Human Systems Integration in Next-Generation Expeditionary Medical Treatment Facilities

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Overview

- Introduction and Background
  - Expeditionary Medicine
  - Human Systems Integration
- Present Study
  - Review current capabilities and emerging technologies
  - Identify and prioritize HSI issues
  - Develop technical tools
- Recommendations

Expeditionary Medical Treatment Facilities

- Mobile/transportable facilities ready to deploy into theater
  - Provides trauma care for military personnel and (sometimes) to local population
  - May provide routine care to deployed personnel
  - Possible use in disaster relief operations
- Typical current generation is EMEDS (Expeditionary Medical Support)

Transformation to
Air Expeditionary Force

- Scale of future crisis is unpredictable
- Need flexibility to optimize configuration based on capabilities vs. risk
- Requirement for light, modular & rapid response (no C-17)

"Portable Hospitals"

Manpower Packages
Equipment Packages
Sustainment Packages

Air Evacuation

Mobile Aeromedical Staging Facilities
"Care in the Air"

"Unique Assets"

In-flight Intensive Care Unit Capabilities

Humanitarian Assistance Rapid Response Team

Positioned, Ready, and Strategically Linked for Global Response

Human Systems Integration

- HSI is the systems engineering process that ensures that all human-related issues are properly identified and addressed in system design and development

- Definition from AFI 10-601, April 2007:

    "HSI is the integrated, comprehensive analysis, design and assessment of requirements, concepts and resources for systems with respect to Manpower, Personnel and Training; Environment, Safety & Occupational Health; Habitability, Survivability and Human Factors Engineering (HFE)."

INCOSE Definition of HSI

According to the International Council On Systems Engineering (INCOSE, 2007): HSI is "*the interdisciplinary technical and management processes for integrating human considerations within and across all system elements. It is an essential enabler to systems engineering*".

Thus, HSI is both:

1. A *management strategy* to ensure that human-related concerns are properly considered in an acquisition program.

2. A *technical strategy* to ensure that human performance issues are addressed early and effectively in an acquisition program.
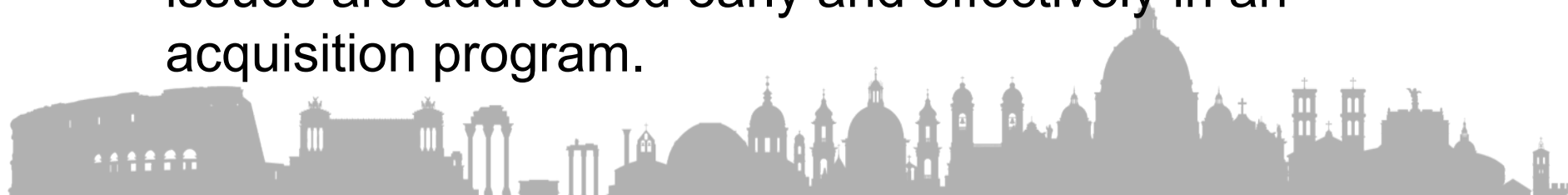
HSI in Future EMTF

- HSI can contribute to future expeditionary medical treatment facilities (EMTFs) in several ways
  - Simpler design of equipment leading to reduced errors and more effective training
  - Optimizing mix of personnel, especially when manpower reductions are imposed
  - Better methods and tools for team training prior to and during deployment

Objectives and Approach

- Identify HSI issues in the next generation of EMTFs
  - reports and interviews conducted with military medical personnel experienced in current facilities
  - published reports of issues in comparable systems
  - issues associated with emerging technologies expected to be deployed in the next generation of facilities
- Develop tools to help address those issues in facility planning, design, and operation
  - Adapt existing guidelines for application to EMTF
  - Conduct studies to generate basis for new guidelines
- Overall focus is on future facilities, not remediation of current facilities

Major HSI Issues

- Identified over 100 HSI issues, many of which affect multiple HSI domains

- Major themes:
  - Reduction of human error
  - Need for improved training
  - Impact of pressure to reduce manpower
  - Shift of certain responsibilities to less-qualified personnel

Example Issues

- *Medical equipment may not interface or be compatible with other equipment or gear (HFE)*

- *Staff (and equipment) may be at risk for secondary exposure to chemical or biological agents (Occupational Health & Safety)*

- *Medical personnel may experience negative transfer due to differences between civilian and military equipment and gear (HFE + Personnel)*

- *There may be an overreliance on training to attempt to overcome device complexity (HFE + Training)*

- *Protective features or equipment may interfere with ability to provide medical care (HFE + Survivability)*

- *The training pace may not be able to keep up with manpower demands (Manpower + Training)*

Emerging Technologies

- Patient Transfer Systems – A modular system, perhaps with robotic assists, could reduce labor required for transport and could improve care during transport

- Baseline Datasets – expect to have complete physiological and cognitive baselines for all personnel

- Ubiquitous Data Networks – transmit data from the field and while en route to prepare treatment plan prior to arrival

- Plasma Based Decontamination – May significantly reduce labor, but creates new need for training and new sources of error

- Simulation and Augmented Reality – For use in training and to assist in treatment and diagnostic procedures

- Robotic Surgery – May reduce the skills required for complex laparoscopic surgeries

Emerging HSI Issues

- Emerging technologies promise performance benefits
  - Create opportunities to improve team performance, and will therefore need corresponding team training
  - May help alleviate impact of pressure to reduce manpower and to shift tasks to personnel with lower qualifications
- Emerging technologies will create need for new skill sets
  - Thus there will be a need for new training
  - May also impact the mix of skill sets needed on a team
- New sources of potential error

Prioritization of Issues

- ## Four factors:

  - **Impact:** Overall importance in future operations (3=high impact, 2=medium impact, 1=low impact).

  - **Gap:** Amount of useful existing guidance (3=little or no guidance currently exists; 2=some guidance exists; 1=useful guidance exists).

  - **Resource:** Resources (funding and special facilities) necessary to mitigate the issue. (3=not resource intensive; 2=somewhat resource intensive; 1=very resource intensive).

  - **Lab:** Suitability of the issue for study outside the operational context (3=suitable for lab research; 2=partially suitable for lab research, 1=not suitable for lab research).

Top Three Issues

Issue	Domains	Overall Score
Situation awareness may not be preserved between shift changes	HFE, Manpower	2.75
Teams may not be able to train as a team prior to deployment	Training, Manpower	2.75
Safety features may be too easily ignored	S/OH, HFE, Training	2.75

Additional Issues

Second tier issues   (scores = 2.5)

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Excessive light and noise may adversely impact medical personnel or patients	
The design of medical equipment and gear may exclude certain operators (e.g., color blind, height / reach requirements)	Poor lighting may impact medical personnel performance (Low lighting levels may lead to errors)
The design may rely too heavily on the short term memories of medical personnel	
The design of medical equipment and gear may make it difficult to detect when errors occur	There may be an over-reliance on training to address safety problems
User interface elements and supplies that are similar may be easily misidentified	Protective gear may interfere with the safe operation of equipment
Alarms and alerts from multiple devices may be confused or obscured	
Protective features or equipment may interfere with ability to provide medical care	There may be a lack of shared mental models and situation awareness
Medical equipment and gear may not be usable under conditions of light or noise discipline	The training may not adequately help teams adapt to new technologies or procedures
Medical equipment or gear may not be suitable for use in direct sunlight	
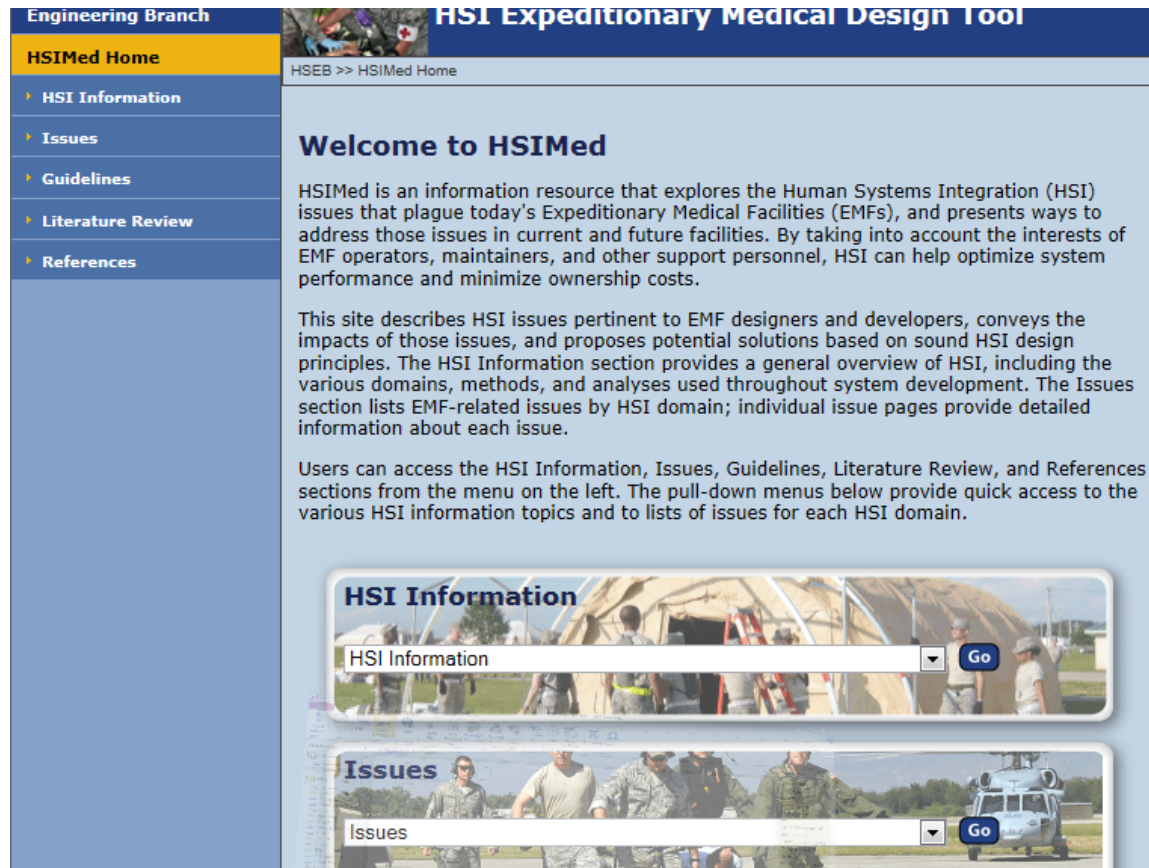
HSIMed

http://hsimed.gtri.gatech.edu/home.php

Example Issue

Teams may not be able to train as a team prior to deployment.

Expeditionary medical teams are rapidly deployed to austere environments to meet immediate challenges. Such teams can be composed of individuals from disparate origins and organizations who have had no opportunity to train together, but are nonetheless expected to function effectively as a team in an environment where there is a high degree of task interdependence and a high need for team coordination (Entin et al., 2007).

Inadequate team training poses a potential risk to patient safety. Leonard, Graham, and Bonacum (2004) suggest that effective communication and teamwork are imperative for safety and patient care, citing communication failures as the leading cause of inadvertent patient harm.

Training specific teamwork skills makes them more robust to stressors in difficult working conditions. High-performance teams use deliberate strategies to ensure that team members possess the needed teamwork and task work competencies. Research has shown that relatively short (2 hour) training interventions targeted at increasing team communication and coordination skills are successful in increasing performance under high-stress and high-workload conditions (Salas, Rosen, & King, 2007).

Potential Solutions

Air Force instruction 10-400 describes the concept of teaming, which helps to ensure that individuals who train together at their home location also deploy together as a team. Teaming means that all individuals who make up a particular Unit Type Code (UTC) come from the same origin or unit. The objective of teaming is to ensure that all UTCs at an employment location come from as few bases at practical. The concept of teaming is designed to provide commanders with a trained and integrated team.

Entin et al. (2007) describe an alternative to co-located training by providing the means for distributed team training via the web. Their example provides pre-deployment training for distributed medical teams using a scenario-based teamwork skills training program incorporating web-enabled collaborative technologies.

Aptima's Teamwork Training and Remote Assessment in a Networked Environment (T-TRANE) is a web-based online course designed to teach teamwork skills to emergency medical practitioners in military and civilian organizations. By focusing on the teamwork skills that complement existing taskwork skills, T-TRANE increases team proficiency and

Recommendations

- Patient Transfer System
  - Integrate physical transfer, information transfer between facilities, and shift-change transfer

- Team Training System
  - Embedded as configuration-managed component
  - Include patient simulators

- System-Wide Safety Audit

Patient Transfer System

- Physical components appropriate for en-route care

- Integrated information systems – forwards information to receiving unit prior to arrival

- Issues addressed:
  - Situation awareness loss across shift change
  - Safety issues in physical transfer
  - Incompatibility of medical equipment with transport equipment

Team Training System

- Should become part of the EMTF configuration, and include appropriate software and hardware components (e.g., patient simulators)

- Issues addressed:
  - Personnel not training as a team prior to deployment
  - Need for training new personnel in theater
  - Training required for new procedures after deployment

System-Wide Safety Audit

- Identify and assess all safety features in current facilities
    - Focus on features that interact with personnel (warnings, lockouts, etc.)
    - Identify system-level features not present in current facilities
    - Generate guidelines for future facilities
- Issues addressed:
    - Safety features too easily ignored
    - Conflicting warning signals
    - Safety procedures difficult to remember

Conclusions

- Future EMTFs face many HSI issues, some continuing from current facilities, others generated by the emerging technologies

- Application of HSI principles during planning, design, and development of these future facilities will create the opportunity to address these issues proactively

- Many issues can be addressed by applying known principles; others will benefit from studies and/or technology development prior to implementation

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