



The History of Worksite Design in Rockets



Human Factors &
Integrated Logistics Engineering

Design of Systems for Safe Launch Operations

Session S-12
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Concept of rocket design

- ⊕ **First focus is performance**
 - ⊕ Getting it to go as far as planned and to the desired location



Concept of rocket design

- ⊕ **First focus is performance**
 - ⊕ Getting it to go as far as planned and to the desired location
 - ⊕ *Without blowing up!*
- ⊕ **So designers worry about**
 - ⊕ **GN&C**
 - ⊕ Avionics
 - ⊕ Electrical power
 - ⊕ Inertial guidance systems
 - ⊕ **Fuels**
 - ⊕ Types
 - ⊕ Amounts
 - ⊕ **Engines**
 - ⊕ Turbines
 - ⊕ Combustion chambers
 - ⊕ Nozzles
 - ⊕ **Plumbing**
 - ⊕ Valves
 - ⊕ Pipes
 - ⊕ **Thermal protection**



People in the system

- ⊕ **Wernher von Braun & the spark**
 - ⊕ Cape Canaveral
 - ⊕ Redstone LV
 - ⊕ Champagne
- ⊕ **Titan II explosion in silo**
 - ⊕ Arkansas, 1980
 - ⊕ Maintenance crew
 - ⊕ Dropped wrench 80'
 - ⊕ Dumped N_2O_4
- ⊕ **Saturn V Skylab launch**
 - ⊕ Micrometeoroid shield let loose

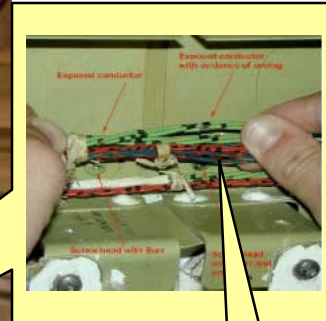
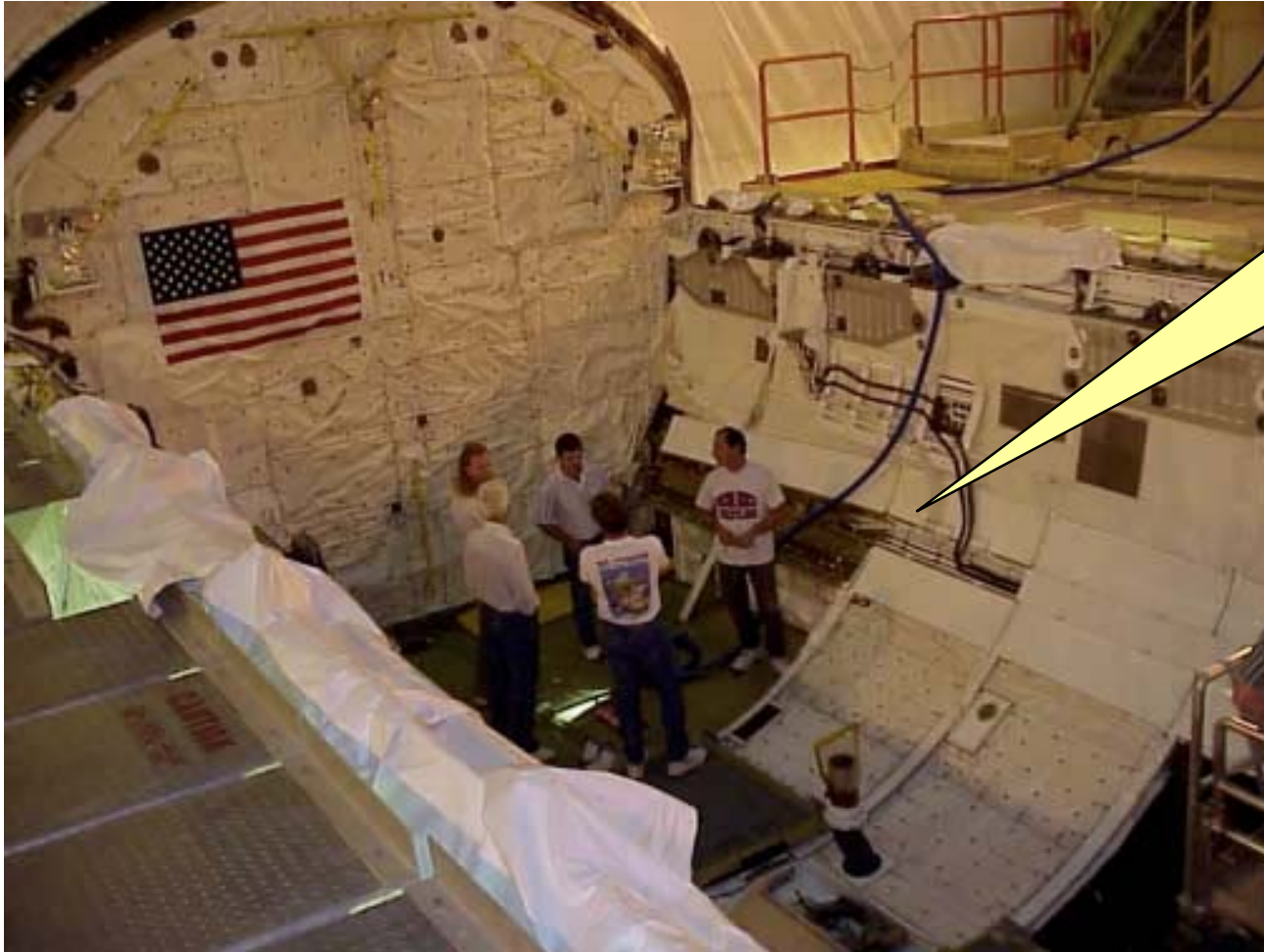


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People in the system, II STS-93



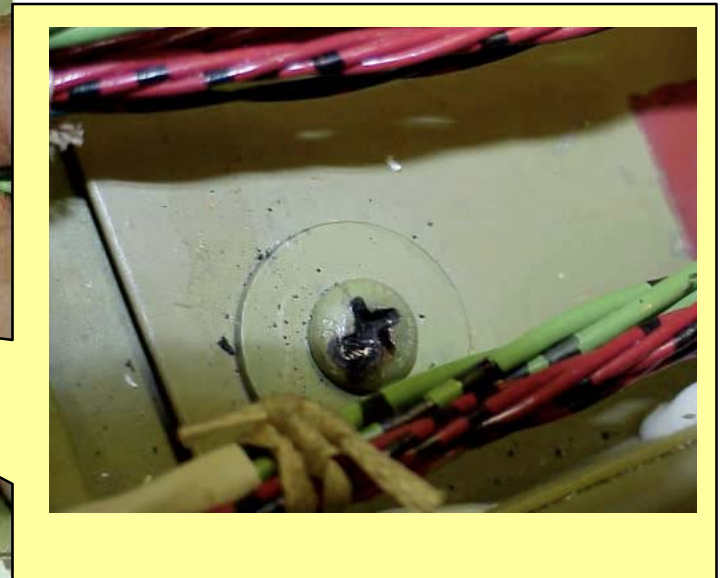
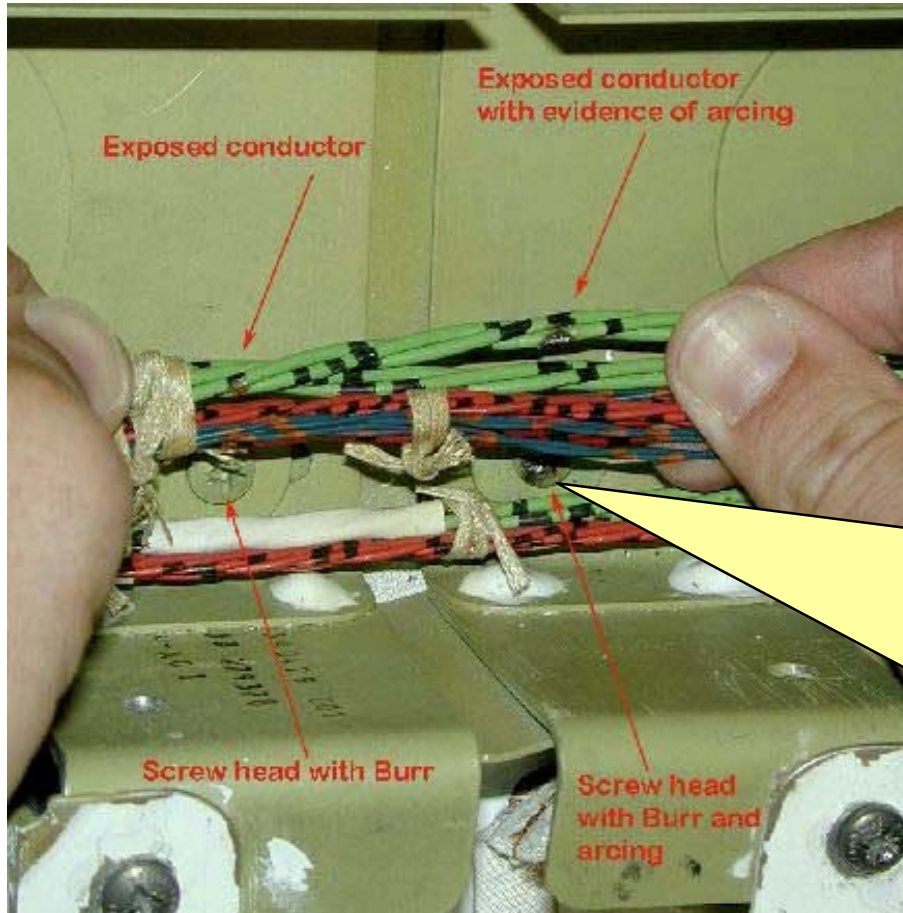


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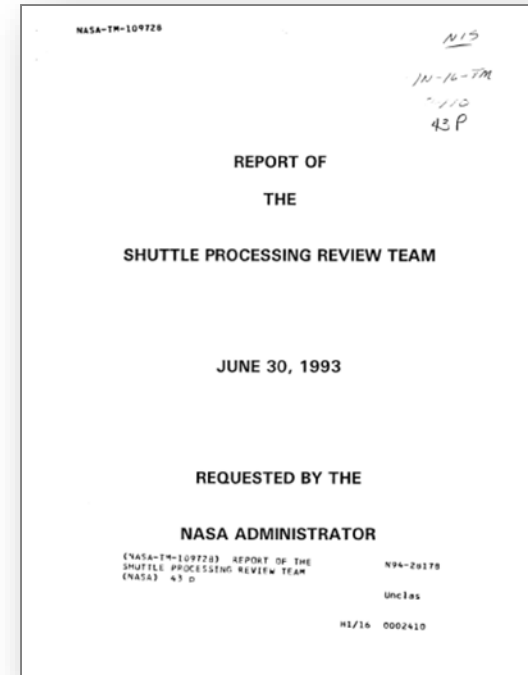
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Issue

- ⊕ **Perry Report (1993; KSC) assessed impacts of “human error” on ground processing**
- ⊕ **Identified numerous examples of damage to flight hardware by ground crews**
 - ⊕ **58% of mishaps due to human factors**
 - ⊕ (includes procedures)
- ⊕ **Recommended extensive tightening of processes**
 - ⊕ **Procedures development and adherence**
 - ⊕ **Quality Assurance**
 - ⊕ **Communication**
- ⊕ **They could not change the design of the vehicle**
 - ⊕ **NASA had no human factors requirements imposed on launch vehicles**





Development of requirements on flight systems

- ⊕ **Constellation Program (2005-2006)**
- ⊕ **Developed requirements on flight systems, *de novo***
- ⊕ **Collaborative effort between Launch Site personnel and Constellation requirements team**
 - ⊕ **Requirements are applicable to:**
 - ✦ “Every-time” assembly tasks
 - ✦ “Known” maintenance
 - Preventive
 - Corrective (LRU)
- ⊕ **After Constellation ended (2010)**
 - ⊕ **Flight systems (now Space Launch System - LV- and Orion crew vehicle) maintained these requirements**
 - ⊕ **Launch Site instituted its own set, applied to design of Ground Support Equipment**
- ⊕ **These are being standardized in NASA-STD-3001**
 - ⊕ **NASA Space Flight Human System Standards**