HSI: Before and After

- Hardware changes made to the Stryker Mobile Gun System crew station:
- Before HSI, the MGS could accommodate approximately 50% of male population.
- Now the MGS can accommodate approximately 73% of males.

Human Engineering the Workspace for the Soldier
Dateline HSI

- What is HSI
- HSI Dimensions
  - Domains
  - Workforce
  - HSI Regulation
  - Processes
- HSI In Action
- HSI Modeling & Simulation
- Why HSI – Risk Reduction
- Our HSI Mandate
- References
What is HSI?

- A comprehensive management and technical program
- To ensure the integration of human considerations (i.e., capabilities and limitations)
- In all phases of the capability development and system acquisition processes.

**Fit the Equipment to the Soldier**

**Not the Soldier to the Equipment**
HSI Dimensions

Enterprise
Industrious & Systematic Advocacy of Soldier in Acquisition

Community
Behavioral Science HFE Health & Safety Training Personnel Survivability

Regulations
AR 602-2 DoD 5000.02

HSI HQ
DCS G-1

TTP
Assessment Assistance T&E

Tools in Action
Model & Sim Real Time Soldier Data Collection

S&T
Advanced Models & Measures Design Guides

Joint HSI & Partners

ROI to Soldier

Powered By Seven Analytic Domains

MANPOWER PERSONNEL TRAINING HUMAN FACTORS SAFETY HEALTH HAZARDS SURVIVABILITY SOLDIER
MANPOWER - number of military and civilian personnel required and potentially available to operate, maintain, sustain and provide training for systems

PERSONNEL CAPABILITY - cognitive and physical capabilities require to train, operate, maintain and sustain material and information systems

TRAINING - instruction, education, and OJT required to provide personnel and units with their essential job skills, knowledge, values and attitudes.

SOLDIER SURVIVABILITY - characteristics of system that can reduce fratricide, detectability, and probability of attack, as well as minimizing system damage, personal injury, and cognitive and physical fatigue

SYSTEM SAFETY - design and operating characteristics of a system that minimize the human or machine errors or failures that cause accidents

HEALTH HAZARDS - design and operating characteristics of a system that create significant risks of bodily injury or death; sources of health hazards include: loud noise, chemical and biological substances, extreme temperatures, and radiation energy.

HUMAN FACTORS ENGINEERING - integration of characteristics into system definition, design, development and evaluation to optimize human-machine performance
The HSI Question – ask it everyday

Can this soldier as part of this unit with this training
perform these tasks under these conditions using this equipment?

Skills Abilities Experience

Mission Terrain OPTEMPO

Stryker
AR 602-2
HUMAN-SYSTEMS INTEGRATION (HSI) in the System Acquisition Process

• Establishes POLICY, RESPONSIBILITIES AND DOCUMENTATION requirements for implementing and supporting HSI.

• Emphasizes FRONT-END PLANNING of soldier-system design as an integral part of system acquisition.

THE LATEST REVISION OF AR 602-2 IS EFFECTIVE 27 January 2015
The Future: Joint HSI

- Early HSI
- HSI MIL-STD
- DoDI 5000.02 (Jan 7, 2017) –

HSI Analytic Domains:

- HFE (Human Factors Engineering)
  - Personnel
  - Habitability
  - Manpower
  - Training
  - Safety & Occupational Health
  - Force Protection & Survivability

OSD HSI Steering Council

<table>
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<tr>
<th>USD ATL</th>
<th>USD P&amp;R</th>
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<td>ASD-M&amp;RA</td>
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<tr>
<td>TOTAL FORCE PLANNING &amp; REQUIREMENTS</td>
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</tbody>
</table>
The HSI Analysis Model

Human Performance

- Capabilities and Competencies
- Workload
- Fitness for Duty

Human Systems Integration

- Human-Machine Interface Design
- Knowledges, Skills and Abilities
- Crew Composition, Health and Status
- Crew Work Distribution

The Foundation for Optimizing Human Performance
Identify MISSION-FUNCTION-TASK Constraints

- Determine HSI constraints that may impact concept feasibility, total system performance & affordability (ICD Key Boundary Conditions of AoA)
- Set HSI priorities to identify acceptable risks associated with automating critical tasks within functional analysis & allocation decisions
- Identify HSI constraints related to Army readiness factors (i.e. fitness, training) that may adversely affect potential KPPs, KSAs, & MOEs
HSI works Form, Fit, & Function

**INPUT**
- Operational concept
- Equipment concepts and technology options
- Mission and environment requirements
- From users
- From IPTs and tech community
- From commanders

**METHODS**
Work performed by HSI Teams
- Models that predict human performance, and cognitive and physical workload
- Subject matter expert assessments
- Soldier hands-on data using prototype equipment in realistic environments

**OUTPUT**
- Function:
  - Can the Soldiers perform the tasks to standard in a realistic environment?
  - Can the Soldier perform the procedures properly and without error?
  - Can the Soldier acquire and maintain required skills and knowledge?
- Fit:
  - Can the operator or maintainer reach the controls and personal equipment?
  - Can the Soldier see the visual displays?
  - Do the controls and displays fit in size limits of the workspace?
  - Is Soldier fitted correctly?
- Form:
  - Are the controls easy to identify?
  - Does the operator understand the information presented on displays?
  - Are the operators and maintainers protected from potential hazard and safety risks?

Feedback to PM/Leaders
Influence Design

From IPTs and tech community
From commanders
From PM/Leaders
Influence Design

Form
- Are the controls easy to identify?
- Does the operator understand the information presented on displays?
- Are the operators and maintainers protected from potential hazard and safety risks?
<table>
<thead>
<tr>
<th>DOMAIN</th>
<th>POTENTIAL RISK</th>
<th>POTENTIAL CONSEQUENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>MANPOWER</td>
<td>Newer vehicle does not accommodate entire platoon/squad</td>
<td>Delay fielding units with qualified personnel</td>
</tr>
<tr>
<td>PERSONNEL</td>
<td>New MOS/ASI required for sophisticated electronics and communications gear</td>
<td>Increased cognitive workload introduces high probability of error &amp; incomplete/delayed task products</td>
</tr>
<tr>
<td>TRAINING</td>
<td>Lack appropriate Training Strategies, TTPs</td>
<td>Individual &amp; unit readiness capability not acceptable</td>
</tr>
<tr>
<td>HUMAN FACTORS ENGINEERING</td>
<td>Poor workspace layout and Operations on the Move</td>
<td>Degraded performance while operating &amp; when dismounting</td>
</tr>
<tr>
<td>SOLDIER SAFETY</td>
<td>Poorly designed Hatch Locks, Hand - Foot Holds</td>
<td>Increased personnel injuries</td>
</tr>
<tr>
<td>HEALTH HAZARDS</td>
<td>Exposure to Gasses, Heat, Vibration</td>
<td>Increased sick call, disorientation, alertness decreased</td>
</tr>
<tr>
<td>SURVIVABILITY</td>
<td>Lack of Friend or Foe ID beyond range of certain armaments</td>
<td>Greater Risk of Fratricide</td>
</tr>
</tbody>
</table>
PEO Soldier – PM Air Warrior

The Degraded Visual Environment (DVE) is a major problem for US Army Aviation

Team HSI - Human Factors Engineers and Cognitive Psychologists addressed the interface design question: Can symbology improve pilot ability to take off/land in DVEs?

NATO Task Group HFM-162 led to early identification of 3D headtracked conformal symbology as a potential mitigation

HSI designed 3D symbology interface using AMRDEC/SSDD APEX II Lab UH-60L fixed base simulator & Army National Guard Pilots

Performance in operationally-vetted missions showed
  • Improved pilot and co-pilot situation awareness
  • Reduced pilot workload
  • Improved safety – eliminating crash landings in DVE
  • Improved takeoff & landing stability and landing zone error
Standard Aircraft Towing System (SATS)

- Just because it’s COTS doesn’t mean it shouldn’t comply with military safety and design standards, and meet performance parameters and thresholds. (AR 602-2)

- Poorly written requirements, specifications, and contracts often result in major safety and human factors shortfalls early in materiel development, and ultimately cost the PMs time and money in the long term.

- HSI practices are mandated by DoD policy and Army regulations but are often overlooked or pushed aside with a justification of “speed to market.”

- Commercial industry may not “speak Army” when it comes to understanding Soldier requirements.

The SATS was a Commercial-Off-The-Shelf (COTS) attempt to standardize the fleet of Army towing equipment. PM Aviation Ground Support Equipment (AGSE) publicly posted their requirements, and through a down-select competitive process arrived at the above (NMC-Wollard) COTS solution.
The SATS had multiple HSI concerns, some of which are shown here:

- **Protruding Bolt**
- **Pinch/Crush Hazard Area**
- **Oil dipstick location/color**
- **(Inadequate handle)**
- **(Reach & identification)**
- **Front Bolts**
- **Rear Bolts**
- **(Initial-design)**
- **(Re-design)**
Issues: Reach & identification

Had HSI been brought in on the mitigation strategy/design changes, these errors could have been avoided and material, time, and dollars saved.
Issue: Inadequate handle

Attempts to correct some of these deficiencies created new hazards for the Soldier.
Standard Aircraft Towing System (SATS)

Initial COTS product (Before)

- Released Grip & Excessive Reach

Design change after HSI (After)

- Captured Retaining Pin

Results

- MIL STD 1472 parameters for lift, reach, and push-pull force limits were not taken into consideration during redesign. The solution was intended to be a single person task and actually had to become a two person task. It retains the same hazards.

- MIL STD 1472 parameters for handle design were not met resulting in an engine deck-lid lift handle that was still too small in diameter (and remains unchanged).

- Recommendations were adopted and the sticky back flimsy labels were replaced with metal placards and the vehicle properly stenciled.
“So how do you integrate HSI into the PM’s decision making . . . and affect change in COTS solutions?”

• Become a team member not just an evaluator/assessor.

• Assist the PM in developing programmatic documents and ensure they clearly articulate HSI & Human Performance requirements & standards.

• Develop relationships with the “stake-holder” agency representatives (TRADOC, CASCOM, CECOM, TPO-AB, ATEC, etc.)

• Quantify the PM’s return on investment or highlight cost avoidance as much as possible.

• Build on the “3 R’s” Relationship, Relevance, and Reputation.
HSI Modeling & Simulation:

The Discovery of Soldier-System Fit
A Govt-owned discrete event simulation tool

- Sets realistic system requirements
- Identify future manpower & personnel constraints
- Evaluate operator & crew workload
- Test alternate system-crew function allocations
- Assess performance during extreme conditions
- Examine performance as a function of personnel characteristics, training frequency & recency
- Identify areas to focus test and evaluation resources

“Can my operators and maintainers meet the system performance requirements?”
IMPRINT Modules

WARFIGHTERS
Personnel Modeling

MISSIONS
Operations Modeling

EQUIPMENT
Maintenance Modeling

FORCES
Manpower Modeling
Ground Combat Vehicle

IMPRINT analysis of Soldier tasks to assess proposed vendor designs prior to construction (focus on user interface) to determine if new design increases operator workload as compared to the current system.

Joint Lightweight Tactical Vehicle

Developing baseline IMPRINT maintenance model, key maintenance metrics and point estimates for use in predicting and comparing performance of different vendor designs; corresponding operations analysis of crew maintenance tasks.

WIN-T Network Operations

Operator Roles & Workload
Constructive Simulation Models

C3TRACE

Command Control and Communications- Techniques for Reliable Assessment of Concept Execution

stochastic discrete event simulation tool

140+ users supporting Army, Navy, Air Force, Marines, NASA, Joint and other organizations across the country
Manpower Cost Modeling
Health Hazard Assessment Categories

- **ACOUSTIC ENERGY**
  - Impulse Noise
  - Blast Overpressure
  - Steady-state Noise

- **BIOLOGICAL SUBSTANCES**
  - Field Sanitation & Hygiene
  - Poisonous Plants & Animals

- **CHEMICAL SUBSTANCES**

- **RADIATION ENERGY**
  - Radio Frequency/Ultrasound
  - Laser/Optical Radiation
  - Ionizing Radiation

- **SHOCK**
  - Rapid Acceleration/Deceleration

- **TRAUMA**
  - Sharp/Blunt Impact
  - Musculoskeletal Trauma

- **VIBRATION**
  - Whole-body (multiple shock)
  - Segmental

- **TEMPERATURE EXTREMES**
  - Heat/Cold

- **OXYGEN DEFICIENCY**
  - High Altitude/Confined Spaces
  - Ventilation
Army Health Hazard Assessment Program: The Medical Cost Avoidance Model (MCAM)
Hazard Assessment / Medical Impact

Hazard: Musculoskeletal

Risk: Hazard Severity & Probability

Hazard Probability

<table>
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<tr>
<th>Hazard Severity</th>
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</table>

AR 40-10 Risk Assessment Codes RAC

MHS Direct Care & Population Data (M2)

Military Personnel Cost Data

MCAM Injury Impact Model

Army Physical Disability Agency Data

VA Disability Compensation Data

Total Medical Costs

Clinic Costs + Hospital Costs + Lost Time Costs + Disability Costs + Fatality Costs

Emergency Care  Surgery-related  Limited Duty, Quarters  Limited Use  None
Hazard Analysis

Medical Cost Avoidance Model

Human Figure Modeling
Human Figure Modeling

- Quantify population accommodation, visibility, reach, mobility profile, etc.
- Less time to evaluate concepts
- Iterative evaluation of concepts

“Model – Test – Model” approach
- Use models to filter concepts and predict performance.
- Refine model predictions and concepts with field tests on best concepts.
- Reuse the improved models to reduce cost and turnaround time.
Because people come in all sizes
90 % of the population is typically modeled
This hand-sizing tool will standardize glove sizing for Soldiers.

One of the greatest design features of the tool is the stopper that measures the index finger.

- The hand-sizing tool was originally a piece of paper that evolved to a piece of laminated paper mounted onto foam with a small block positioned to keep the hand in the correct position.

- The stopper is to measure the length of the trigger finger, since sensitivity in the tip of this finger is what will be used to feel their trigger.

- The stopper is brought down as far as needed to measure for a tight fit at the finger tip.
Hatches may look big until a 90 percentile soldier, fully equipped, tries to egress.

Sufficient side to side hatch opening clearance with elevated arm posture

Front to back hatch opening clearance tight with Large Male equipped with combat gear
Mine Resistant Ambush Protected Vehicle (MRAP)

Workspace Analysis

Seat pan too short to safely & completely accommodate large sized occupant with full combat gear
Quickly assessing CAD drawings to effectively and safely accommodate Female Aviators ability to reach all cockpit controls.
Head tilted down 30°

Horizontal line at seated eye position

Line of sight 30° from horizon

15.0° from L.O.S.

25.7° from L.O.S.
right lower leg and knee clearance issues
Limited foot space degrades ability to safely and quickly ingress/egress without personnel injury.
Seated Accommodation Assessment

Mid Size Male helmet contact with DVE display in the stowed position degrades system usability and accessibility.
Why HSI: Risk Identification & Mitigation

- **Information Flow**: Can’t keep up with events or stay focused on critical tasks
- **Workload**: Sustained tasks and high Workload
- **Decision-making**: Can’t meet decision timelines

**Distributed Decision Makers Roles and Functions**

- **Command**
- **Decision Authority**
- **Plans**
- **XO/Chief of Staff**
- **Collectors**
- **Field OPS**
- **BOG**

**Who & Where**

**How to Fix**

- **Reduce Inputs**
- **Monitor & Update Collection**
- **Interface Access Specifications**
- **Data Manipulation & Analysis Methods**
- **Automation**
- **Another Team Member**
- **Simplify Ack, Report & Dissemination**
- **Decision Process Redesign**

**Who & Where**

- **Who**: Distributed Decision Makers
- **Where**: MISSION AOR

**What: Performance OK?**

- **YES**
- **NO**

**Information Flow**

- **Revise Response Reqs**
- **Reallocate Task**
- **Change Display**
- **Review Low Level Data Required**

**Cost vs. Risk**

- **MPT Skills & Tng**
- **HFEA Design $**
- **Safety & Health Trades**

**When: Now**
To Sum up . . .
A car is not this....
...it is this!

Mostly materiel with human interface
The Soldier system is not this...
Mostly human with materiel interface
HSI’s premise: Manpower and human performance objectives must determine materiel design. They should not be the consequences of design.

- Why HSI
  - Manpower is currently 50-60% of systems’ life-cycle costs
  - Manpower requirements must be considered at every stage of system acquisition
- HSI is: A scientific and technical approach to system design that integrates analyses of:
  - Improved system design
  - Reduced system life-cycle costs
  - Reduced manpower requirements
  - Reduced risk to soldiers
  - Greater operational suitability

HSI is the G-1’s only influence over the Army’s manpower needs and expenditures for systems.
New Wallet Size!

‘Fit the equipment to the Soldier
Not the Soldier to the equipment’

The Seven HSI Domains

MANPOWER - number of military and civilian personnel required and potentially available to operate, maintain, sustain and provide training for systems

PERSONNEL CAPABILITY - cognitive and physical capabilities require to train, operate, maintain and sustain material and information systems

TRAINING - instruction, education, and OJT required to provide personnel and units with their essential job skills, knowledge, values and attitudes.

www.HSI.army.mil

The Seven HSI Domains

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SOLDIER SURVIVABILITY - characteristics of system that can reduce fratricide, detectability, and probability of attack, as well as minimizing system damage, personal injury, and cognitive and physical fatigue
Common HSI Analysis Tasks

- Set realistic system requirements
- Identify future manpower & personnel constraints
- Evaluate operator & crew workload
- Test alternate system-crew function allocations
- Assess required maintenance man-hours
- Assess performance during extreme conditions
- Examine performance as a function of personnel characteristics and training frequency & recency
- Identify areas to focus test and evaluation resources
- Quantify human system integration risks in mission performance terms to support milestone review
- Represent humans in federated simulations

HSI analysis involves trade-offs