Human Systems Integration

Bounding the Human Within the System

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HUMAN IN SYSTEMS

Users

Hardware-Dominant Systems

THE HUMAN IS AN INTEGRAL ELEMENT OF EVERY SYSTEM

Maintainers

Human-Dominant Systems

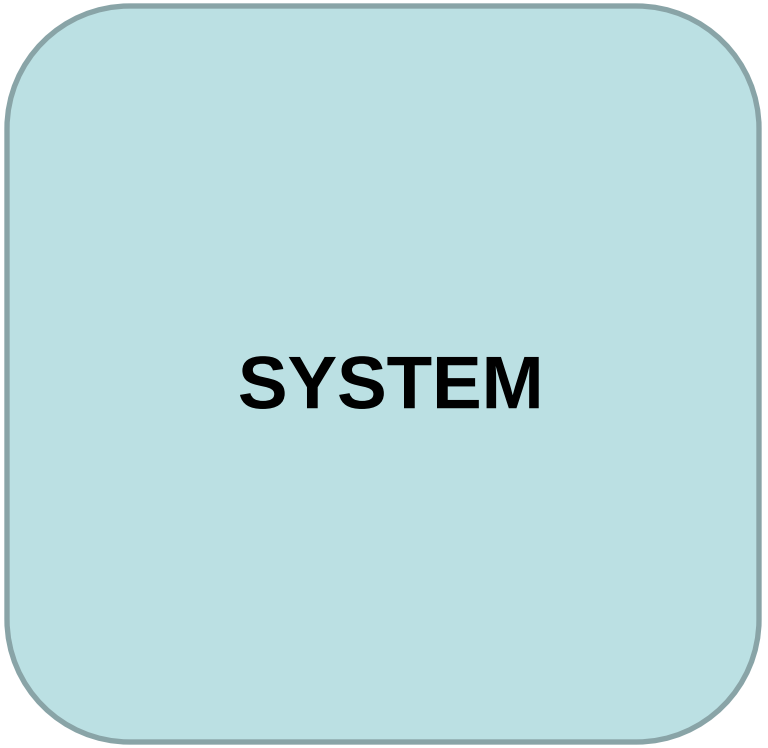
Software-Dominant Systems

BOUNDING

- ***Process of defining what is inside and what is outside of a system***

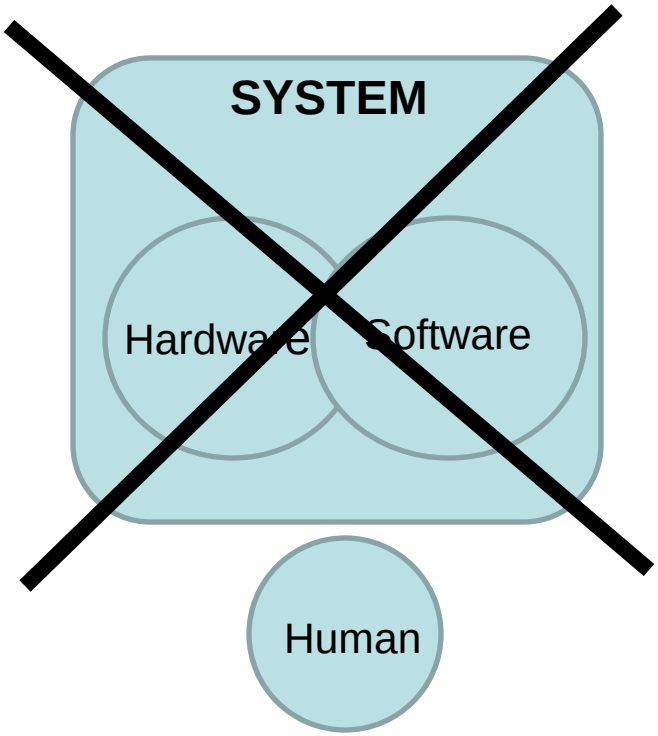
  - Identifies system internal and external components

  - Helps focus development decisions and efforts



“Defining the boundaries of a system is critical but often neglected” – Dennis Buede, The Engineering Design of Systems

BOUNDING HUMAN OUTSIDE SYSTEM



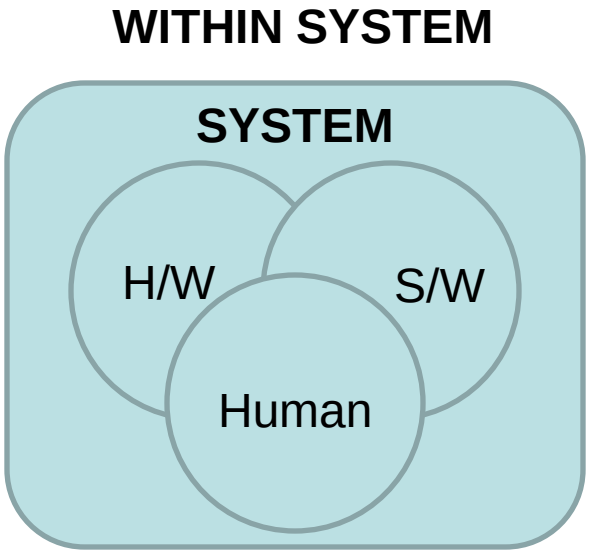
- ***Enables attention to interfacing technology (hardware/software) of system with external components (e.g., the human)***
- ***However, easy to get focused on hardware and software***

- ***Often neglect human in design and trade-off decisions, resulting in:***
  - ***Degraded system performance***
  - ***Costly modifications***

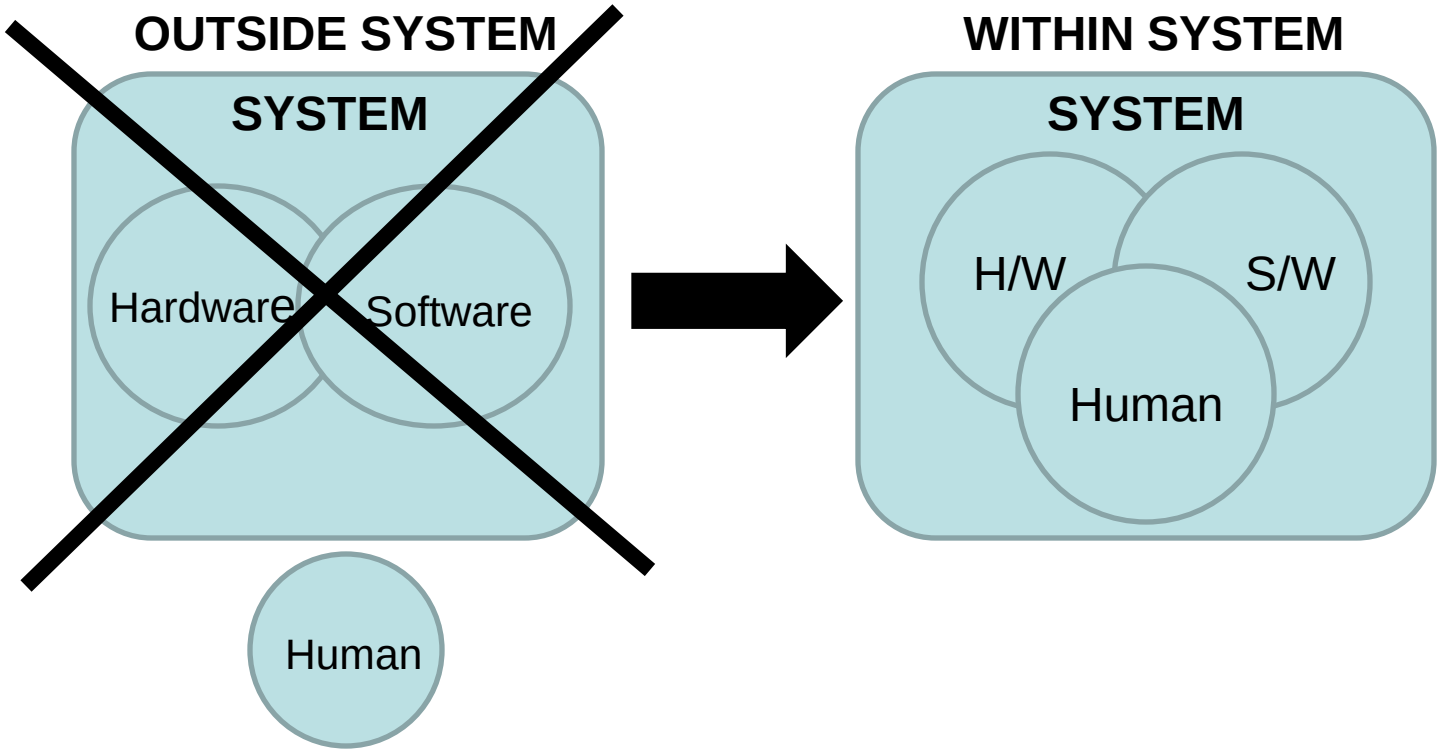
BOUNDING HUMAN WITHIN SYSTEM

- Promotes **consideration of human in conjunction with hardware and software in requirements development** and system development and design decisions

- Requirements drive system functional, physical, operational, and interface architecture



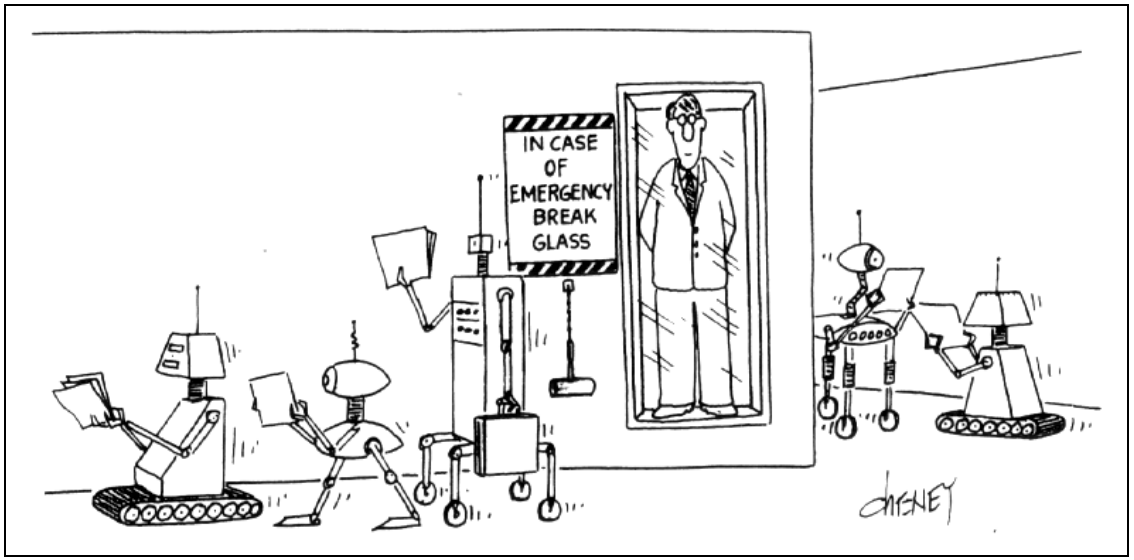
BOUND HUMAN WITHIN SYSTEM



Need to BOUND HUMAN WITHIN SYSTEM to better assure addressing essential human considerations in development & design of systems

HUMAN IN SYSTEMS

- *There is no such thing as an unmanned system*
- *The "human" in HSI includes all people who interact with the system:*
  - *users/customers*
  - *system owners*
  - *operators*
  - *maintainers*
  - *support personnel*
  - *trainers*
  - *etc.*



THE HUMAN IS AN INTEGRAL ELEMENT OF EVERY SYSTEM

DEFINITION

Human Systems Integration (HSI):

The interdisciplinary technical and management processes for integrating human considerations within and across all system elements; an essential enabler to systems engineering practice

Human Systems Integration Working Group, International Council on Systems Engineering (INCOSE), 2007

GOALS OF HSI

ENSURE THAT SYSTEMS, EQUIPMENT, FACILITIES:

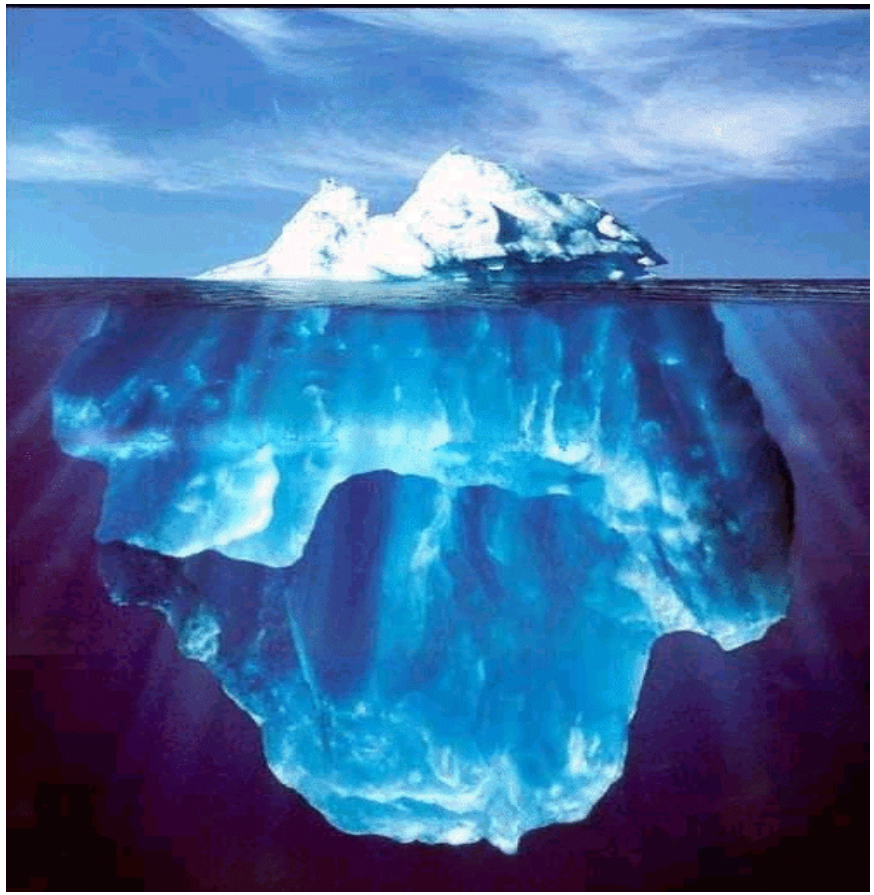
- Incorporate **effective human-HW/SW interfaces**
- Achieve the required levels of **human performance**
- Make **economical demands upon personnel** resources, skills, and training
- **Minimize life-cycle costs**
- **Manage risk of loss or injury** to personnel, equipment, or environment

HSI brings human-centered disciplines and concerns into the SE process to improve overall system design and performance – BOUNDING THE HUMAN WITHIN SYSTEM PROMOTES A TOTAL SYSTEM APPROACH

IMPORTANCE OF HSI

- **DoD studies reveal:**
  - Over 90% of operating & support costs are determined early in development
  - **O&S costs are significantly HSI-related**

Source: GAO-03-57



- **Critical to INCLUDE HSI EARLY in system concept development to realize greatest LIFE CYCLE COST SAVINGS**

BOUNDING HUMAN WITHIN SYSTEM demands inclusion of HSI early

HSI KEY PART OF SYSTEMS ENGINEERING PROCESS

System

An integrated composite of **people**, product, and processes that provide a capability to satisfy a stated need or objective

EIA - 632

HSI is that part of SE that focuses on the human component over the system life cycle

Systems Engineering

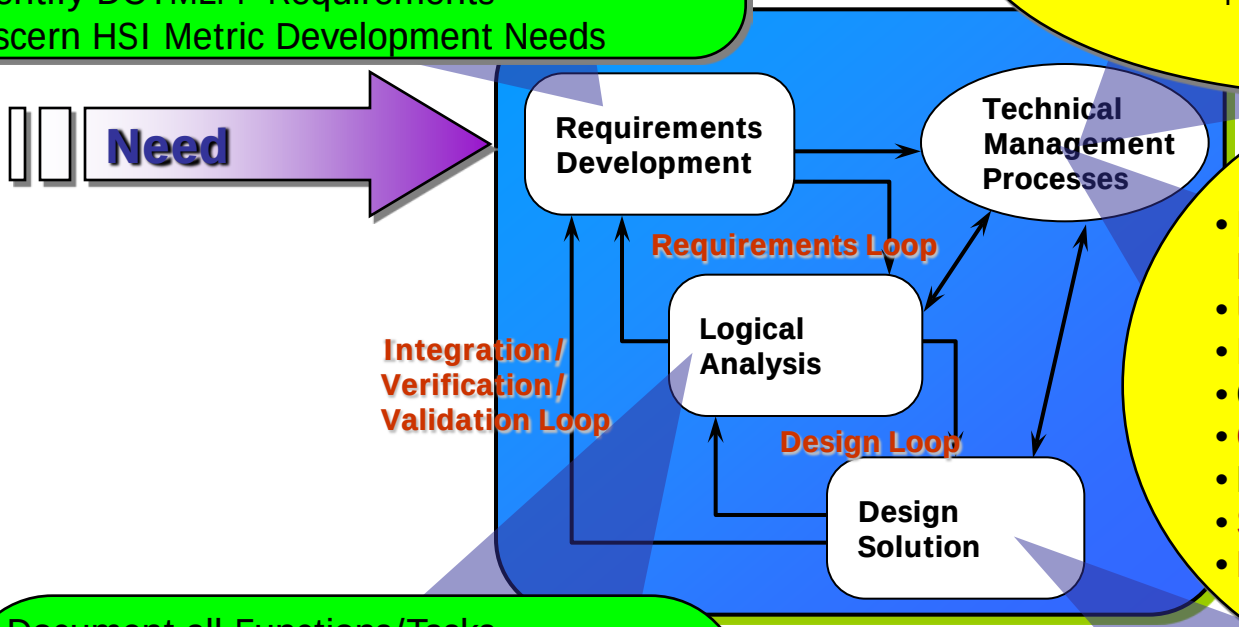
- **Integration**
- **Balance**

Adapted From: Booher, Principles and Applications of Human Systems Integration. SPAWAR CHARLESTON, 04 November 2003.

HSI CRITICAL PART OF SE PROCESS

Identify Human Performance Component of Total System Capability/Requirements
Identify Total System Environment
Identify HSI Research Needs
Capabilities Document Review for HSI Impact
Identify DOTMLPF Requirements
Discern HSI Metric Development Needs

FUNCTIONS
Manning Optimization
Human Performance Optimization
Decision Support Aid
Plan for Trainers/Simulators
HSI Metric Development
FoS / SoS Impacts
T&E Support



TRADE STUDY CRITERIA
- Human Performance
- Usability
- Maintainability
- Cost
- Quality of Life
- Redundancy
- Suitability
- Effectiveness
- Reliability
- Availability & Recovery
- User Population Characteristics
- Organization/ Career Impacts
- Trainability
- Resilience
- Supportability

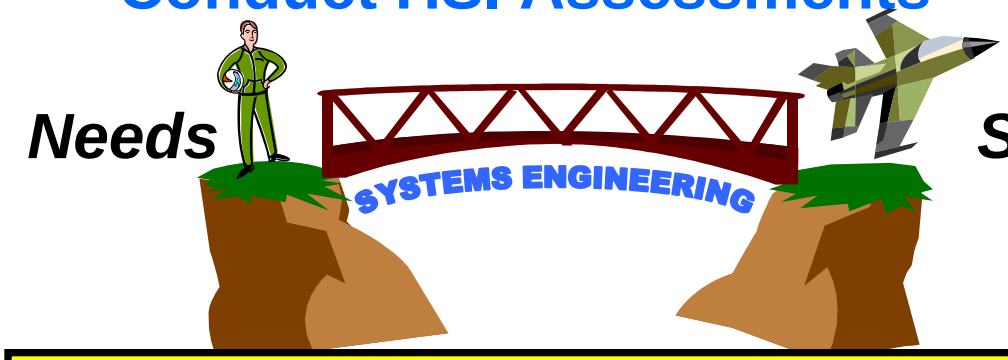
Document all Functions/Tasks
Identify Human/Automation Allocations
Evaluate Technology Integration Feasibility
Analysis of ESOH Issues
Identify Human Interface Issues
Address Workspace/Living Space Design
Design for Interoperability & Survivability

System Capability

Participate in IPT's to ensure optimization of the Total System by designing to optimize the Human Element

KEY HSI TENETS

- Initiate HSI Early
- Identify Issues and Plan Analysis
- Document/Crosswalk HSI Requirements
- Make HSI a Factor in Source Selection for Contracted Development Efforts
- Execute Integrated Technical Processes
- Conduct Proactive Tradeoffs
- Conduct HSI Assessments



HSI most effective when HUMAN BOUNDED WITHIN SYSTEM from early concept development

F-117 vs. F-22 STORY

– **F-117**

- **No access panels originally designed into aircraft**, so had to cut holes in structure to perform routine maintenance
- Eventually some access doors added to production F-117, but routine maintenance still not easy

– **F-22**

- HSI input from maintainers led to advanced door seal and associated technologies making aircraft much more maintainable
- **Success in F-22 led to high level of HSI attention in F-35, balanced with rest of aircraft's stealth and operational characteristics**

Source: New Concepts in Human Systems Integration, Potomac Institute for Policy Studies Report PIPS-08-01, March 2008

HSI makes good SE sense and can help to address emerging technology challenges in system development

F-22 HSI SUCCESS STORY

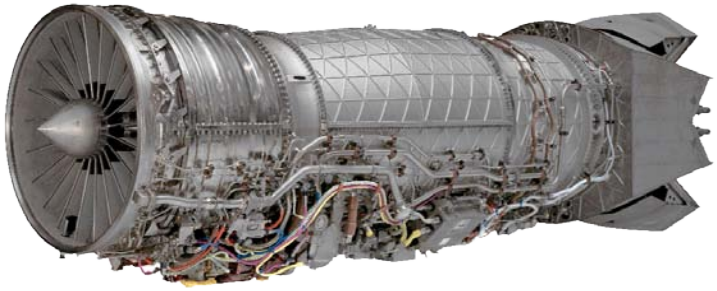
- **Senior NCOs attached to every system and subsystem team**
  - NCOs had to assess each full-scale mock-up before it was approved
- **Minimized number of AF Specialty Codes and people needed to operate and maintain F-22**
  - Reduced training requirements & life cycle costs
- **Avionics operational flight program modified to be usable in ground training simulators without major redesign**
  - Avoid "version skew"
- **Composite skin designed to resist damage from maintenance activities**
  - Reduced need for extra maintenance to fix induced damage

Source: New Concepts in Human Systems Integration, Potomac Institute for Policy Studies Report PIPS-08-01, March 2008

F-22 design gave strong consideration to HSI

F119-PW-100 ENGINE DESIGN HSI SUCCESS STORY

- **F119-PW-100 Engine Design**
  - **F-22**
  - **"Blue Two" Visits – Program Office and Industry Executives worked side-by-side with airmen performing normal maintenance**
  - **F119-PW-100 Chief Engineer Mandated:**
    - **All line replaceable units (e.g., Full Authority Digital Engine Controllers, Computerized Engine Diagnostic Units, and all pumps) would be mounted along the bottom half of the engine**
    - **Would be no more than 6 standard tools, available from Sears, needed to do external engine maintenance**
  - **F119-PW-100 engine is maintainer-friendly, while still giving highest engine performance in any fighter**



Source: New Concepts in Human Systems Integration, Potomac Institute for Policy Studies Report PIPS-08-01, March 2008

F-119 engine design changes are direct result of CONDSIDERING THE HUMAN AS CRITICAL ELEMENT EARLY IN DESIGN AND DEVELOPMENT

USS ZUMWALT (DDG-1000)

US Navy Destroyer

- Designed as multi-mission ship with a focus on land attack

- **Specifically designed to require a smaller crew** (142 vs. 330 on Spruance destroyers and 200 on Perry frigates)

- **Reduced crew represents significant reduction in life cycle costs**, since staffing is a major contributor to that cost on a warship

Source: Naval Technology

THAAD MISSILE SYSTEM TACTICAL OPERATIONS CENTER

Theater High-Altitude Area Defense (THAAD) Missile System, TOC – Mobile system to detect and eliminate enemy missiles

- **Used standard office chairs on rollers**
- **Not enough leg room for larger soldiers**
- **Inside operator had to squeeze past foreground operator to enter/exit work station**
- **No storage for MOPP gear**
- **Operators bumped switches when putting on MOPP gear**
- **Took 2-3 days to assemble the TOC, starting from an empty vehicle**

Source: "Pit Stop Engineering," presentation by Dennis Carlson, Jan 08

THAAD MISSILE SYSTEM TOC IMPROVED CONCEPT DESIGN

- **SEATING:**
  - Replaced standard office chair with seat bolted in place (several notches to allow adjustment)
  - Ample leg room for 1-99 percentile human
- **MOPP GEAR:**
  - Stored in bins
  - Seats rotated so soldiers could don gear in aisle without bumping equipment
- **ASSEMBLY:**
  - Using modular units, able to assemble equipment in empty vehicle in just minutes
  - Modules color-, number-, and shape-coded for ease of assembly

- **Greatly improved performance of system**
- **Significantly reduced set-up and maintenance time**
- **Savings estimated in billions**

CONCLUSION

- ***The HUMAN is an essential element of every system***

- ***Key to successful HSI is INTEGRATION:*** ***Integration of human considerations with hardware & software considerations***

Critical to BOUND HUMAN WITHIN SYSTEM from early concept development to enable informed decisions and optimize overall system success