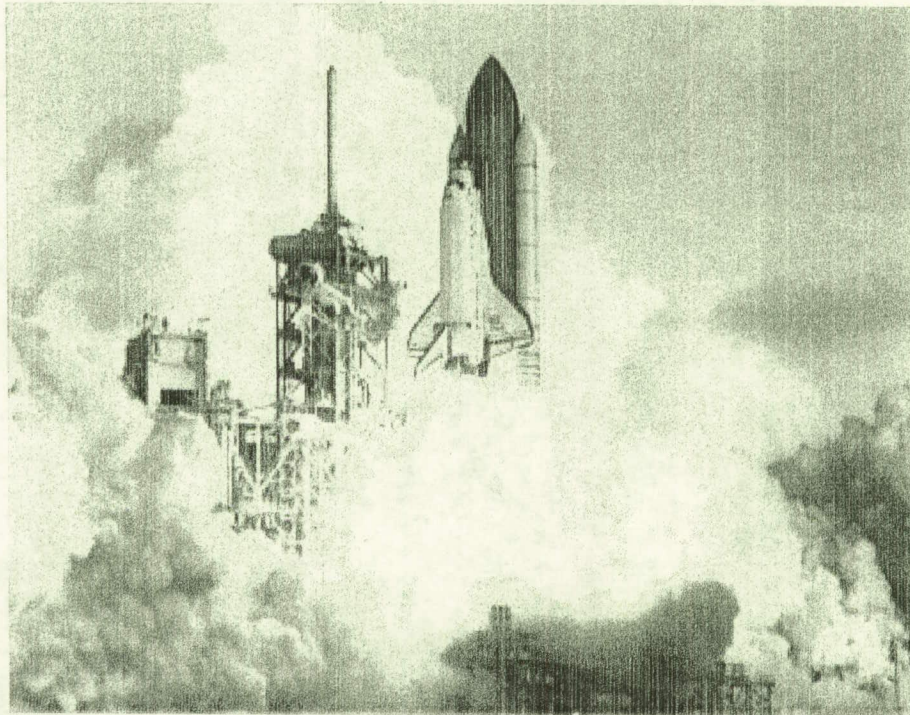


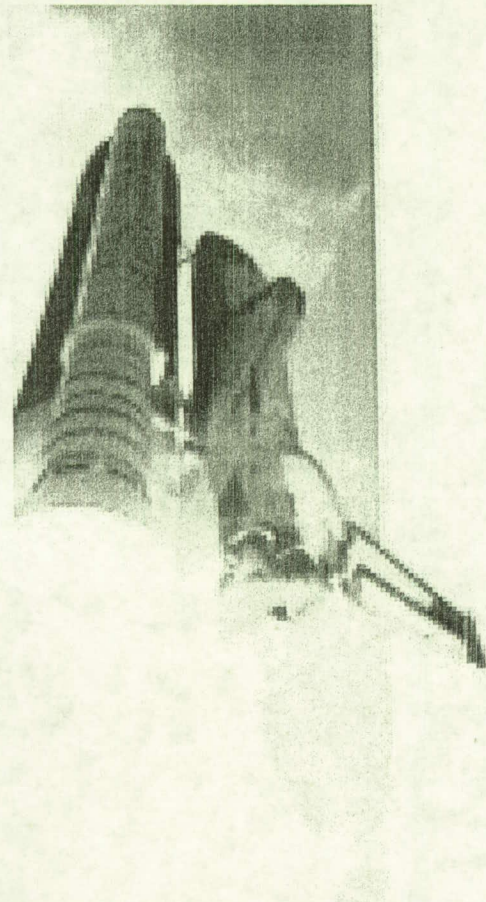
How Can the Past Influence the Future?

Industrial and Human Engineering for Spacecraft Design, Maintainability, and Operational Support



Jeffrey R. Ewald
May 6, 2005

Agenda



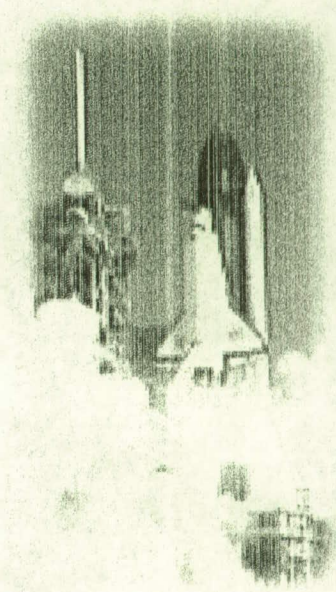
- Introduction
- Shuttle Processing History
- Role of Industrial and Human Engineering (I & HE)
- Lessons Learned:
Workspace Opportunities/
Enhancements
- I&HE Techniques and Tools
- Vision for Future
- Summary and Questions

Introduction/Background

- **Manager, Ground Systems Support Safety/I & HE, KSC**
- **_____years in Shuttle Program**
 - **Technician 19 XX-19 XX (or # years)**
 - **Quality 19XX-19XX**
 - **Lead_____19XX-19XX**
- **BS, Aeronautics, ERAU, 19XX**
- **MBA, _____, 20XX**

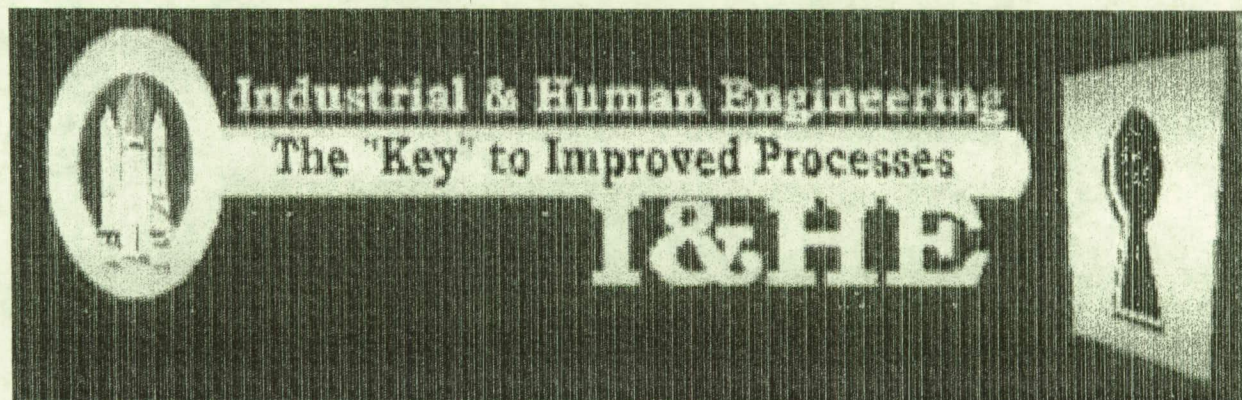
Shuttle Processing History

- **Conceived as “Space Truck” to support lower Earth orbit and Station activities:**
 - Designed and became operational in an era of declining budgets
 - Reliable
 - Easily Maintained
 - Rapid Turnaround
- **Reality:**
 - Complex, experimental vehicle requiring extensive testing & maintenance
 - IE/HE considerations not incorporated into vehicle and support design
 - Access
 - Ergonomics
 - Efficiency
 - “Can Do,” Safety-Focused workforce compensated for lack of I&HE
- Extensive mods and workarounds = Increased cycle times and cost
- “Pay Now or Pay Later” points to future



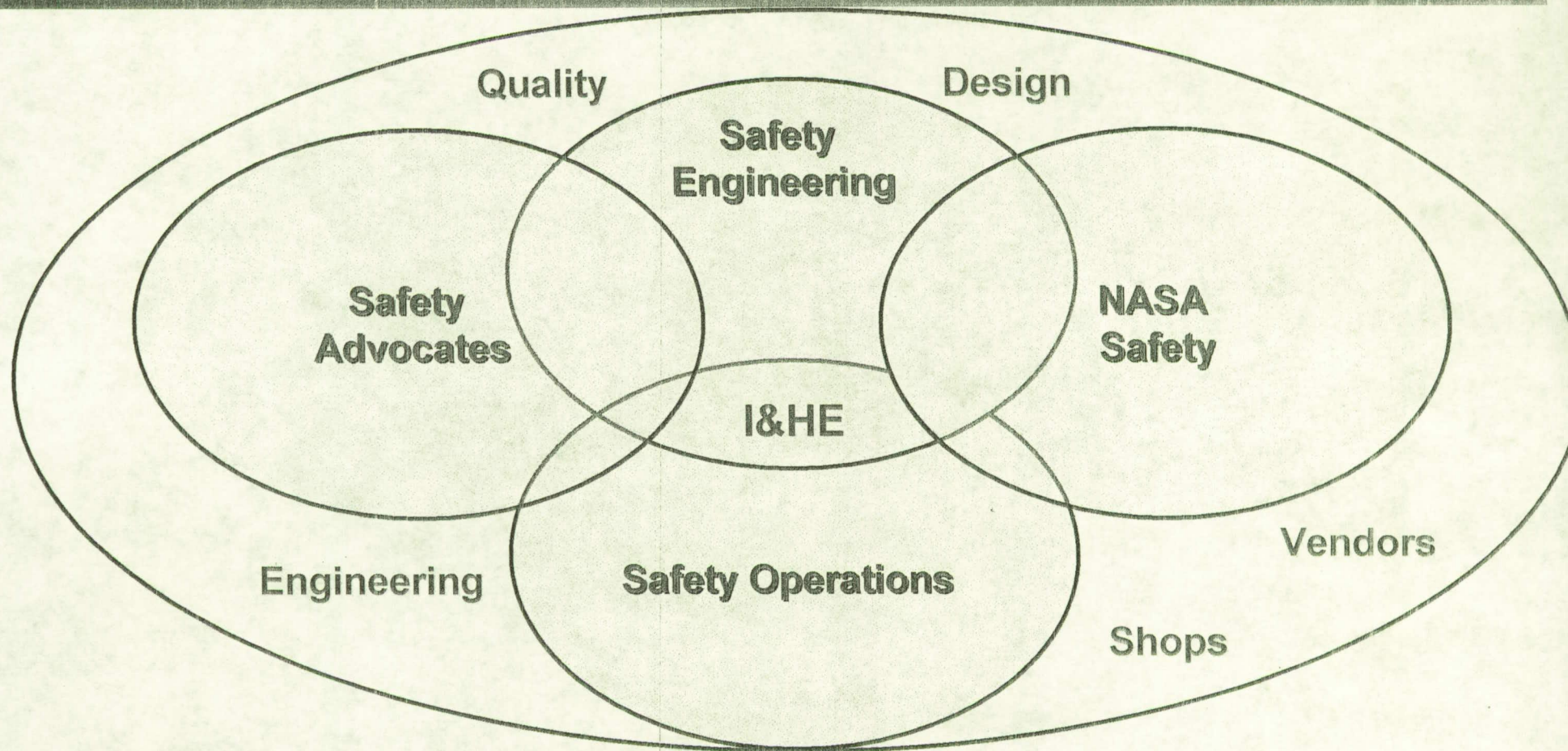
Industrial and Human Engineering (I & HE)

- 2000: Department formed in Ground Operations
- 2005: Integrated into Safety, Quality & Mission Assurance: Safety Operations
 - Orbiter
 - Launch
 - Ground Systems Support



“The dual roles of Industrial and Human Engineering (I&HE) are to reduce the potential for mishaps and to increase efficiency of Shuttle processing.”

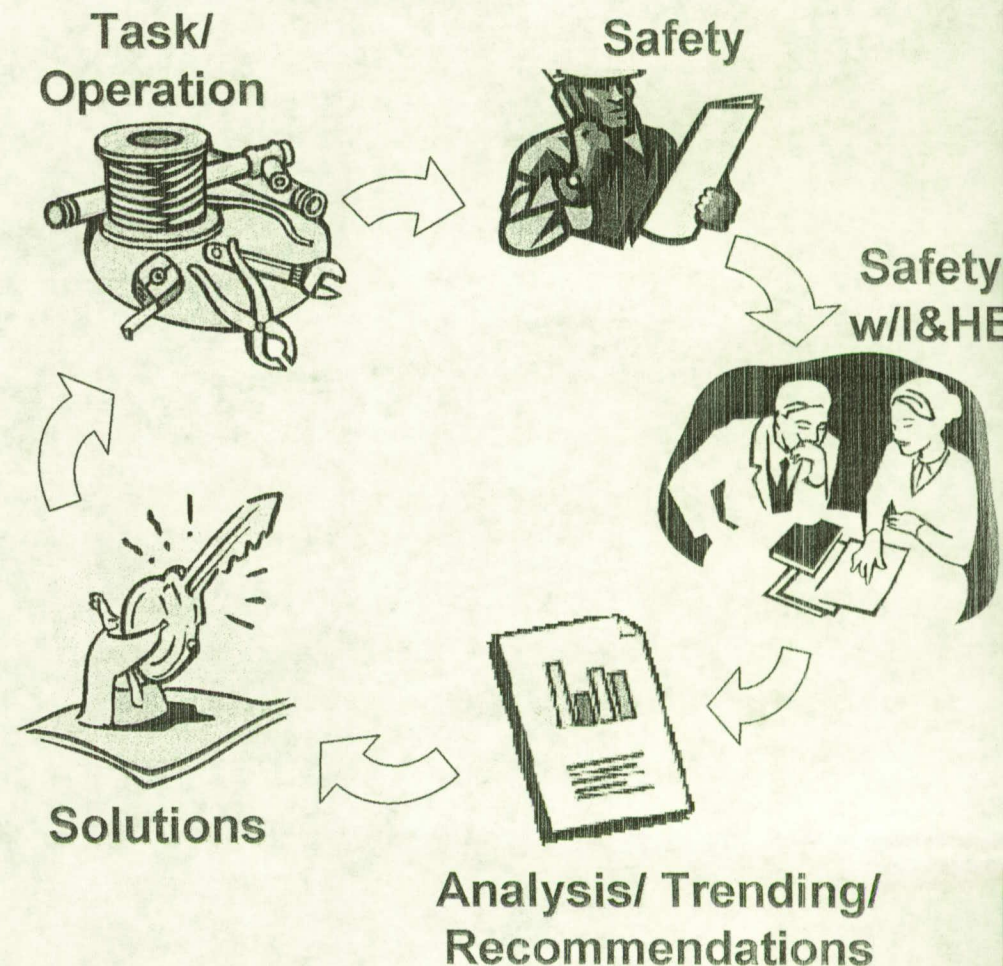
Safety Connection/Network



- Teaming among functionalities
- Daily, weekly, bi-monthly, monthly interactions
- Project/activity involvement, events, organizational insights

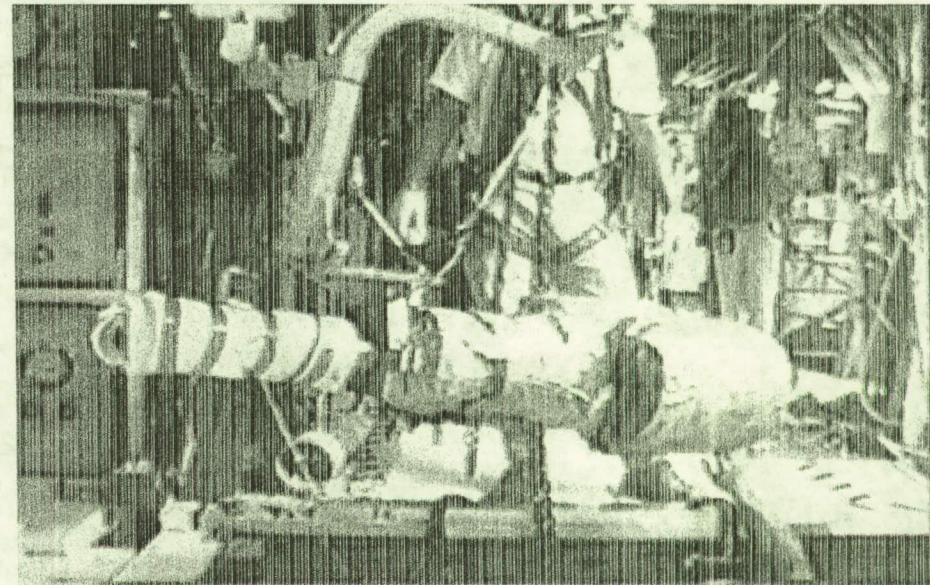
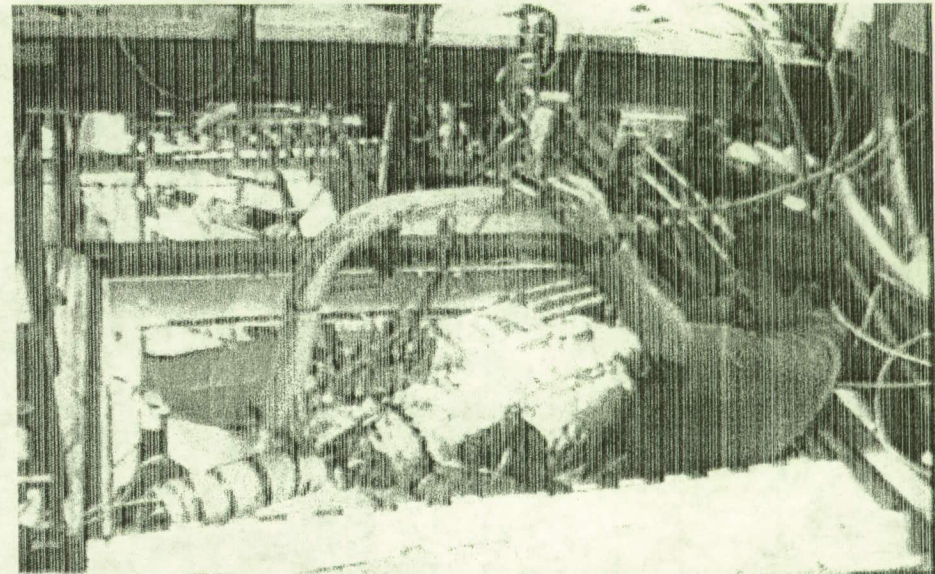
I&HE Integration into Safety Operations

- Safety Operations
 - Walkdowns
 - Operational Involvement
 - Assure Compliance with Safety Requirements
- I&HE
 - Seek solutions to mitigate recurrences of issues
 - Walkdowns, assessments, safety analyses with multiple functionalities
 - Requirements Definition
 - End-User Input and Concurrence
 - Formal Request/Funding Submittals



Safety/Human Error Reduction Emphasis

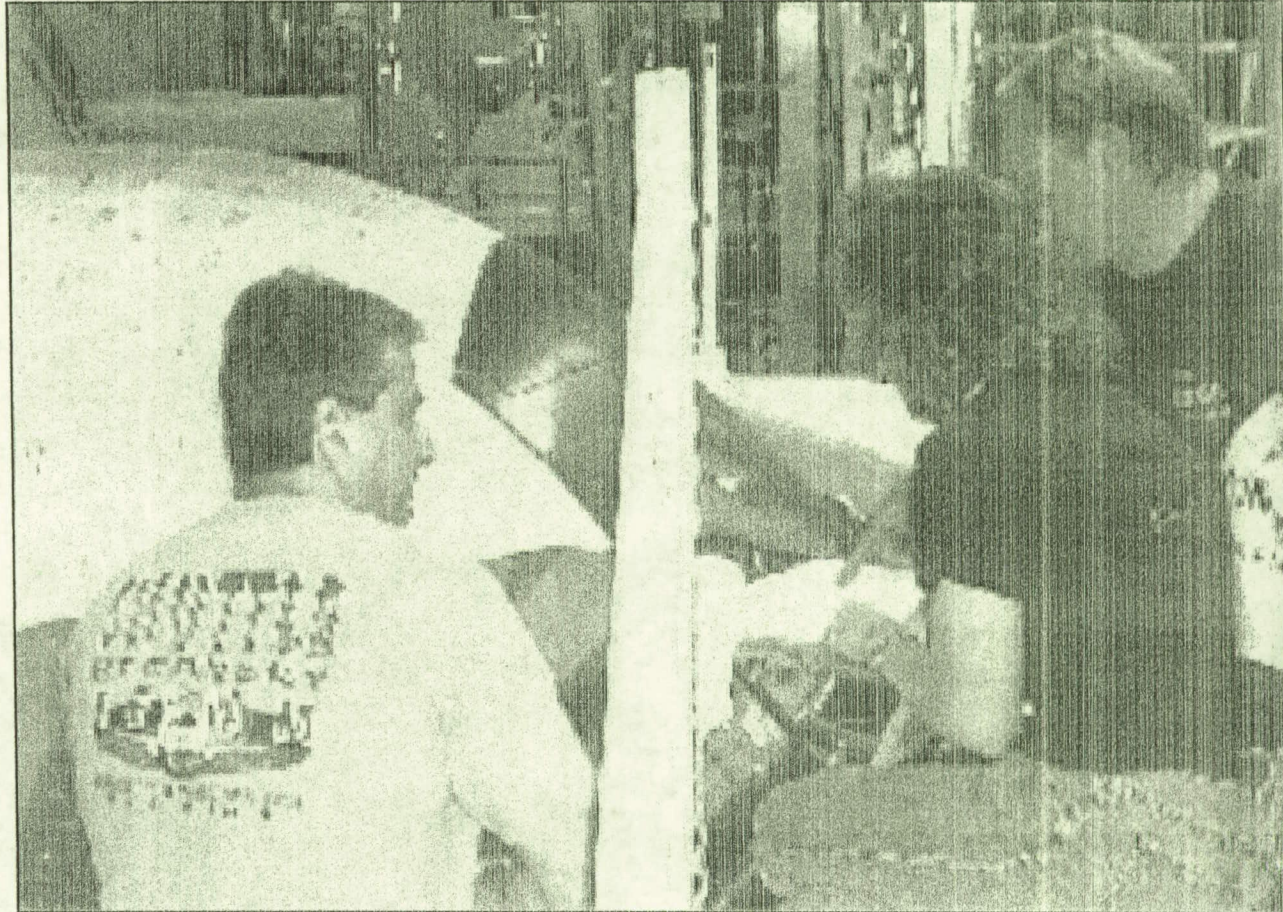
- **Safety Teams/Initiatives Support**
 - **Process Failure Modes & Effects Analyses**
 - **Risk/Safety/Usability/Task Analyses**
 - **Process Hazard Analysis (PHAs)**
 - **Shop and Engineering Requirements**
 - **Engineering Support Request Assessments for I&HE impacts**



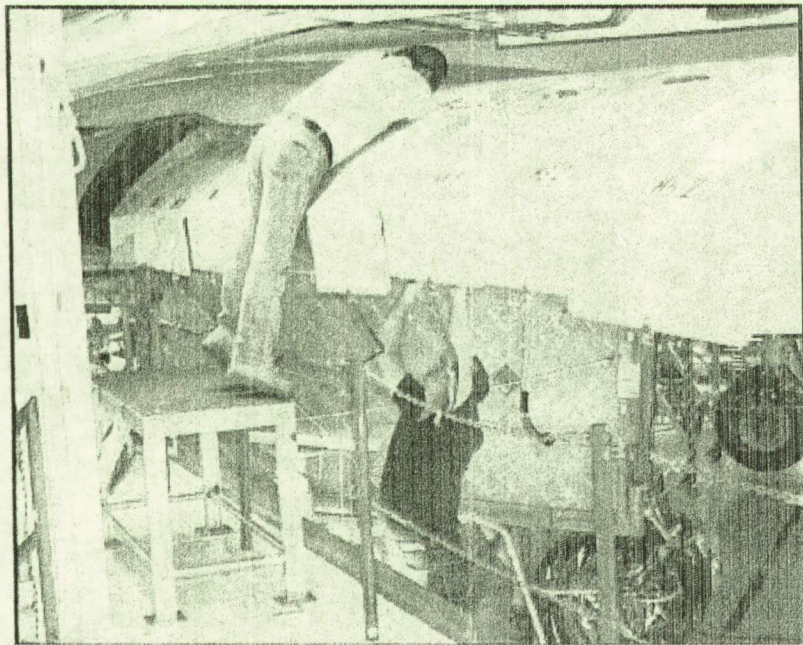
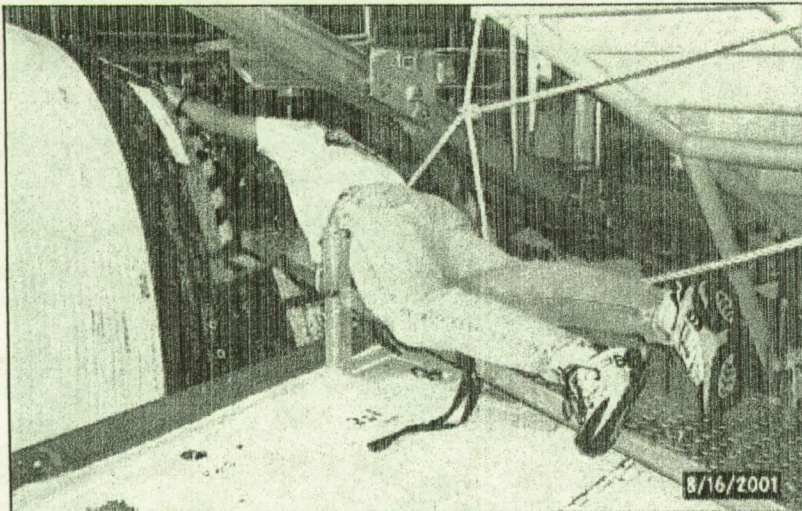
*As of 8/2004

Real-Time Observations/Shop Input

- **Objective**
Resource:
Logical Decision
Making vs.
Subjective
- **Stakeholder and**
End-User
Involvement/
Concurrence
- **Work Instruction**
Metrics/Feedback

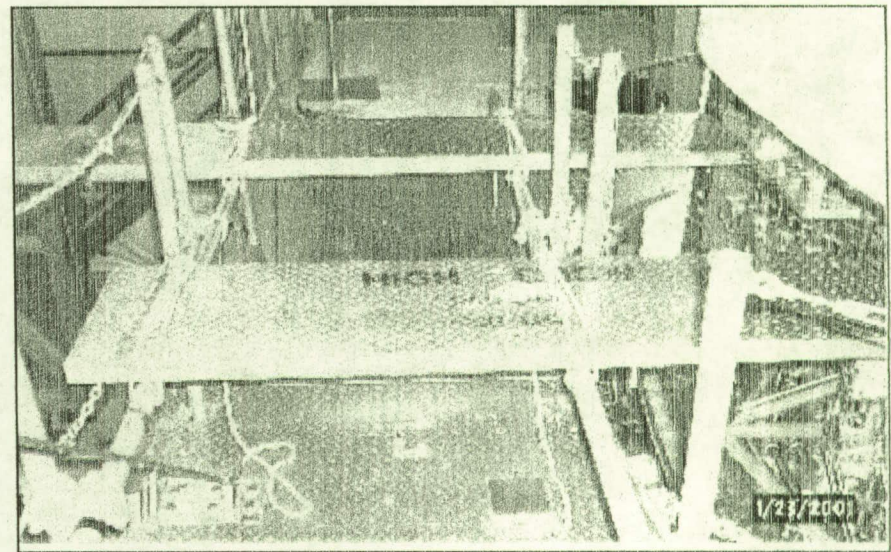


Workspace/Access Opportunities Identified



Temporary Access Opportunities Identified

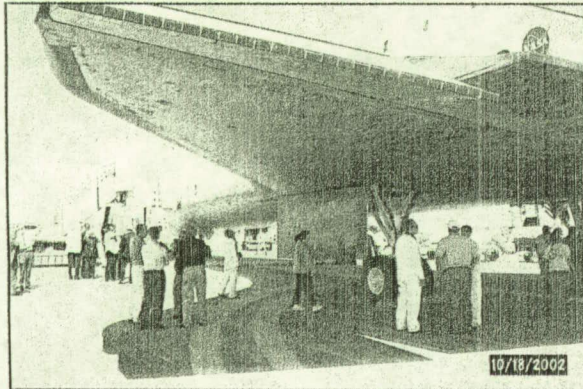
- Limited workspace
- Awkward postures
- Extended Reach
- Other



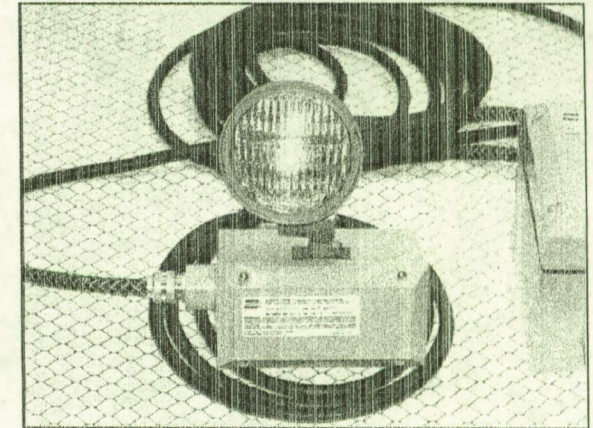
Lessons Learned: Workspace/Operational Enhancements

Opportunities Identified have included:

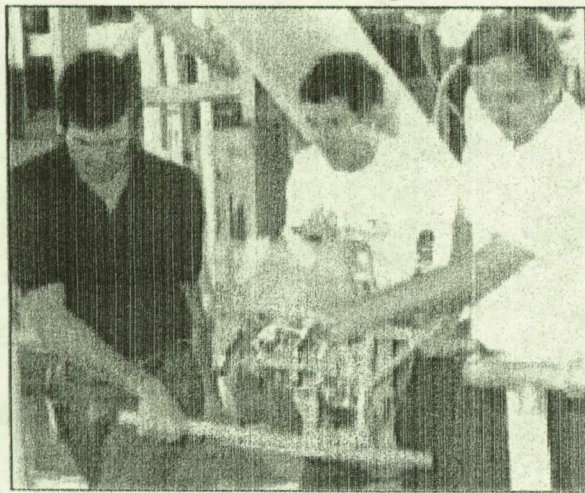
Processing



Lighting

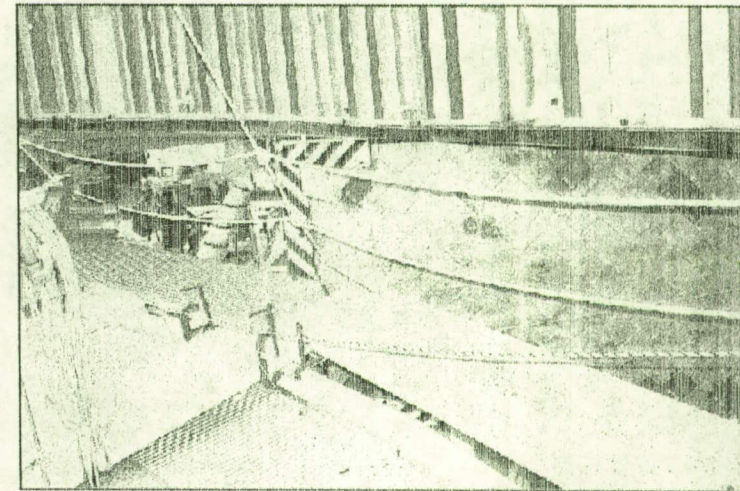


Handling

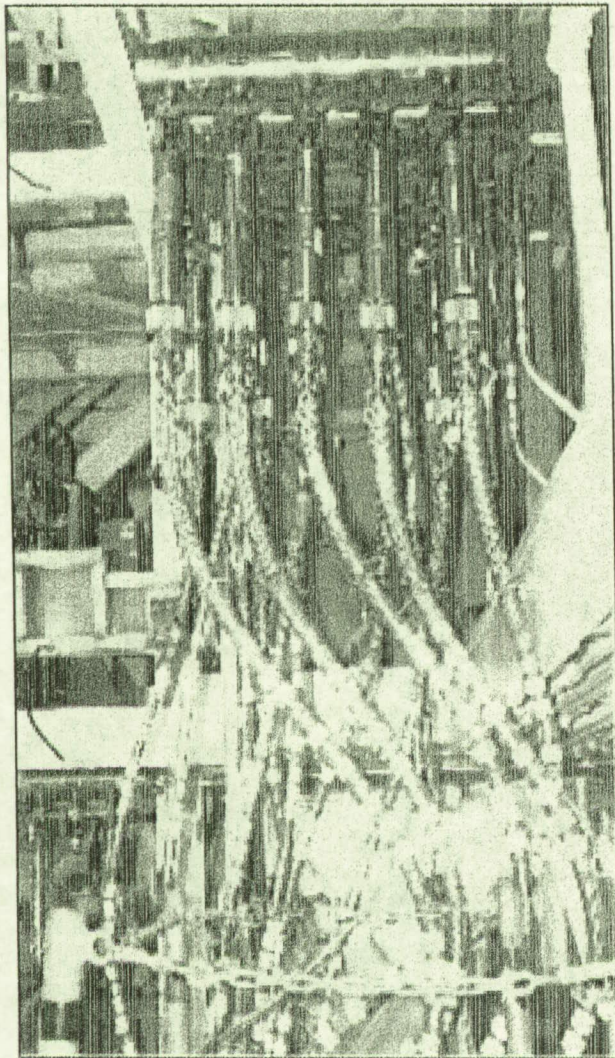


- Access
- Lifting
- Protection
- Floor Space
- Organization
- Procedures

Limited Workspace

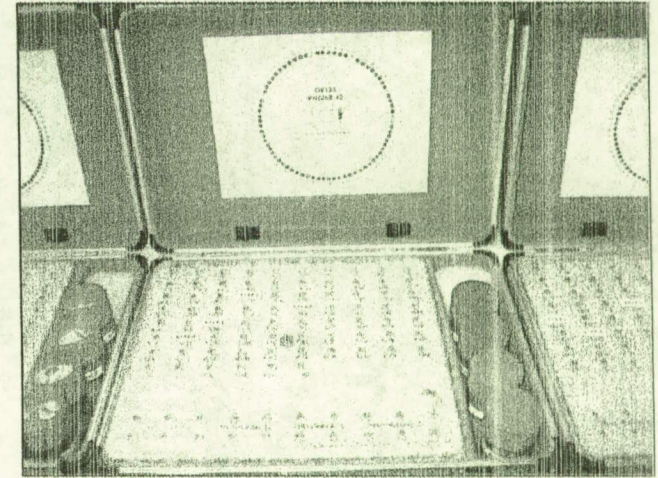


Organization/Shadowboxing

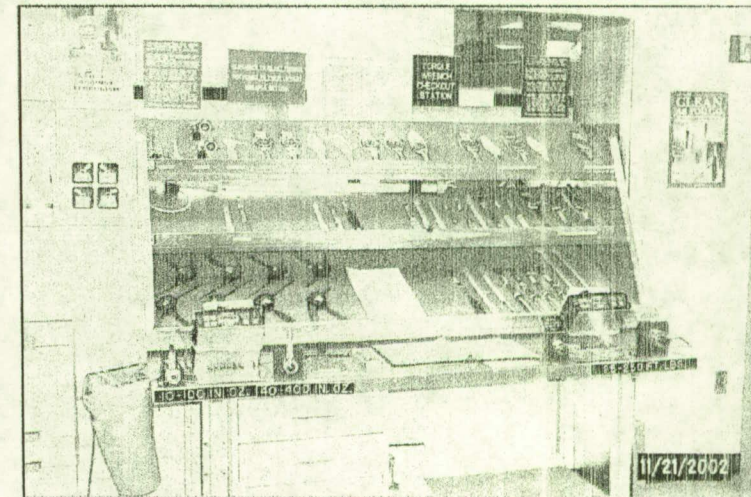


Flex Hose Lexan
Organization

- Reduce Human Error
- Improve Efficiency
- Improved parts identification
- Improved parts tracking



Small Parts contained in tote box

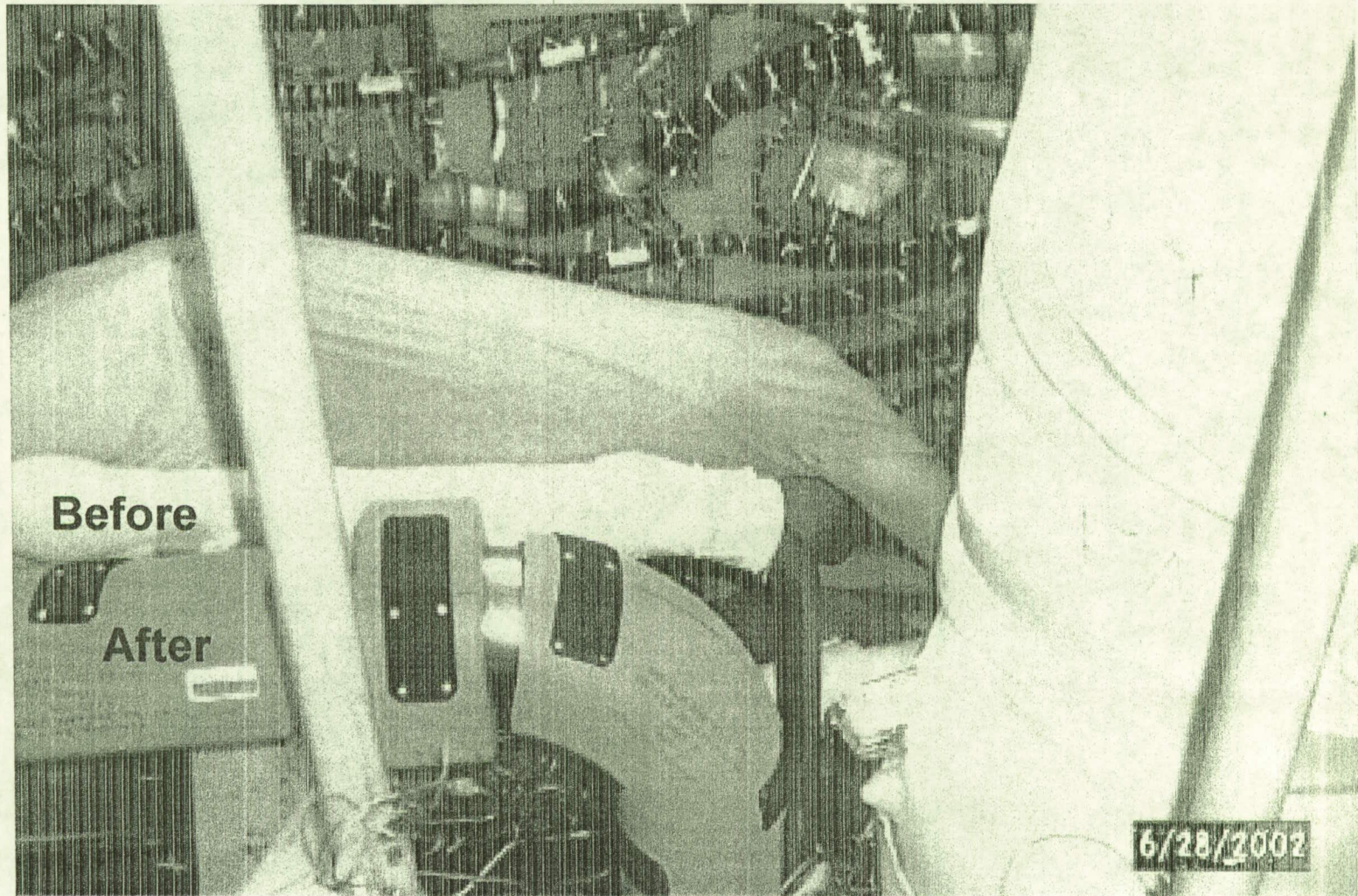


Tool Locations Shadowboxed

Workspace/Operational Enhancements

Limited Workspace:

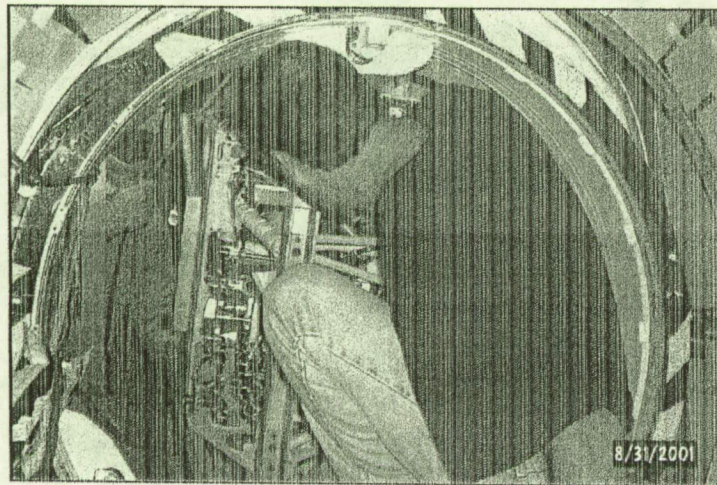
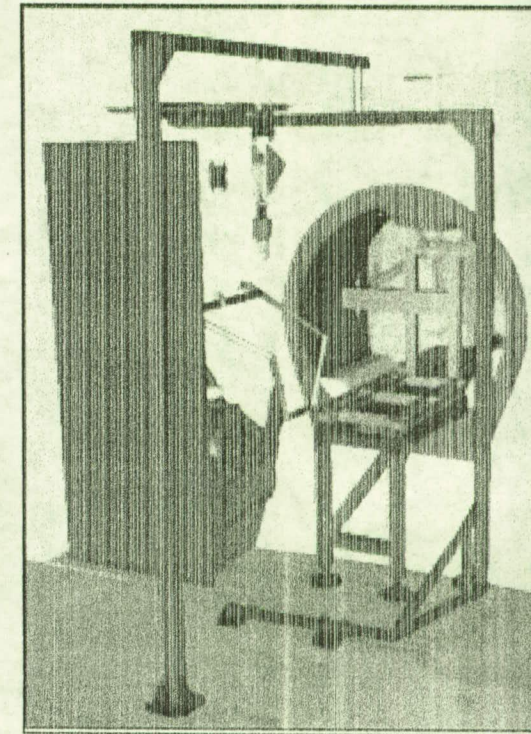
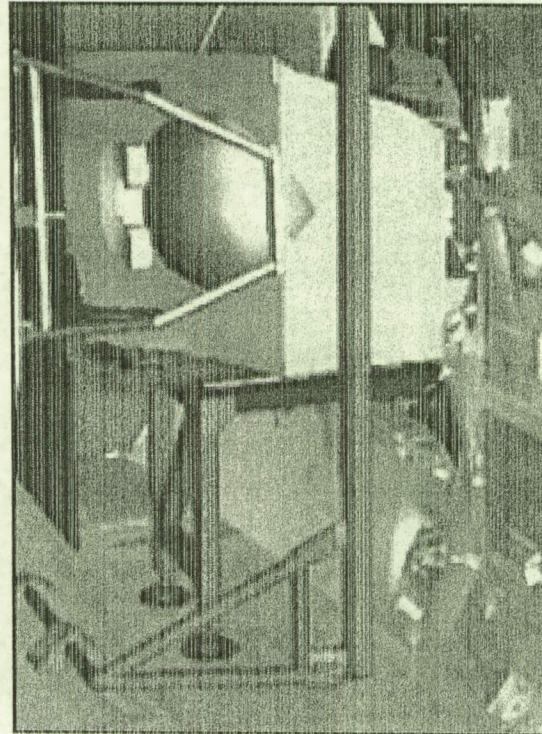
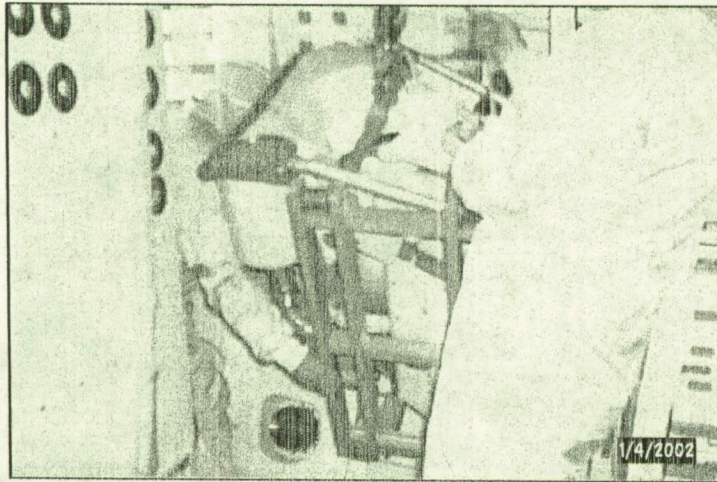
Aft Access & Hardware Protection



Workspace/Operational Enhancements

Manual Handling/Limited Workspace:

Waste Collector Subsystem Removal



**Simulated Design Concepts:
Ground Support Equipment
Modifications Nearly
Complete**

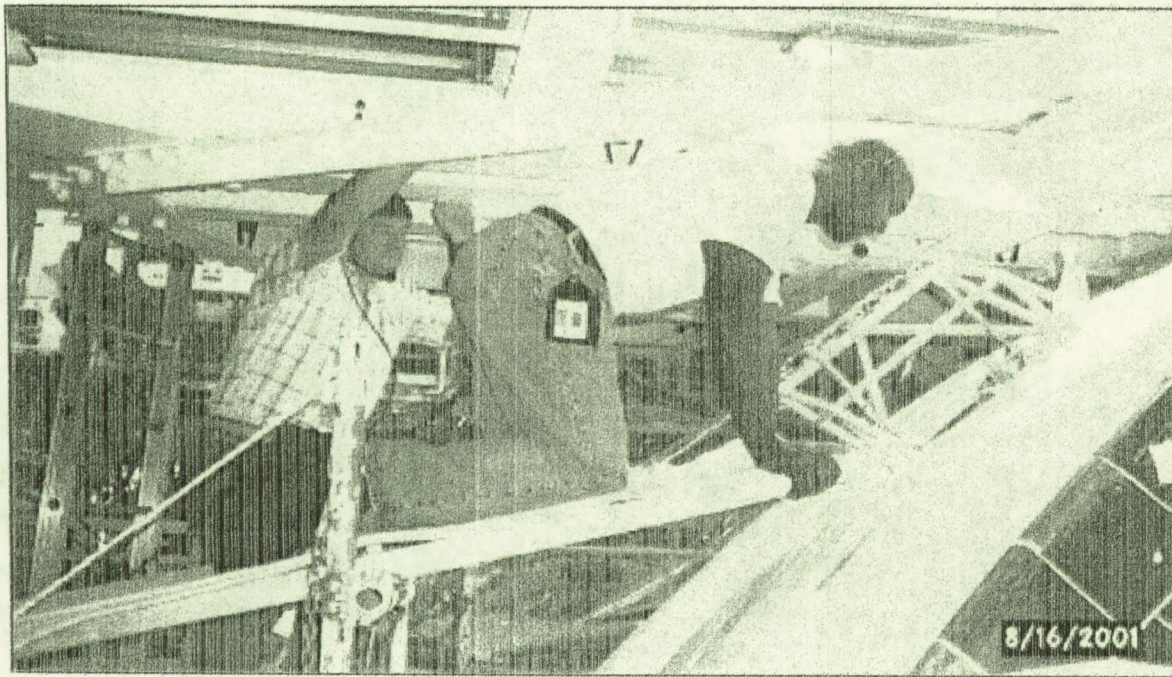
Workspace Opportunities & Enhancements

Temporary Picboard Setups:

- Contact Stress on Knees
- Limited workspace
- Restricted hands-free operations

Lean Stand

- Vertical posture
- Optimal reach

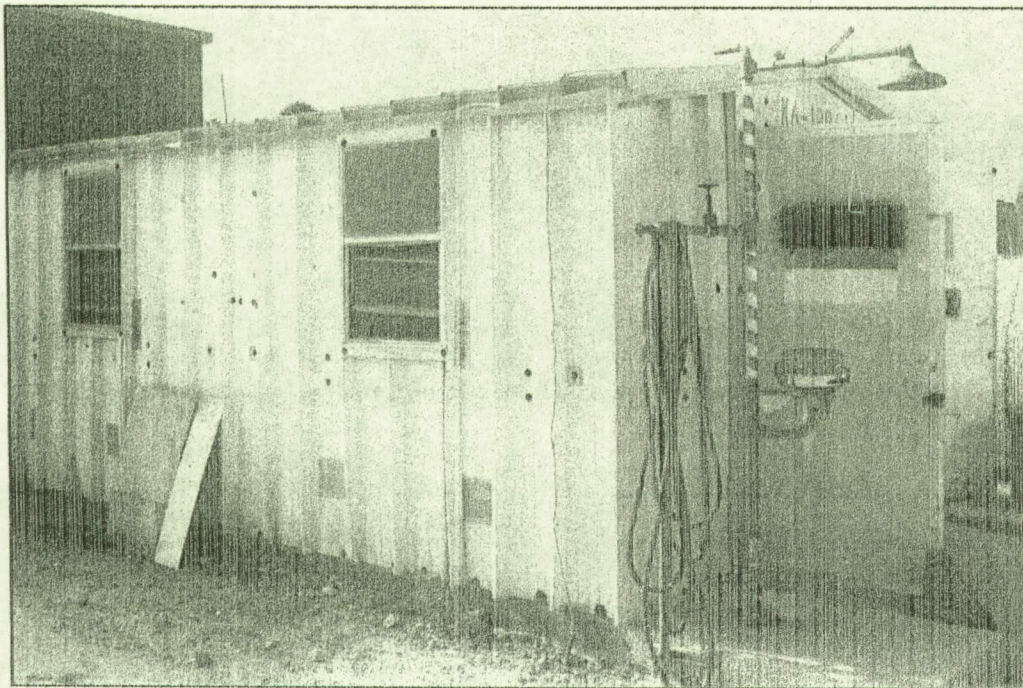


Workspace/Operational Enhancements

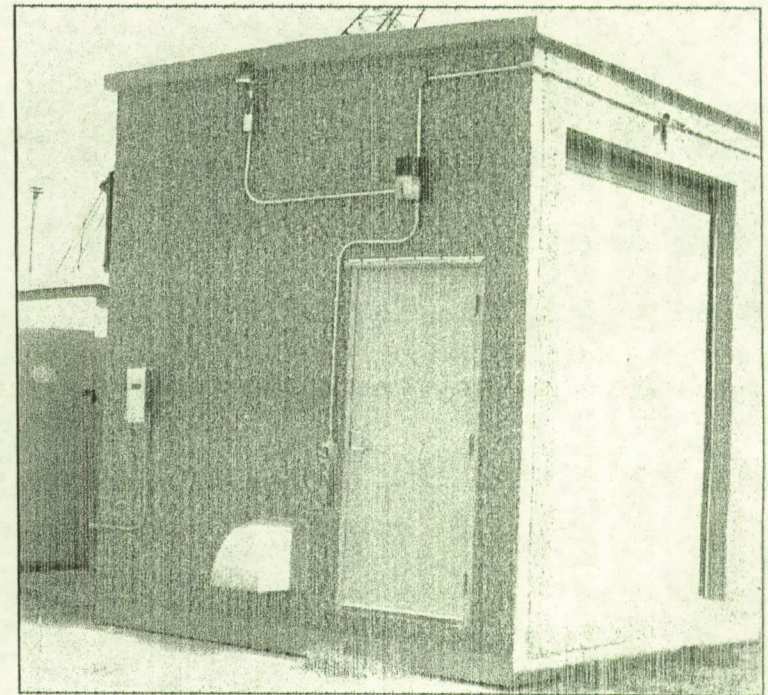
Processing Facilities:

Battery Shop

Before

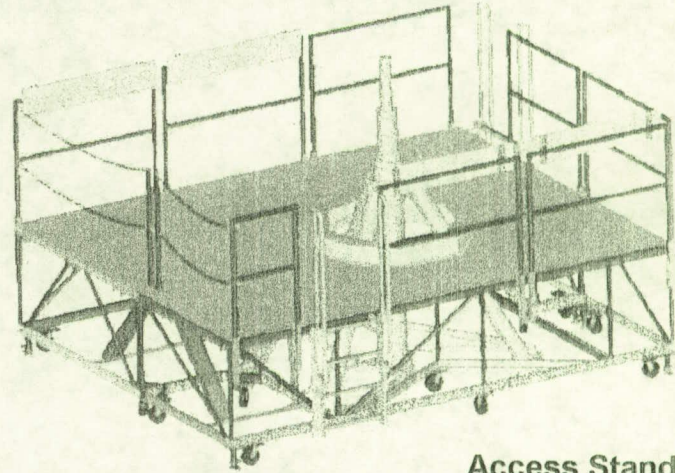


After

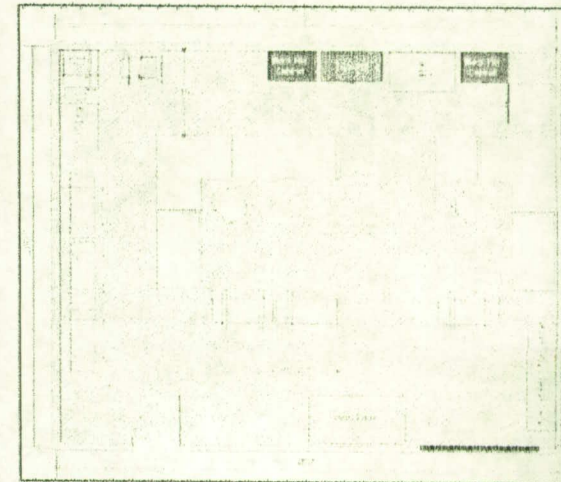
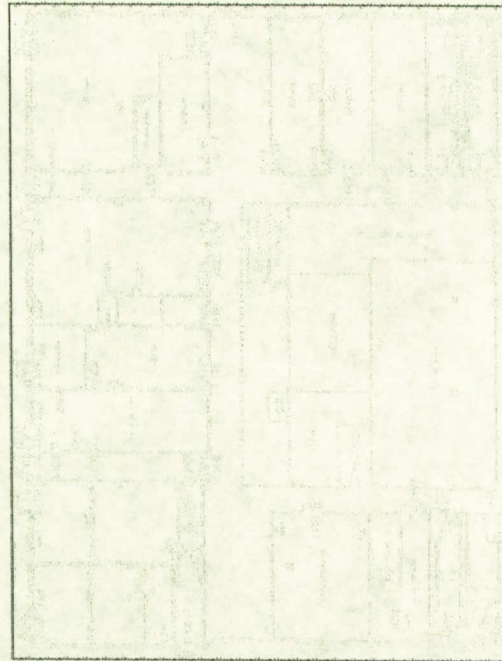


Design/Facilitation/Analysis

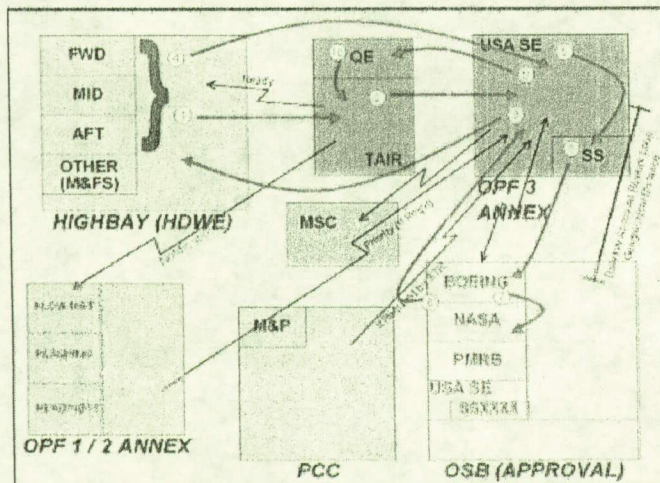
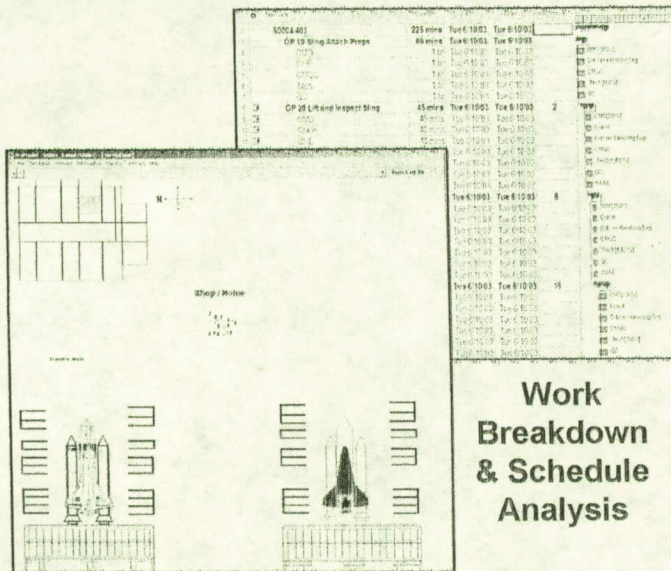
- Design concepts/reviews, modifications, and project management to GSE, vehicle, facilities, tools
- Facility and work flow optimization



Access Stand
Concept Designs



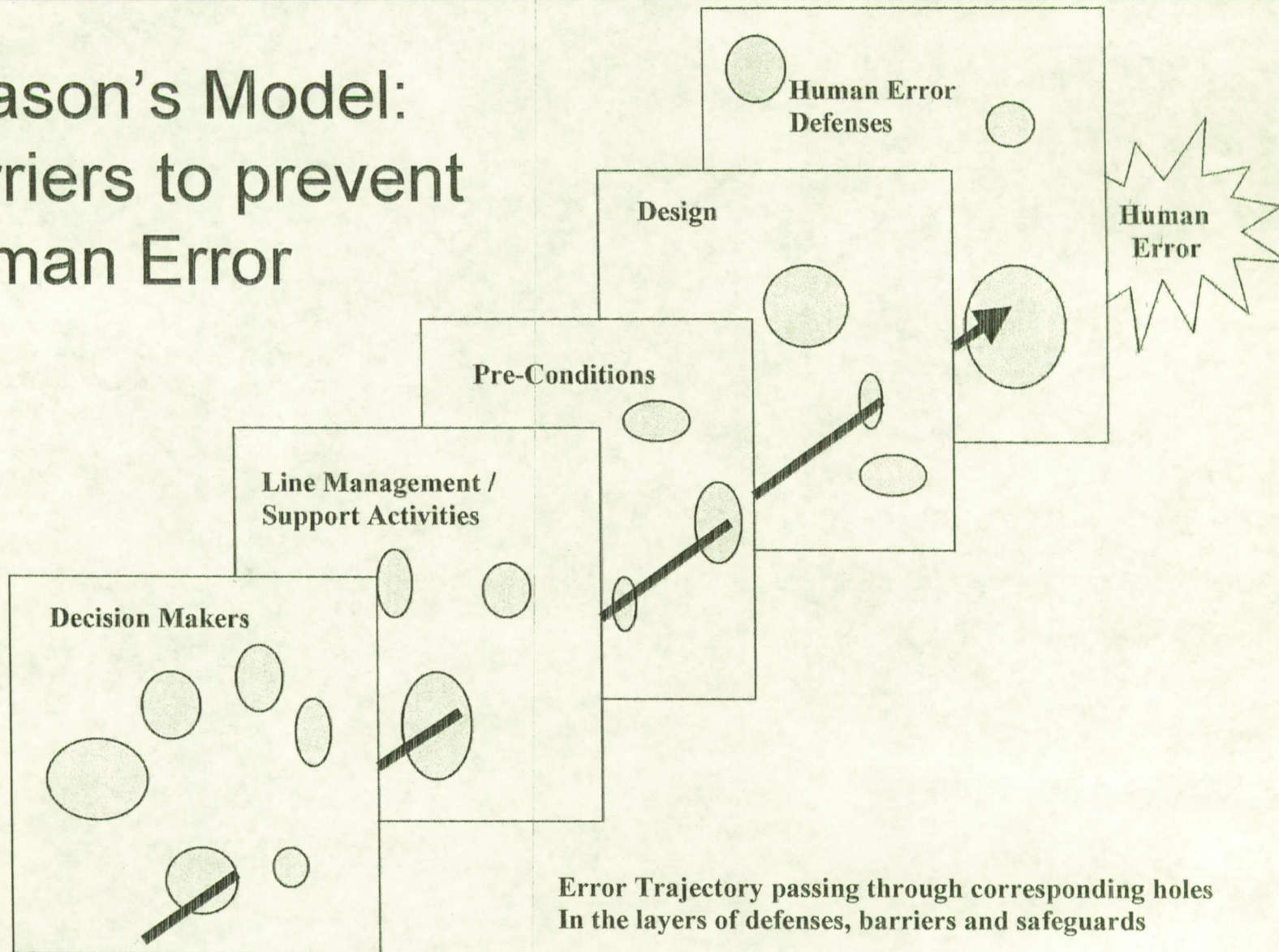
Process Analyses: Techniques/Technology



- **Process Analyses:**
 - Reduce waste
 - Increase throughput/
Reduce cycle time
 - Optimize resource utilization
 - Supply Chain
- Work sampling, data collection and analysis techniques
- Discrete Event Simulation (ProModel)

Human Error Mitigation

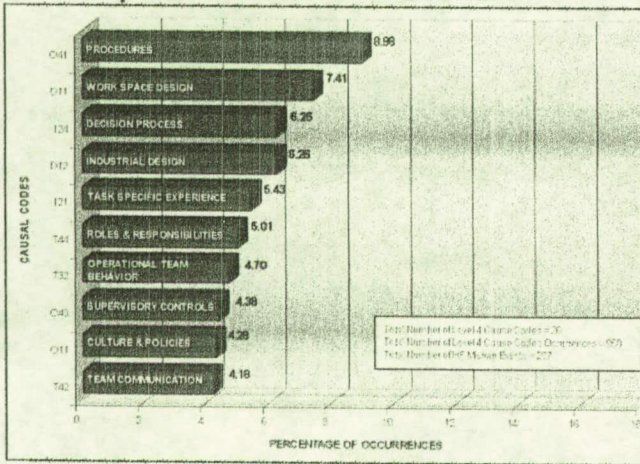
Reason's Model: Barriers to prevent Human Error



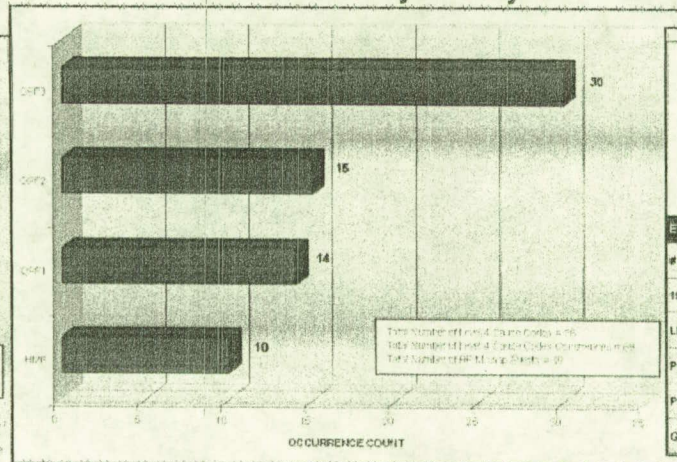
Mishap Investigation & Human Error Analysis

- Human Error Management
 - Mishap Investigations
 - Procedure Review for Compliance & Workability
- Training
 - Work Instructions, Fact Finder, Human Factors Awareness, etc.
- I&HE Human Factors Mishap Investigation Database
 - Enhanced Trending and Analysis of Systemic Issues
 - Unique in Industry

Top 10 Cause Codes - Overall



Cause Codes- By Facility



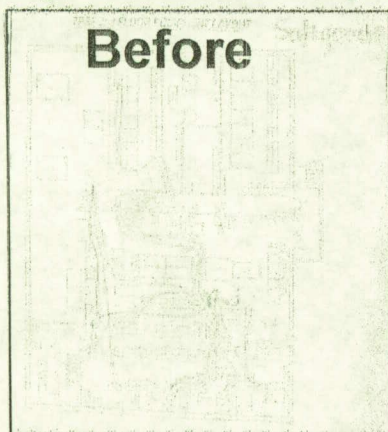
Cause Codes: Facility Location Breakdown

EVENT TITLE	Cause Codes													
	D11	D12	D13	D11	D21	D22	D24	D11	D21	D31	D41	T11	T42	T4
#2 Window Damaged (DV-103) in OFF-3														
19-2 Platform Extension Fell		1										1		
LH FWD PLBD Came Loose From Support Stanchion														1
Payload Bay Door Head Injury		4	1					2		2				1
Platform 15L Collision with Light Fixture			1										1	1
Grand Total	5	1	1	2	2	1	2	4	2	2	3	2	1	2

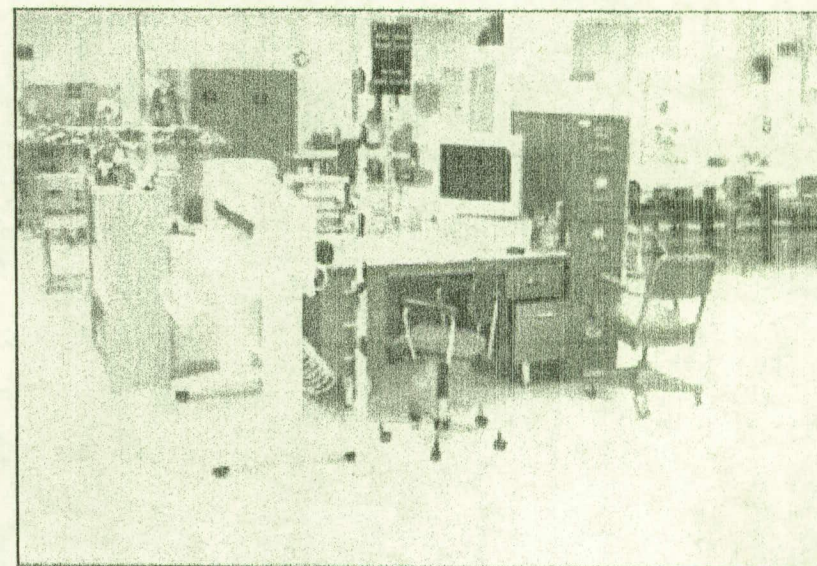
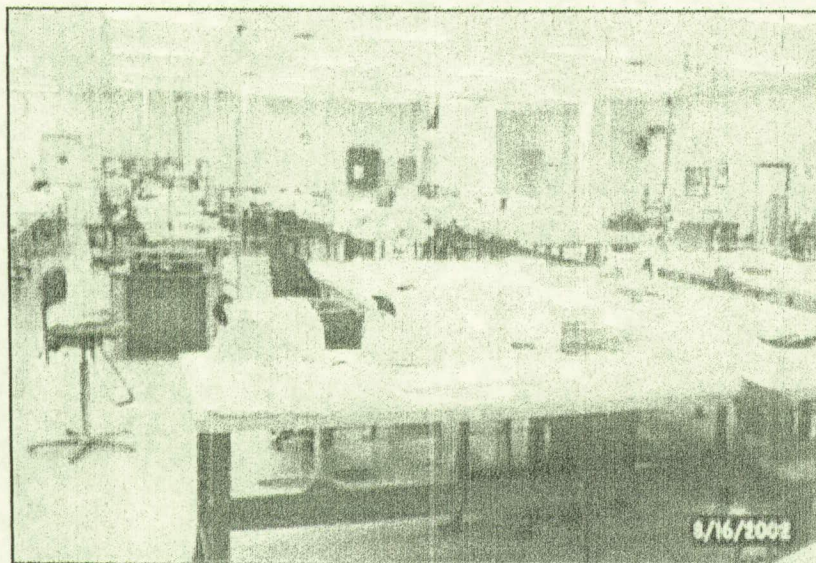
I&HE Overview within Spacecraft Operations

Assess processes & conditions

Identify and implement opportunities



Soft
Goods
Shop

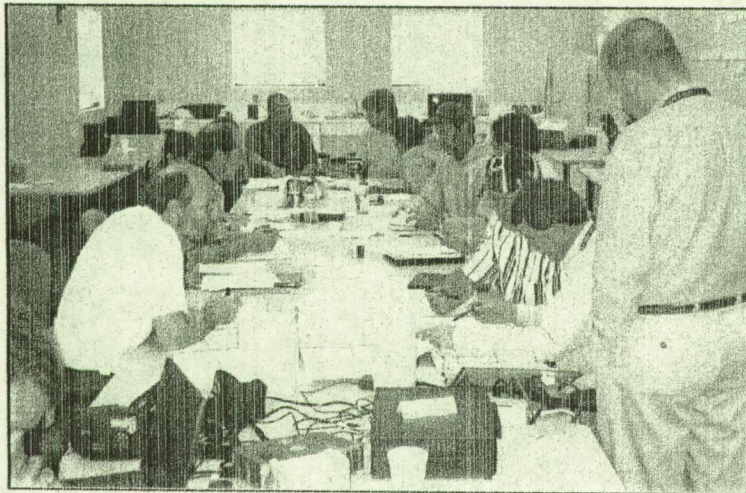


Process Improvement/Facilitation

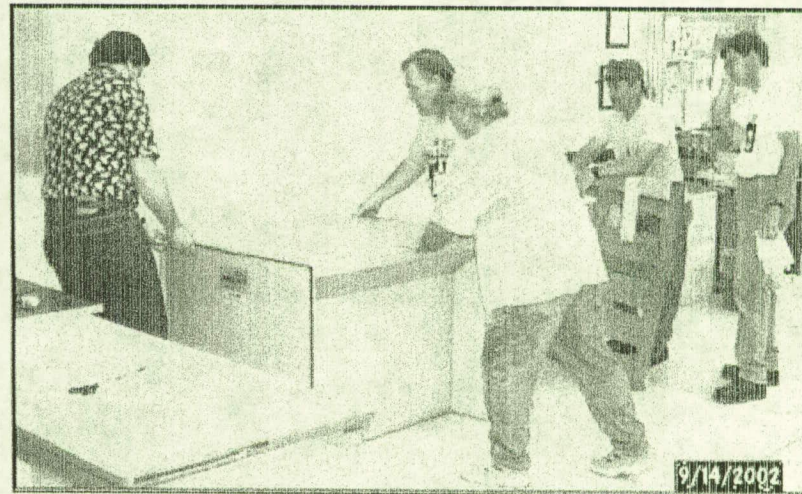
- Process Improvement Teams (PITs)/ Kaizens/5S, problem solving, process enhancement, and risk, safety, and task analysis



Multi-Functional Teams



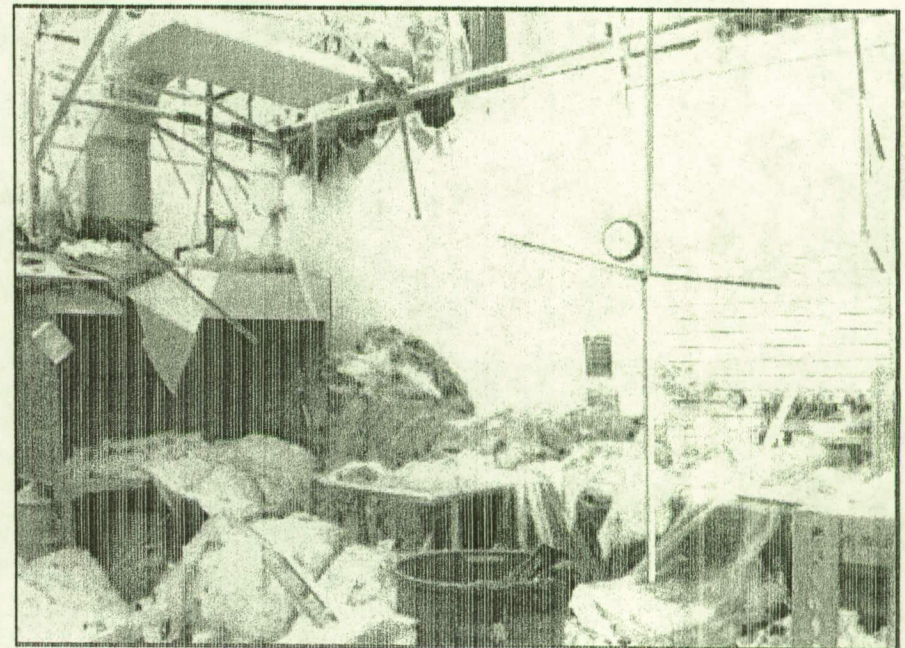
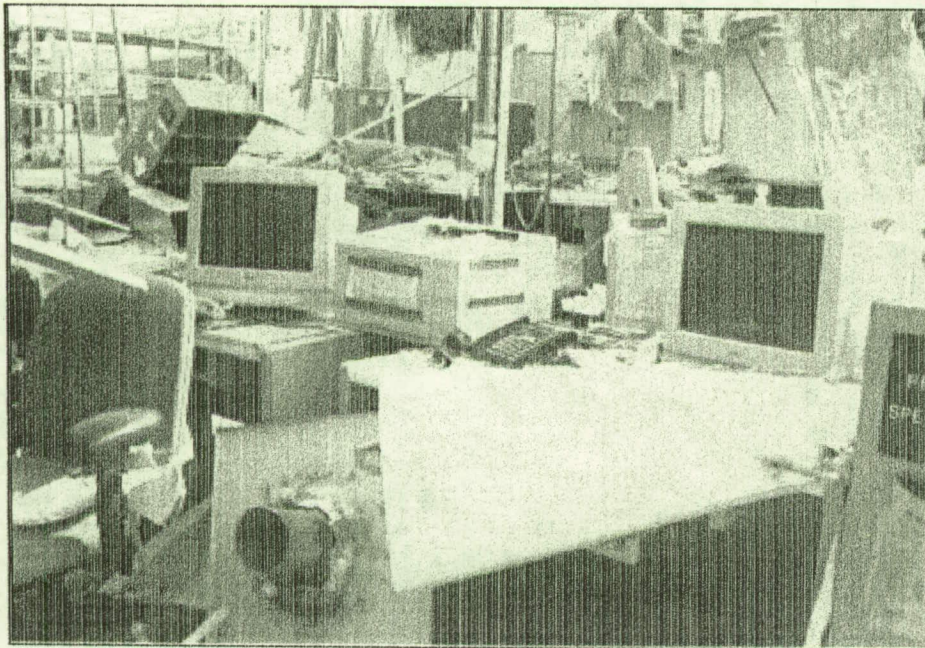
Implementation



When the Unexpected Happens

- Capture Lessons Learned
- Respond and facilitate improvements

Soft Goods Shop: Post Hurricane Frances, Summer 2004



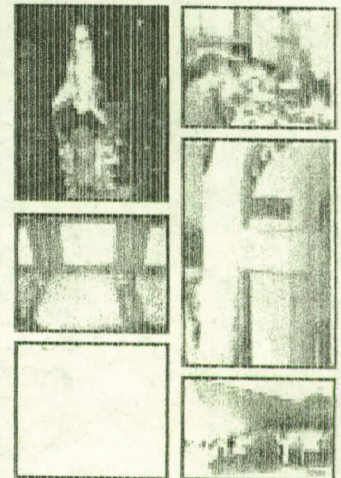
I&HE Summary: Spaceflight Processing

Industrial & Human Engineering

- Unique skill sets and expertise to benefit spacecraft design, support, and processing
- Ability to focus on key enhancements
- Generation of significant labor-hour reductions and material savings
- Significant additional intangible benefits supporting company and program goals
- Centrally-located valuable services to customers

Industrial and Human Engineering

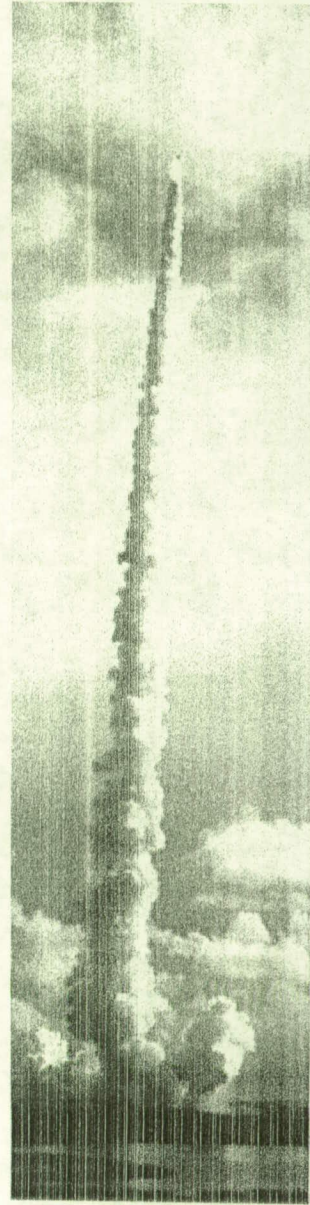
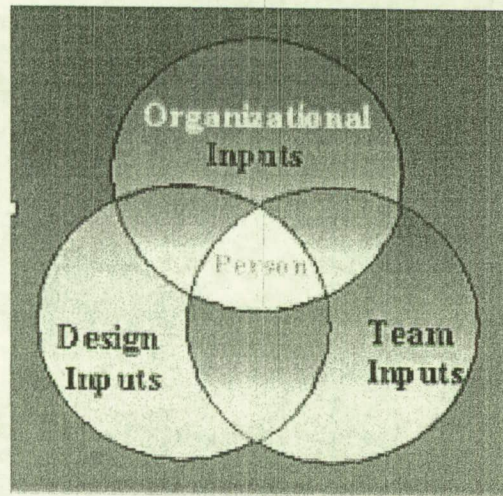
Safety, Quality & Mission Assurance



USA
United Space Alliance

Vision for Future

Investment in I&HE, incorporated at the start of spacecraft design, will ensure safety, efficiency, maintainability, and operational support and continue to create long-term benefits for the life of the system.



QUESTIONS ?

Industrial and Human Engineering