You want me to do WHAT?
With WHO?
Integrating Humans with Technology

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Agenda

• 1\textsuperscript{st} Hour: what is HSI?
  – History
  – The domains

• 2\textsuperscript{nd} Hour: Everybody’s doing it!
  – The integration: thinking
  – The integration: doing

• 3\textsuperscript{rd} Hour: Doing HSI
  – Infrastructure
    • Data
    • Models
    • Other tools
    • Actually integrating

• 4\textsuperscript{th} Hour: What are the outcomes?
  – Process
  – Policy
  – Where do we go from here? What’s left to do?
What is Human Systems Integration?

Human Systems Integration (HSI) is the formal systems engineering discipline that ensures consideration of the human in warfighting capability definition and system development.

- Disciplined, unified, and interactive approach
- Integrate human considerations into system design
- Domains are interdependent and addressed together
- Improve total system performance
- Improve mission effectiveness and suitability
- Reduce total cost of ownership
Human Systems Integration

HSI is the component of Systems Engineering that focuses on the HUMAN

- Manpower, Personnel, Recruiting, Retention
- Training
- System Safety, Occ Health, Environmental
- Human Factors, Quality of Service
- Personnel Survivability
- Habitability, Quality of Life
What is HSI?

**History of Navy HSI**

- **End of WWII**
- **Army Air Corps begins using HFE ideas in airplane design**
- **1940**
- **1950 . . . 1980 1990**
  - HFE used in offshore platform design
  - Autonomic Ship
  - Ship Systems Automation
  - Smart Ship Started
  - DD21 Started
- **LSD 41: 1st HFE inclusion in a design**
- **Mid 1970's 1st HFE inclusion in a Navy Spec**
- **SNAME Panel 0-38 founded**
- **1990**
  - 1st HSI Symposium
- **2000**
- **2001**
- **2002**
  - Task Force EXCEL
  - Standup of NAVSEA 03
  - 2nd HSI Symposium
- **2003**

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HFE

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The PM shall have a comprehensive plan for HSI in place early in the acquisition process

• to optimize total system performance
• minimize total ownership costs
• ensure that the system is built to accommodate the characteristics of the user population that will operate, maintain, and support the system
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## HSI Domain Considerations

(Ref: Draft Navy Program Manager’s Human Systems Integration (HSI) Guide, Vol 1, 19 May 03)
HSI Impacts on Capability & Cost

Reduce **Life Cycle Cost**
- Reduce Manpower
- Reduce Skill Levels
- Reduce Training
- Reduce Tasks
- Reduce Mishaps
- Reduce Injuries
- Reduce Deaths

**Total Life Cycle Cost**

**Adjusted Total Life Cycle Cost with HSI Cost Avoidance**

**Reduce Life Cycle Cost**

**Increase Warfighter Capability**
- Match Manpower and Personnel to Tasks
- Optimize the Human Interface
- Maximize Availability

**HSI permits increased capability while reducing cost.**
Early Application = Reduced LCC

Early decisions drive life cycle cost - 
HSI impacts 40-60% of LCC
Building Blocks of Capability

\[ P_{OC} = (P_C \times P_T) \times P_H \]

- \( P_{OC} = \text{Operational Capability} \)
- \( P_C = \text{CONOPS} \)
- \( P_T = \text{Technology Performance} \)
- \( P_H = \text{Human Performance} \)

Human Systems Integration

- **Human Performance**
  - Human Capabilities/Competencies
  - Human Workload
  - Human Fitness for Duty

- **Human Factors Engineering**
  - Human-Machine Interface Design, procedures and aids

- **Personnel**
  - Knowledge, Skills and Abilities

- **Training**
  - Work Distribution over Crew

- **Manpower**
  - Human is qualified, rested, motivated, vigilant and healthy

- **Safety & Health**
  - Habitability

- **Survivability**
  - Personnel

- **Human Capabilities/Competencies**
  - Bringing together the necessary skills and abilities to perform tasks effectively and efficiently.

- **Human Workload**
  - Ensuring that the workload is balanced and manageable to prevent overburdening.

- **Human Fitness for Duty**
  - Ensuring personnel are physically and mentally fit to perform their duties.

- **Human Factors Engineering**
  - Designing systems that accommodate human limitations and capabilities for optimal performance.

- **Personnel**
  - Managing the allocation and distribution of personnel across tasks.

- **Training**
  - Providing necessary training to ensure personnel are capable of performing their duties.

- **Manpower**
  - Striving for personnel to be qualified, rested, motivated, vigilant, and healthy.

- **Safety & Health**
  - Ensuring personnel safety and health in all conditions.

- **Survivability**
  - Ensuring personnel survivability under all circumstances.
TOTAL SYSTEM ENGINEERING

Hardware

Software

People

TOTAL SYSTEM PERFORMANCE

Measurable and Certifiable
HOW Would We Do This??

More than anything – more than data, tools, technology, ontologies, architecture frameworks, etc. – what is required is *INTEGRATION*. 
Working Differently
SEAPRINT: Navy Enterprise Approach to HSI

Navy Enterprise Approach to HSI to addressing DoD and DoN HSI policy processes, programs and initiatives
- Standardizes HSI execution across Navy
- Ensures all aspects of HSI are addressed
- Facilitates HSI analyses

Meets JS/DoD Requirements:
Fulfills Navy’s HSI responsibilities in accordance with CJCSI 3170 (series), DoD 5000 (series) and SECNAVINST 5000.2

Program Management & Technical Process:
Integration of human considerations into system acquisition to:
- Enhance human/system design
- Reduce life cycle ownership costs
- Optimize total system performance

Congressional Mandate
SEAPRINT Technical Process

1. Target Audience and Inventory Assessment
   Use data/insights available from HSI community (e.g., SkillsObjects) to guide CONOPS, DOTMLPF analyses, capability definition, technology selection and initial design considerations. **Inputs to TAD, SSMP, AS, ICD, APB, HSIP.**

2. System Design & Trade Offs
   Identify HSI issues. Use HFE to analyze/allocate human functions. Identify design parameters. Determine projected manpower and KSAs for new system. Compare to TAD. Assess current inventory. Determine gaps. Make adjustments/trade-offs. **Inputs to SSMP, HSIP, CDD, TEMP, MER, NTSP.**

3. Integrated Technical Process
   Use HFE to refine system to meet required human performance. Determine final HSI requirements. Identify changes required to realign inventory to meet new needs. **Inputs to SSMP, HSIP, CPD, and updates to MER and NTSP.**

4. Inventory Realignment and Personnel Delivery
   Using Sea Warrior tools, begin aligning the inventory to meet new requirements. Assign workforce as required. Feedback inventory changes and assignments for future concept development. **Inputs to next generation HSIP. Foundation for next generation TAD.**
The Challenge

Generic Model
Human Capital and HFE Data Element Associations

PERFORMANCE

FUNCTIONAL AREA

Task 1
Task 2
Task 3
Task 4

Training Analysis

FUNCTIONAL CONCEPT

Analysis of Materiel Approaches

INTEGRATED ARCHITECTURE

Overarching Policy
NSS/NMS/Joint Vision

Joint Capstone Policy

MISSION

Function 1
Function 2

Requirements
Integrated Decision Meetings
Acquisition

Oversight

Requirements
Integrated Decision Meetings
Acquisition

DAB
JROC
Increment 1
Increment 2
Increment 3

MS A
MS B
MS C

Feedback

CDM
CPD

Increment 1
Increment 1
Increment 1

Concept Refinement
Technology Development

CDM
CPD

Increment 1
Increment 1
Increment 1

Functional Area Analysis

DSTL

DSTL

DSTL

DSTL

Future Linkage
Current Linkage
Human Capital Inventory Elements
Training Analysis Inventory
HFE Analysis Inventory

Generic Model
Human Capital and HFE Data Element Associations

PERFORMANCE

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Increment 1

Functional Area Analysis

DSTL

DSTL

DSTL

DSTL

Future Linkage
Current Linkage
Human Capital Inventory Elements
Training Analysis Inventory
HFE Analysis Inventory
• **Integrate Force Management Initiatives (SkillsNET)**
  • Determined role/usage of SkillsNET job and task data
  • Link KSAT constructs to HFE task taxons
  • Identify/analyze relevant job characteristics
  • Determine task-to-task mapping (post data collection)
  • Identify/Modify tools to enable feedback and database growth
“Step 2”
Current / Projected Inventory Assessment

SKILLSNET
Skill Object

Target Audience / Resource Pool
Physical Characteristics
Cognitive Capabilities
Recruiting and Retention Trends
Manning Levels
Current Jobs
Available KSAs

Task 1
KSA11
KSA12

Task 2
KSA21
KSA22
KSA23

Task 3
KSA31
KSA32
KSA33

ICD
“Step 3”
Develop a Feasible Solution

IMPRINT Task Network  Initial Design Requirements  Initial MPT Requirements
“Step 4”  
Current Capability Assessment and  
Gap Analysis
“Step 5”
Trade offs and Final Requirements

Mission Success

Mission Failure

Re-run IMPRINT Task Network

CDD

Mission Success
How To Get There

• Begin HSI Early
• Address All Aspects of HSI as Part of DOTMLPF
• Define Measurable and Testable HSI Requirements
• Take a Total Systems Approach – HW, SW & Humans
• Use Analyses to Make Trade-Offs
• Assess Human Performance Throughout the Life Cycle
• Feedback Lessons Learned into Future Acquisitions
What Is The Big Picture?

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**Operational Concepts**

**Integrating Concepts**

**Acquisition and Systems Engineering Processes**
- Capability Needs & Solution Definition
- Concept Development & Refinement
- Technology Selection & Development
- System Development & Demonstration
- Production & Deployment
- Operations & Support

**Human Systems Integration**
- Systems Engineering
- Trade-off Analysis
- Manpower
- Personnel
- Training
- Human Factors
- Occupational Health
- System Safety
- Sailor Survivability
- Habitability

**Warfighter Optimization**
- Career Mgmt / Planning
- Growth & Development
- Distribution / Position Mgmt
- Performance

**Warfighting Systems**
- Optimal Manning
- Reduced TOC
- Performance
- Mission Readiness

**Executable Architecture Framework**

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**Domain Management**

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**Composable Integration Services**
Alignment of Work across Industry Types

**Business & Industry**
- National Skill Object Database
- O*NET Job Titles
  - Critical Work Function(s)
    - SkillObjects
      - Tasks
      - Skills & Abilities
      - Tools/Equipment
      - Unique Knowledges
      - Reference Materials
  - Performance Standards
- Industry Certifications
- Job Family Standard Occupation Code (dashed line)

**Navy**
- Fleet
- Ratings
- Job/Position
  - Critical Work Function(s)
  - SkillObjects
  - Performance Standards
  - NEC's

Tasks
Skills & Abilities
Tools/Equipment
Unique Knowledges
Reference Materials
**HSI Tools for Modeling**

- **Human Performance Models**
  - Cognitive models
  - Physical/Human Figure models
  - Team performance models
- **Use these models with other Human Performance tools**
  - Workload measurements
  - System Performance measurement
- **Incorporate with Process Models**
  - Descriptive models
  - Active models
  - To build system level models that include all the component subsystems (including human operators)
Top-Down Requirements Analysis

- Front-end of HSI Process
- Described in MIL-HDBK-46855, MIL-HDBK-763, and DoD ACQ Deskbook
- Provides analyzed REQs, allocation concepts, workload estimates, human task models, system metrics, & manning models
Modeling and Simulation

- Modeling allows each element of HSI to actively participate in the Systems Engineering Acquisition Process:
  - possible design alternatives
  - determine the effects of changes on the overall system
  - Determine effects of system performance in designated missions
- Modeling is a low cost, low risk tool for exploring the trade space in new ways for human requirements experts
- Modeling is an excellent tool in which to study the effects of the various HSI disciplines on each other and on mission performance
Run Models to Verify

a. Verify the number of people proposed is appropriate
b. Verify the type of people proposed are appropriate
c. Verify the distribution of people proposed (the number of each type) is appropriate
d. Verify the ability of Systems (given a proposed Crew alignment) to meet required capability
   i. Identify the percentage of capability attainable given the proposed crew complement
   ii. Identify the potentially “better” crew alignments to achieve higher capabilities
Anthropometric Modeling

- Metrics include:
  - workload performance measures
  - reach and view assessments
  - collision and interference detection
  - strength or reaction force assessment
  - psychomotor task load
  - fatigue
- Shows design limitations as a function of human size and movement. First step to further analysis & improvements.
What Does Human Performance Modeling Do?

It helps you...

- Set realistic system requirements
- Identify future manpower & personnel constraints
- Evaluate operator & crew workload
- Test alternate system-crew function allocations
- Assess required maintenance manhours
- Assess performance during extreme conditions
- Examine performance as a function of personnel characteristics, training frequency & recency
- Identify areas to focus test and evaluation resources
Gathered from such sources as existing data, algorithms, and estimates from SMEs

- Time and accuracy of each task
- Consequences of “poor” performance

- Mission performance
- Variable snapshots
Initial Mapping

SKILLSNET

Skill Object

Task 1
- KSA11
- KSA12

Task 2
- KSA21
- KSA22
- KSA23

Task 3
- KSA31
- KSA32
- KSA33

HFE Hierarchical Task Analysis

Occupational Job Analysis
Second Mapping

Human Task Network Model

System Process Model
Whole Person Assessment and Non-Cognitive Modeling

- Improve the quality of Sailors who are selected and classified
- Reduce unwanted attrition
  - Understand attrition processes to mitigate individual and organizational dissatisfiers
- Broaden range of personal characteristics assessed for S&C
  - Ability, personality, interests
- Increase range and quality of outcome measures
  - Training, job performance, job satisfaction, career progression, retention
- Improve quality of classification decisions
  - Use more information, multidimensional models
  - Maximize person-job fit
- Example non-cognitive measures include:
  - “conscientiousness” valid predictor across many occupations
  - “emotional stability” generalizable predictor for overall performance
APPLICATIONS

HP Models Must Be Interoperable & Net-centric!!

Actual Aircraft & Pilots

Simulated Aircraft & Pilots

Other Simulated HW/SW

EDA

Actual Controllers on Simulators

Simulated Controllers

Airspace Scenario

Dynamic data exchange