacity limits  PPE  Padding  Team communications  Optimal work heights and reaches.  Conduct human-system analysis for potential task risks  Identify areas where loads/grasps are prohibited  Mitigate multiple physical exertion demands (i.e., twisting while squatting or carrying awkward load while climbing).
- 10. Tools or Shop Aids** - ALIGN TOOLS TO THE TASK AND USER POPULATION.  Limit variety. Consider for standard and any specialized tools/aids:  Tool or equipment handling  PPE  
 Work environment  Training  Other human-system variables.
- 11. Personal Protective Equipment (PPE): Gear/Attire** - ACCOUNT FOR GEAR OR ATTIRE THAT MAY ALTER TASK PERFORMANCE. Consider:  Altered mobility  Dexterity  Senses  Weight  Size  
 Time. Plan for:  Weather protection  Clean room attire  PPE combos  Material handling  Travel paths  Hose management.
- 12. Task Design and Training** - CONSIDER USERS AND HUMAN SYSTEM INTEGRATION IN TASK DEVELOPMENT AND EVOLUTIONS.  
 Involve workers through concepts, work development, and changes  Reduce system interface complexities  Conduct task analysis and human-system-integration reviews  Conduct on-the-job training  Practice with actual items  Use common materials or high-fidelity models, simulations, physical mockups  
 Document, incorporate lessons learned  Provide clear, correct, complete work instructions.
- 13. Consistent Work Practices and Cognitive Factors** - STANDARDIZE AMONG SIMILAR FUNCTIONS, WORK AREAS.  Account for psychological, organizational variables  Use standard conventions  
 Inform of irregularities  Outline work  Align work with schedules and biological breaks  Employ situational awareness checks  Limit multitasking, decision making, complacency  
 Provide measurement goals and tolerances  
 Avoid mental calculations.
- 14. Damage/Error Prevention, Detection and Recovery** - PREVENT HUMAN ERROR AND HUMAN-INDUCED SAFETY OR COLLATERAL DAMAGE OPPORTUNITIES.  Provide means of detection by inspection or test  Offer capability to recover  Define and plan for contingency procedures  Offer hardware and personnel protection  Make consequences of errors on safety or system performance clear.

This list is not all inclusive. There may be other areas to consider.

## GENERAL REFERENCES

- MIL-STD-1472 Design Criteria Standard Human Engineering
- FAA-HFDS (HF-STD-001) Human Factors Design Standard

Figure 1: Kennedy Space Center Human Factors Checklist, Side 2

## 2. FOCUS ON THE PEOPLE

All designs and operations can be improved by maintaining a focus on how humans will interface with the entire system or project lifecycle. By defining task steps and human interfaces ahead of time, the HF Checklist can be used to identify HF issues early in the lifecycle, saving time and reducing the cost to make changes.

### 2.1. System Lifecycles

NASA considers HF throughout system and project lifecycles, including the following phases [2]:

- A - Concept and Technology Development
- B - Preliminary Design and Technology Completion
- C - Final Design and Fabrication
- D - System Assembly, Integration and Test, Launch
- E - Operations and Sustainment
- F - Closeout

### 2.2. Task Steps and Human Interfaces

For each phase, taking the time to consider the individual task steps and all of the places where people interact with each other or with systems will target areas that may pose HF challenges. As conceptual aspects mature into more detailed renditions, additional structures, features, and human aspects will emerge.

For example, planners conceived that placing a Space Shuttle Orbiter into its horizontal processing hangar would involve only a few floor-based work stands. As processes began, needs arose to add platforms and adjustable components to allow personnel to reach and view each area.

Even with the best planning, events may change in any phase of the lifecycle, resulting in reconsideration of designs, task steps, or human interfaces.

Since predicting future modifications is not always clear in early phases, best practices include designing for flexibility and robustness.

Foreseeing evolutions in designs, maintenance schedules or other components can prevent future human-system-integration risks or delays. For example, initial concepts pointed to leaving Space Shuttle engines installed between flights, but engineering analysis determined that removal was needed more often, changing a task that was expected to occur infrequently into a frequent activity.

### 2.3. HF Checklist Application

The checklist can aid in addressing HF issues after identifying task steps and human interfaces and prior to finalizing designs or tasks in various applications.

Applications for the checklist can include: Concepts of operations, design reviews, operations planning, task analyses, procedure development, dry runs or prototyping, training, test/checkout, modifications, and communications of HF concerns.

Topics may range from physical operations and maintenance tasks to software and human-computer processes.

### 2.4. Supplement to HF Expertise

While the checklist is versatile, its intent is not to replace the involvement of HF experts. Many checklist items appear as common contributors to mishaps, close calls, process escapes, or lessons learned. Designers and planners should consider the HF checklist basics and contact HF expertise for more complex concerns.

HF experts recommend that developers and planners refer to the checklist during task analysis activities to involve users and HF expertise in concepts of operations, procedure development, and other task design components. The team can merge subject matter proficiencies to develop improved components and processes for mitigating risks [3].



Figure 3: HF Expertise at Task Analysis Review

## 3. HF CHECKLIST

The 14 checklist items can be used to address thousands of human factors requirements and best practices. The checklist is not intended to replace the requirements. Nevertheless, it is a good place to start focusing discussions and targeting further analysis.

The following HF Checklist item descriptions provide quick overviews and examples. However, they are not all-inclusive.

### 3.1. Work Environment

Since the work environment can be indoors or outside, ground level or elevated heights, or composed of multiple facets, it becomes one of the first

considerations in designing or improving the human-system integration aspects.



Figure 4: Launch Site Work Environment

Account for work location variables, such as lighting, noise, temperature, vibrations, distractions, material handling, weather, wildlife, communications, travel paths, work surfaces, elevations, portable and fixed items. Mitigate with personal protective equipment (PPE), scheduling, training, controls, or barriers.

### 3.2. Personnel Workspace (Work Envelope Volume)

After addressing the broader aspects of the work environment, the personnel workspace, or envelope, should be the next focus.

Provide clear and adequate physical access to perform intended work including space to operate and stage hardware and tools; interface with equipment or consoles; work adjacent to facility, hardware, or other personnel; and to work individually or in teams. These considerations are also applicable to planning for work in tight quarters to prevent, avoid, or mitigate narrow or limited workspaces.



Figure 5: Limited Workspace May Warrant Mobility or Handling Aids

### 3.3. Adjacent Work Areas

When two or more operations can be performed side-by-side, it is important to look beyond the individual workspaces.

Separate or account for activities that could conflict. Plan for clear communication and provide appropriate

communication devices. Prevent conflicting functions (e.g., sanding near painting; electrical near plumbing; sensitive work near vibrations, reaching across workstations). Mitigate items crossing work areas (e.g., hoses, lines).



Figure 6: Communication - Key when Adjacent Work Visibility or Noises are Factors

### 3.4. Remote/Local Operations – Control Rooms

When operations require teams to be separated due to hazardous or other conditions, the integration between the local hands-on team and the remote operators is essential.

Align data and communications among the task sites and their control areas to promote consistency. Provide console or control room teams with data or camera coverage of task site team. Supply communication and safety methods for hands-on team whether working in different facilities, different rooms in same facility, or in same room or area using verbal or other data commands.

Besides physical tasks or designs, the HF checklist provides benefit to software, programming, and other human-computer interfaces. For example, a visual icon changing to accompany color-coded, categorized text can provide two modalities to aid the decision making process.



Figure 7: Control Room Operations & Communication

### 3.5. Visual Access

Ensuring visibility to work tasks encompasses several variables.

Provide direct visual access to work tasks. Provide task-specific lighting, glare mitigation, and direct lines of sight. Otherwise, provide displays for viewing remote or hard-to-see operations.

Designs and plans should preclude visual or physical obstacles, positioning items beneath or behind others, or requiring mirrors to view items. Designs or tasks should prevent, avoid, or mitigate limited visibility configurations or conditions.

Together, multiple personnel could provide different vantage points to several Space Shuttle tasks such as lifting valuable flight hardware. At those times, additional communication was key in ensuring information transferred appropriately.

### 3.6. Information Displays

Viewing various forms of media or indicators can be a key communication aspect.

Provide clear, legible, functional identifications. Account for visual variables such as impairments, color blindness, and PPE. Employ various indicators such as audio, visual, tactile, movement, color, dimension, or size. A mixture of these can further aid safety or time-sensitive systems (e.g., text or alarms accompanying color-coded indicators; categorized maps for inspection coverage, 3D views with 2D drawings).

During Shuttle processing, three similar processing hangars housed the Orbiters between landing and launch operations at KSC. Two facilities were parallel and nearly identical to each other while the third differed by 180 degrees. When Orbiters, work stands, hardware, equipment, and other items were in place, it became challenging to look around and easily determine east, west, north, or south directions as guided on some crane and hoist operations. To improve situational awareness, HF practitioners worked with technical shops to add large directional signage. Located above each Orbiter's payload bay, they clearly identified east, west, as well as forward and aft to note the nose-end and tail-end orientations. To ensure consistent processes, authors updated procedures as well to match the nomenclature of the cost effective information displays. Besides improving operational communications, signage also assisted in potential emergency reporting to better identify incident locations. As noted, information displays can provide multiple benefits. Many HF Checklist components apply.

### 3.7. Consistent Nomenclature

If confusing or conflicting messages are possible, the outcomes can vary from planned intentions. The goal is for checklist users to ponder and mitigate options to prevent multiple choices or differing results.

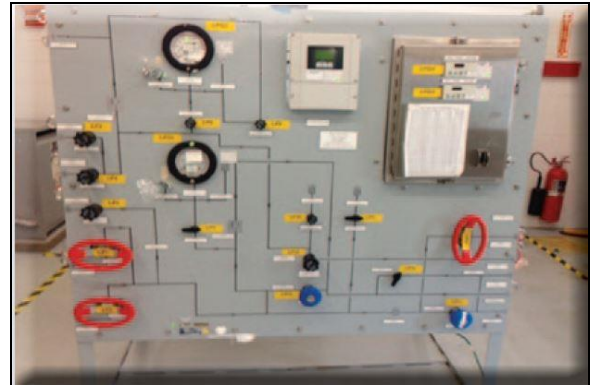


Figure 8: Nomenclature and Color-Coding Combined

To avoid this, standardize nomenclature and formats among locations, functions, and components. Ensure consistency in terminology, interface labels and signage, color-coding, and types of labels, placards, or markings for switches, circuit breakers, and panels.

### 3.8. Mating/Connections

Mating and connector tasks require clear communication and other risk mitigation components. Promote standardization, clearances and correct alignments. Provide design, controls, and barriers to prevent mis-mating hardware or configurations (e.g., mechanical, electrical, fluid, fasteners, cables, software). Offer clearances for grasping, carrying, staging, and work motions, and provide checks to match intended configurations, hardware, and documentation.



Figure 9: Mating – Physical & Visual Access

### 3.9. Physical Tasks

Physical tasks may include lifting, pushing, pulling, carrying, climbing, postures, and other biomechanical aspects. Challenging or repetitive physical tasks could further compound risks.

Account for personnel variability and task demands. Consider user populations, weight loads, workspace sizes, postures, travel paths, elevations, protective gear, and other physiology or material handling variables. Provide handles, handholds, mobility aids, load capacity limits, PPE, and team communications devices and plans.

Conduct human-system analysis for potential task risks. Identify areas where loads or grasps are prohibited. Mitigate multiple physical exertion demands such as twisting while squatting and carrying awkward loads while climbing.

### 3.10. Tools or Shop Aids

It seems obvious to choose the right tool or aid for the job at hand, but doing so should encompass several human system integration factors.

Align tools to the task and user population. Limit the variety of tools or aids. For standard and any specialized tools/aids, consider tool or equipment handling, PPE, work environment, training, and other human-system variables, such as frequency, duration, and reach.

With such expansive Space Shuttle surfaces, blends of tools and flexible shop aids brought workers to the hardware (Fig. 10), fitting the job to the person rather than creating individually designed components.



Figure 10: Work Stands with Attachments can Place Personnel/Tools/Equipment at Arm's Reach

### 3.11. Personal Protective Equipment (PPE) Gear/Attire

Protective gear or attire can add to personnel workspaces and affect task design or planning.

Account for gear or attire that may alter task performance such as altered mobility, dexterity, senses, weight, size, and time. Plan for weather protection, clean room attire, material handling, travel paths, hose management, and PPE combinations, such as communication headsets under helmets.



Figure 11: Gloves & Suits Impact Senses/Dexterity

Designers should be encouraged to don PPE to understand first-hand how the protective gear or attire can affect the intended work. Obtaining subject matter expertise from field personnel who have donned or used such PPE can also provide significant lessons learned. Learning the effects of visual perception, mobility, tactile, dexterity, or other challenges in PPE

can also be obtained from modelling and simulations if actual practicing with gear or hardware is not possible.

### 3.12. Task Design and Training

Prior to work execution, diligence to training and task design can impact desired outcomes.

Consider users and human system integration in task development and evolutions. Involve workers through concepts, work development, and changes. Reduce system interface complexities. Conduct task analysis and human-system-integration reviews. Conduct on-the-job training. Practice with actual items, or use common materials or high-fidelity models, simulations, physical mock-ups. Document and incorporate lessons learned. Provide clear, correct, and complete work instructions.



KSC-2014-2572\_May2014 SAN DIEGO U.S. Navy & Jacobs TOSC Orion boilerplate test vehicle from BTA

Figure 2: Practice with Orion Crew Module

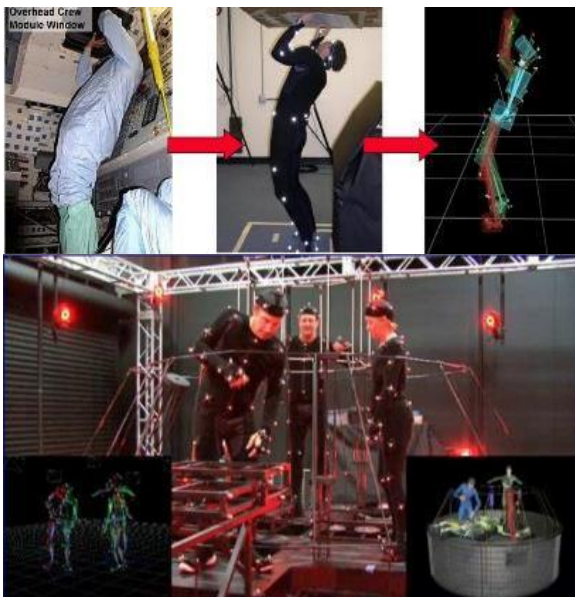


Figure 13: Shuttle Motion Capture Evaluation

Shuttle processing and operations planning for the new Orion crew module employed an example of a task design tool. HF practitioners teamed with computer science entities to develop a means to perform motion

capture while assessing real-time human factors and ergonomic data. The tool assisted with a variety of activities ranging from evaluating improvements for the removal of wing leading edge panels to stepping across open flaps or doors on the Shuttle. During design phases of the new crew module, technician teams assisted HF and designers in the validation of collecting dynamic biomechanical, biomedical, fatigue, and collision data. They evaluated did this while performing seat, avionics boxes, suited, and panel handling tasks. Information aided the design, order of operations, staging options, and risk mitigation. Having a quantitative HF tool enhanced the traditional task design and training toolsets [4]. The checklist can assist such tool application or other task design options and training components.

Off-nominal tasks and non-routine situations often compound HF issues. Even with tasks viewed as potentially never or rarely performed, designs and planning phases should consider spending as much or more time designing the procedures and training so that contingency, emergency operations, and troubleshooting aspects will be available allowing focus on the contingency task resolution.

Such practice can occur with acting out actual contingency or emergency tasks such as astronaut rescue at the launch pad (Fig. 14). Other practices or dry runs can start with discussions and use materials and components available.



Figure 14: Astronaut Emergency Egress Simulation

At a minimum, the operators of systems can provide essential information during system designs or execution planning and into procedure development.



The HF Checklist can assist those phases. Utilizing HF practitioners and tools in task designs and training can provide an even broader aspect, especially to more complex tasks.

### 3.13. Consistent Work Practices and Cognitive Factors

Among systems, personnel, and their environments, consideration to consistency and other cognitive factors must also occur.

Standardize among similar functions and work areas. Account for psychological and organizational variables. Use standard conventions and inform of irregularities. Outline work and break down tasks to align with schedules, biological breaks, and challenges of the steps at hand.

Employ situational awareness checks. Limit multitasking, decision making, and complacency. Provide measurement goals and tolerances. Avoid requiring personnel to execute mental calculations. Instead, provide users with intended goals and acceptable ranges.

Clear labels and actions for controls and displays reduce chances of injury, damage, and errors. On the other hand, data indicators using inconsistent coloring could lead to human error.

### 3.14. Damage/Error Prevention, Detection, and Recovery

Designing out potential risks or human error opportunities is the most effective approach. Being able to detect any damage during processing and having means for recovery are key to finalizing robust tasks and designs.

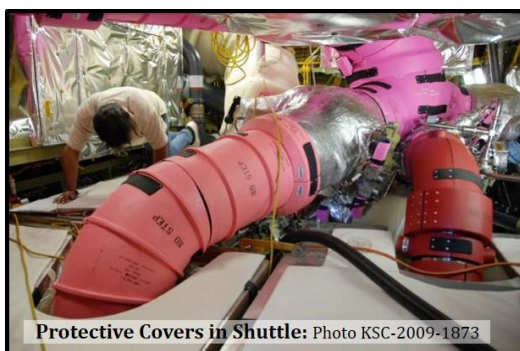


Figure 15: Protective Covers Protect Hardware and Personnel

Prevent human error and human-induced safety or collateral damage opportunities. Provide a means of detection by inspection or test while providing the

capability to recover. Define and plan for contingency procedures.

Offer hardware and personnel protection. Make consequences of errors on safety or system performance clear.

System experts rely on many lessons learned from Shuttle processing. Through knowledge sharing and HF training, engineers and designers are encouraged to review aerospace and industry lessons learned, gain tribal experiences from legacy experts, as well as conduct activities to increase interfaces with users, practice tasks, and continually evaluate and implement means to mitigate damages and errors.

## 4. SUMMARY

From initial concepts through designs, testing, implementations, and evolutions, the basic HF Checklist can be a quick tool for highlighting key HF topics while keeping the focus on the people.

Intangible and tangible results may include safer and easier systems to operate and maintain. Cost effective options can also overlay enhancement opportunities.

Summarizing thousands of requirement topics into a manageable set of HF topics makes it easy to use in aerospace activities. Reductions in undetected errors and collateral damage risks can enhance ground crew operations and could ultimately improve flight crew safety [5].

HF Checklist's simplified format also makes it applicable to general industry and outside of the work environment.

As a good place for anyone to start, the checklist provides a beneficial snapshot of many HF topics. Employing HF practitioners in further evaluations provides added advantages to designs and processes.

“Thinking Human Factors and Focusing on the People” throughout lifecycles and evolutions leads to better designs, improved planning and execution, in addition to error reductions.

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