Air Force Human Systems Integration Handbook

Planning and Execution of Human Systems Integration

Directorate of Human Performance Integration
Human Performance Optimization Division

711 HPW/HPO, 2485 Gillingham Drive
Brooks City-Base, TX 78235-5105

Distribution A: Unlimited Distribution

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Executive Summary

The purpose of the U.S. Air Force Human Systems Integration (AFHSI) Handbook is to provide a detailed look at the Air Force Human Systems Integration (HSI) process and identify key considerations for the development of HSI plans and implementation of HSI programs. The Handbook can serve as a training aid for new Air Force HSI practitioners and requirements developers, as well as an introduction to HSI for those unfamiliar with the process. It may also serve as a desktop reference to HSI processes and general guidelines for experienced professionals. The instructions and processes addressed here are best used as a starting point for thinking about system concepts and designs. The user should not assume that the Handbook provides comprehensive coverage of all possible elements; general guidelines and lessons learned should be used as appropriate.

This Handbook is intended to provide the practitioner with an introduction to HSI and an improved understanding of why HSI is important. This includes consideration of the relationship between HSI and the Systems Acquisition Process, emphasizing the importance of addressing HSI early in system design and acquisition. Early consideration of HSI is necessary in order to maximize system performance benefits and reap maximum return on investment, resulting in minimal redesigns required later in the acquisition process. This Handbook addresses the integration of the HSI domains of human factors, manpower, personnel, training, environment, safety, occupational health, survivability, and habitability such that interdependencies can be organized and influenced and optimal design can be achieved.

Teamwork and integration are the key to good HSI. This Handbook identifies skill sets and organizations for collaboration, as well as detailed resources such as tools and educational resources.

To further aid the practitioner, key steps in each stage of the HSI implementation process are identified here by checkmarked bullets. These are provided to emphasize recommended general guidelines for success in executing and managing HSI programs.

When using this Handbook, to review AFHSI processes, to identify key considerations for the development of HSI plans and implementation of HSI programs, or as a training and reference guide, keep in mind that human systems integration is completely centered around the user.

> <u>General Guidelines</u>
>
> ✓ Checkmarked bullets indicate recommended general guideline steps for success in executing and managing an HSI program.

1. Introduction to Air Force Human Systems Integration

Human Systems Integration (HSI) is a robust process by which to design and develop systems that effectively and affordably integrate human capabilities and limitations. HSI should be included as an integral part of a total system approach to weapon systems development and acquisition. The Defense Acquisition Guidebook (DAG) (2005) states, "The total system includes not only the prime mission equipment, but also the people who operate, maintain, and support the system; the training and training devices; and operational and support infrastructure" (p. 233).

1.1 HANDBOOK PURPOSE

The purpose of the U.S. Air Force Human Systems Integration (AFHSI) Handbook is to provide a methodology for developing and implementing HSI within Systems Acquisition using the systems engineering process. The Handbook can serve as a training aid for new Air Force HSI practitioners and requirements developers, and may also be useful as a desktop reference to HSI processes, tools, and general guidelines. Key ideas that this Handbook focuses on are to explain what HSI is, the importance of HSI, how HSI fits into the acquisition process, and to provide helpful HSI references within the Air Force community. The instructions and processes identified here are best used as a starting point for thinking about system concepts and designs. Further information on implementing HSI within the acquisition life cycle can be found in the *Air Force Human Systems Integration Development Guide*. The *AFHSI Development Guide* can help focus on who performs HSI, when HSI is considered, how HSI is included in the system requirements, and the available tools and methods to assist in incorporating HSI.

The Human in HSI refers to all personnel, including users, operators, maintainers, supporters, and trainers involved with the system. These may include any and all active duty, Reserve, Guard, Civil Service, government and contractor personnel who interact with the system throughout the entire system lifecycle. HSI domains collectively define how human capacity or requirements impact (1) the hardware and software of any given system, in terms of its design, effectiveness, operation, support and the associated affordability of these components, and (2) how the hardware and software of that same system impact human performance. According to the DoD Instruction 5000.2 (2003), "HSI practitioners support programs by focusing attention on the human in the system, and by integrating the HSI domains of manpower, personnel, training, human factors engineering, environment, safety, occupational health, survivability and habitability into the acquisition process" (section E7). The National Security Space (NSS) Acquisition policy 03-01 provides guidance for the USAF Space System Acquisition policies. It closely reflects the HSI recommendations in the DoD 5000 series as they relate to the space acquisition process.

In combination with the HSI Capabilities Based Requirements Development Guide, this Handbook identifies important considerations for each of the HSI domains. These considerations should be addressed in the process of determining requirements and design criteria for weapon systems development, acquisition programs, modifications and HSI assessments.

1.2 HISTORY

Human Factors began during World War II and came out of the disciplines of industrial engineering and experimental psychology. Many discipline practitioners served in World War II and witnessed very poor system designs that were often unsafe and difficult to operate. The field of human factors emerged from these lessons learned. Although some progress was made during the 1950's, 60's and 70's, the Armed Services recognized the need for greater attention to human design. The field of HSI was conceived in the early 1980's as a methodology to address a rapid increase in mishaps, manpower, personnel and training costs, and to reduce total life cycle systems costs. U.S. Army General, Max Thurman asserted, *"We must quit manning the equipment and start equipping the man."*

Since 1982, The U. S. Army has utilized a robust HSI program known as Manpower and Personnel Integration (MANPRINT). The U.S. Navy also has an HSI program within its Naval Sea Systems

Command Human Systems Integration Directorate (NAVSEA 03). The Air Force began its HSI program as IMPACTS in 1982 and has since revived the effort into the Air Force Human Systems Integration Program. Other nations, most notably The United Kingdom, Australia, Canada and New Zealand have established HSI programs to integrate their military defense systems. These programs were modeled after the original MANPRINT concept. In conjunction with each of these programs, many private sector companies have begun to focus efforts on providing HSI expertise.

Each of these HSI programs integrate the following key human elements, now referred to as HSI domains: human factors engineering (HFE), manpower, personnel, training, environment, safety, occupational health, survivability habitability. These domains are divided or binned differently by the various services. Depending on the specific HSI program some domains are grouped rather than considered separately:manpower, personnel, and training are sometimes referred to as MPT, while environment, safety, and occupational health are referred to as ESOH. For the purpose of this handbook, all domains exist as separate entities.

Within the Air Force, each domain is considered and addressed separately before determining possible trade-offs between domains. Domain considerations are integrated throughout system design, development, fielding and sustainment. This process ensures that potential HSI issues are identified during the requirements generation and pre-systems design phases of the acquisition process. The goal of HSI is to develop and acquire optimized weapon systems that enhance human/system performance, maximize operational utility and effectiveness, and reduce life cycle costs (LCC). Figure 1 illustrates a snapshot of the main HSI elements within an overall system. At the same time, HSI focuses on increasing safety margins, and decreasing the use of expensive retrofits to fix design shortcomings.

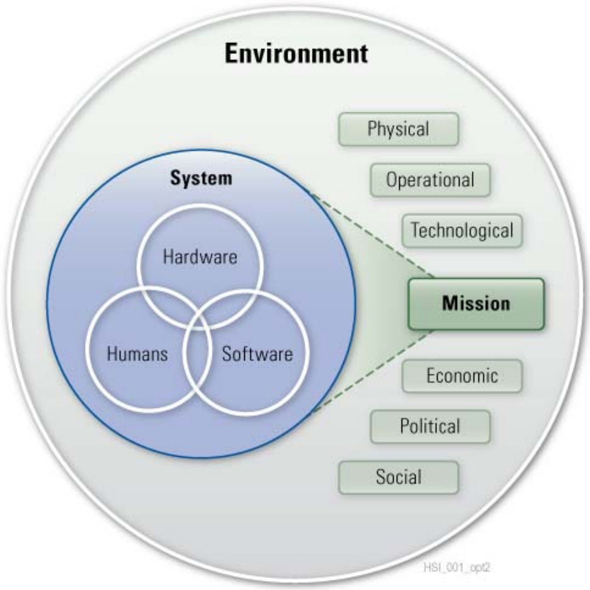

Figure 1: Elements of HSI

The DoD, its component services, other nations and many experts have published HSI relevant guidance including: DoD Instruction 5000.2, the Defense Acquisition Guidebook (DAG), Human Engineering Guide to Equipment Design (Van Cott & Kincade, 1972), MANPRINT (Booher, 1990), Human Factors Compendium (Boff & Lincoln, 1986), the MANPRINT Handbook (Army, 2005); the Human Systems Integration Handbook (Booher, 2003); Mil Std 1472, Mil Std 1787, Human System Integration in the System Development Process: A New Look (Pew and Mavors, 2007), MIL-HDBK 1908B, MIL-HDBK 46855A, Definitions of Human Factors Terms (1999), and many others. Each is a useful resource to complement this work. They are further supported by more recently evolving policies and instructions such as the Air Force Instruction for Life Cycle Systems Engineering (AFI 63-1201) and the soon-to-be published Enterprise Policy for Acquisition and Sustainment (AFI 63/20-1). Guidance is also rapidly evolving in such forms as the Navy's Virtual Systems Command's three-volume HSI Guide; the recently published International Council on Systems Engineering Handbook and the United Kingdom's "Human View for MODAF." While many of these documents are not regulatory in nature, they are referenced frequently in this document to provide the HSI practitioner access to pertinent and relevant information to guide their efforts.

1.3 Key Concepts

Three key concepts define an effective HSI program. First, systems are comprised of hardware, software, and human personnel (DoD 5001.1, 2005, E1.29), all of which operate within a surrounding environment. Too often, acquistion systems programs fail to consider the human capacity or requirements as part of the system. This leads to poor task allocation between hardware, software, and human users or supporters. To promote ideal task allocation, it is critical that the human element be considered early in system development.

Second, successful HSI depends upon integration of the functional HSI domains into acquistion planning efforts such as participation on program High Performance Teams (HPTs) and Integrated Product Teams (IPTs). HSI domains often exist as independent disciplines or functions due to the location of expertise within the structure of the Air Force . Under a “stovepipe” approach, each discipline must fight its individual way into the acquisition process. Proper implementation of HSI through participation on HPTs and IPTs integrates these domains/disciplines to leverage and apply their interdependencies, and thus to attain an optimal design. By this process, domain interests can be integrated to perform effective HSI through trade-offs and collaboration. This provides a common basis upon which to make knowledgeable decisions. The results of the integration effort should be reflected as updates to system requirements and documents through objectives, and thresholds in the Capability Development Document (CDD) and capability prodcution document.

Finally, HSI must be considered early in the requirements development phase of system design and acquisition. This will provide the best opportunity to maximize return on investment (ROI) and system performance. HSI requirements must be developed in conjunction with capability-based requirements generation through functional analyses within the Joint Capabilities Integration and Development System (JCIDS). HSI requirements will drive HSI metrics and embed HSI issues within the system design. After a system is designed, implementation of HSI oversights can be very expensive.

1.4 Domains

Human Systems Integration is a comprehensive management and technical approach for addressing the human element in weapon system development and acquisition. HSI incorporates functional areas, referred to as domains. The are: Manpower; Personnel; Training (sometimes combined into MPT); Human Factors Engineering; Environment; Safety; and Occupational Health (the previous three are commonly grouped as ESOH); Survivability; and Habitability. As factors of human behavior and performance, these domains are ultimately interdependent and so must at some point be considered in terms of their possible interactions. Explanation of each of these domains is illustrated in Figure 2.

Manpower

The number and mix of personnel (military, civilian, and contractor) authorized and available to train, operate, maintain, and support each system acquisition.

Personnel

The human aptitudes, skills, knowledge, experience levels, and abilities required to operate, maintain, and support the system at the time it is fielded and throughout its life cycle.

Training

The instruction and resources required to provide Air Force personnel with requisite knowledge, skills, and abilities to properly operate, maintain, and support the system.

Human Factors Engineering

The comprehensive integration of human capabilities and limitations (cognitive, physical, sensory, and team dynamic) into system design, development, modification and evaluation to optimize human-machine performance for both operation and maintenance of a system. Human Factors Engineering designs systems that require minimal manpower, provide effective training, can be operated and maintained by users; and are suitable and survivable.

Environment

Environmental factors concern water, air, and land and the interrelationships which exist among and between water, air, and land and all living things.

Safety

Safety factors are design and operational characteristics that minimize the possibilities for accidents or mishaps to operators which threaten the survival of the system.

Occupational Health

Occupational Health factors are design features that minimize risk of injury, acute and/or chronic illness, or disability, and/or reduced job performance of personnel who operate, maintain, or support the system.

Survivability

The characteristics of a system that reduce risk of fratricide, detection, and the probability of being attacked; and that enable the crew to withstand man-made or natural hostile environments without aborting the mission or suffering acute and/or chronic illness, disability, or death.

Habitability

Factors of living and working conditions that are necessary to sustain the morale, safety, health, and comfort of the user population which contribute directly to personnel effectiveness and mission accomplishment, and often preclude recruitment and retention problems.

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Figure 2: HSI Domains and Definitions

2. Implementing Air Force Human Systems Integration

There are two specific Air Force organizations focusing on HSI as a whole, however there are also other organizations within the government with which these organizations collaborate. The collaboration amongst all of the organizations is key to the success of HSI. The following sections provide some insight into the primary AFHSI organizations along with their collaborating partners.

2.1 Primary AFHSI Organizations

The Air Force has two organizations, the Air Force Human Systems Integration Office (AFHSIO) and the 711th Human Performance Wing Directorate of Human Performance Integration (711 HPW/HP), which have been tasked to implement HSI in the Air Force. These two organizations make up the strategic (AFHSIO) and tactical (711 HPW/HP) arms, of Air Force HSI. While each of these organization serves a common purpose, they perform their work through different methods. Neither reports to the other and they are in different sectors of the Air Force. For more information on the details of the organization, please reference Appendix VI for contact information.

2.1.1 Air Force Human Systems Integration Office (AFHSIO)

The vision of the AFHSIO is to integrate Air Force personnel and technology to ensure total weapon systems performance, at affordable life cycle costs, and to support Air Force missions effectively and efficiently. Additionally, it is the mission of AFHSIO to ensure that all Air Force warfighting systems are designed, built, operated, and sustained in a manner that optimizes human performance to increase total system performance at every warfighter level.

The goals of AFHSIO are to optimize warfighter capability and sustain readiness by integrating HSI processes into the Integrated Acquisition, Technology, and Logistics Life Cycle Management Framework to equip and sustain the Warfighter; institutionalize HSI as the way of doing business to increase total systems performance and to ensure affordable life cycle costs; sustain HSI through collaboration with partners in the Office of the Secretary of Defense (OSD), Air Force (AF), sister services, industry, and academia; and to affect AF policy and guidance, while improving HSI processes through metrics, feedback, and lessons learned.

The AFHSIO therefore provides strategic guidance to:

- Facilitate and advocate integration of HSI into the integrated lifecyle management framework and AF policies and guidance to comprehensively implement, assess, and improve HSI.
- Develop and deliver comprehensive HSI education and training, tools, technology and methods to support Program Executive Officers (PEOs), Program Managers (PMs), Systems Engineers (SEs), and others involved in requirements development, acquisition and sustainment.
- Provide expert advice, real-time assistance, and implementation strategies for HSI.
- Support the development, communication and implementation of HSI initiatives.
- Oversee and advocate HSI focus in activities regarding systems integration, systems engineering, total system performance and total operating costs. (AFI 63-101 DRAFT, 2008, p. 46)

2.1.2 The 711th Human Performance Wing, Directorate of Human Performance Integration (711 HPW/HP)

The vision of the 711 HPW/HP is to implement HSI as an embedded business practice within the Air Force. The mission is to advocate, facilitate, and support the application of HSI principles to optimize operational capabilities. This is done by integrating human performance sustainment, optimization and enhancement through the application of operational knowledge and evidence-based HSI. Another goal of this organization is to ensure an overwhelmingly effective USAF warfighter through the integration of people and technology for total systems performance, as well as, to be the AF human performance and HSI lead execution agent to DoD, Air Staff, Major Commands (MAJCOMs), system program offices, science and technology, and acquisition, logistics, and test centers.

The Human Performance Optimization Division is a part of the 711 HPW/HP (711 HPW/HPO). The 711 HPW/HPO seeks to advance human-centered design in the acquisition of weapon systems to maximize total system performance and reduce life cycle costs. This division facilitates HSI process implementation during weapon systems acquisition across the Air Force enterprise areas of aeronautical; Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR); munitions; and space/missile. The 711 HPW/HPO also consults with High Performance Teams, Program Managers, Systems Engineers, and Integrated Product Teams to execute HSI at a tactical level in the Air Force.

2.2 COLLABORATION

The purpose of collaboration is to create a structure that enables stakeholders and experts to consider and address relevant issues and challenges of shared concern. The goal is to create an ideal vision that all stakeholders can agree upon, commit to, and finally create action plans to support.

Within any team and/or organization, there are strategies that can be implemented to increase dividends, improve leverage, and enhance collaborative skills. The same collaborative skills that work well within teams and organizations can also be effective in reaching across organizational boundaries and customers.

A key element of HSI is the integration of the different domains and collaboration between the stakeholders. The integration of these disciplines provides the benefits of utilizing HSI within system development. Inter and intra-organizational collaboration offer the best knowledge and tools for efficient and effective HSI.

2.2.1 Skill Sets and Collaboration

HSI requires the involvement of highly qualified personnel who understand how to integrate human performance and capacities into research, design, development, and system implementation. The demand for HSI practitioners will naturally grow as a result of improved HSI requirements. There is a growing need for new and additional HSI education and training programs to serve the needs of existing practitioners, and to supoprt new personnel who wish to become HSI practitioners.

To establish effective HSI in a program, it is necessary to identify and include HSI competencies and formalized collaboration amongst the domain SMEs. This may require gap analysis to identify HSI skill sets needed to meet current and anticipated HSI workload. HSI specialists should have academic backgrounds and experience to accomplish the desired tasks. Two questions should be raised and answered: (1) What HSI specialists are needed to fill the gap? and (2) How will each specialist contribute? Appendix V provides an additional reference to assist in keeping all of the HSI team members on the same page through policy letter examples.

Figure 3 illustrates basic academic specialties as well as HSI tasks that are typically associated with each. Together, these contribute to the framework that define Air Force Specialty Codes (AFSCs) and Job Series requirements. AFSCs and Job Series are used to accomplish defined tasks within research, acquisition, and regulation.

Figure 3: Areas of Domain Expertise

According to Booher (2003), “The major categories are HSI domains and systems engineering and integration. As might be expected, HSI competencies start with expertise in the HSI domains. Outlined in [table 1] are the HSI core competencies, which are collectively needed by HSI jobs for all relevant functions throughout the research and acquisition lifecycle, and the regulatory systems engineering and integration categories (including policy).” (p. 668) This information leads into the content that is outlined in table 1. Table 1 overviews two separate but related listings of the HSI Core Competencies from the *Handbook of Human Systems Integration.* Both of these columns provide key components of achieving overall system integration.

Table 1: HSI Core Competencies, Handbook of Human Systems Integration

HSI Competencies	Systems Engineering & Integration
• Statistics	• Requirements determination
• Experimental Design	• Systems requirements analysis
• Regression Methods	• HSI issues and criteria
• Nonparametric	• MPT trade-offs
• Sensory and Perceptual Processes	• Materiel improvement
• Cognition & Decision Making	• Acquisition process models
• Physical Abilities & Limits	• Traditional
• Anthropometry & Work Physiology	• Streamlined
• Simulation Methodology	• Nondevelopmental items
• Human Systems Modeling	• Systems design and management
• Human Performance Measurement	• Human-centered design
• Design of Displays, Controls & Workstations	• Requests for proposal, proposal development, and evaluations
• Skill Acquisition	• HSI assessments
• Personnel Selection	• Program management
• Team Performance	• Testing and evaluation
• Environment, Safety & Occupational Health	• Measures of effectiveness and performance
• Human survivability in hostile environments	• HSI in test design plans
	• HSI in test reports
• Organization design	• HSI technology research and development
• Analytical techniques	• Operations research
• Early comparability analysis	• Integrated logistics support processes
• Manpower staffing analysis	• Safety engineering and management
• Information requirements analysis	• Training approaches and methodologies
• Task, function, and workload analysis	• Economic and cost analyses
• Training effectiveness analysis	
• Training Design	
• HSI domain trade-off analysis	
• Accident analysis	
• Human error and reliability analyses	

Each HSI domain requires core competencies and training to effectively fulfill responsibility obligations and to successfully complete required tasks. Each HSI domain is associated with numerous responsibilities and tasks. Table 4, adapted from the *Handbook of Human Systems Integration* (Booher, 2003), provides a sample of the responsibilities and tasks for each domain.

Table 2: Responsibilities and Tasks for Domain Areas

Responsibilities and Tasks for Each Domain	
Environment: • Conduct pollution prevention assessments • Assess risks from environmental hazards (i.e. Ozone Depleting Chemicals, Environmental Protection Agency(EPA) 17, hazardous materials) • Develop, update, and maintain Programmatic Environmental, Safety and Occupational Health Evaluation	Safety: • Develop analytical models and methods • Collect data on errors, failures, or accidents • Perform safety analyses • Conduct root-cause analyses • Perform failure-mode and effects analyses • Develop and analyze fault trees • Develop, update, and maintain system safety plans
Manpower: • Document changes to organizational structure caused by the introduction of a new system • Determine numbers of required and authorized personnel for the units and types of personnel that will use, maintain, and support a new system • Calculate whether a new system will require more personnel than is authorized or required currently	Personnel: • Specify human user, operator, or maintainer requirements (aptitudes and experience) • Document changes to agency personnel, personnel management, and personnel policy caused by the introduction of a new system • Develop, update, and maintain a description of the equipment operator, user, and maintainer • Discuss knowledge, skills, and abilities (KSA'S) of the system user
Training: • Prepare instructional or procedural documents • Define instructional requirements • Specify training objectives • Assess the effectiveness of training (systems, courses, aids, simulators) • Conduct training • Design training aids • Develop training content and instructional methods • Design simulation systems • Document the changes to agency training strategy, plans, policy, and procedures caused by introduction of a new system	Human Factors: • Assess mental workload • Assess physical workload • Analyze effects of environmental stressors • Perform human reliability analyses • Apply human factors criteria and principles • Verify design conformance to human factors specification • Design human equipment interfaces • Design workspace layouts • Design software—user interfaces • Prepare/review drawings for conformance to human factors specifications • Develop, update, and maintain human factors
Habitability: • Conduct habitability assessments • Develop habitability enhancement procedures	Occupational Health: • Assess performance risks from occupational health hazards categories (noise, contaminants, etc.) • Support product liability litigation • Prepare product warnings • Develop, update, and maintain occupational health hazards prevention plans
Survivability: • Conduct survivability assessments • Support casualty analyses • Develop survivability enhancement procedures	

As referenced by Booher (2003),“HSI research is primarily concerned with producing results that advance the state of the art for quantitative human parameters and HSI technology” (p. 123). Nearly all HSI-related work is engaged during different phases of the development process (research, acquisition, and regulatory and policy). The Air Force should have organic HSI expertise or access (through collaborative efforts) to HSI experts who are knowledgeable in each area.

The HSI specialist must understand that HSI implementation should occur throughout the systems engineering and acquisition lifecycle management processes. These processes include logistics, manpower, training, safety, and test and evaluation. Regulatory HSI jobs should involve setting, integrating and applying standards and practices for every HSI domain through policy development. “Practitioners should employ HFE to design systems requiring minimal manpower; that provide effective training; can be operated and maintained by users; and are habitable and safe with minimal environmental and occupational health hazards, and survivable” (DoDI 5000.2, 2003, section 3.9.2.2).

2.2.2 Air Force-Wide Collaborations

In order for HSI to be effectively practiced in the Air Force, there must be collaboration and cooperation between many government organizations. These supporters could provide subject matter expertise and/or receive HSI support. The listings below are considered to be high-level organizations with ideal expertise and experience in HSI. While there are many other organizations, these are the key players in HSI success. If there are questions concerning additional outreach organizations, please see Appendix VI for appropriate contact information.

2.2.2.1 Air Force Major Commands (MAJCOMs)

The Air Force has HSI reachback capabilities in many organizations outside of the 711 HPW/HP and AFHSIO. Specifically the Major Commands (MAJCOMs) contain cells of HSI expertise. These include individuals referred to as the local HSI practitioner, as well as those who have obtained HSI expertise through their prior and current experience (often Human Factors Engineers). The Air Force MAJCOMs are:

- **Air Combat Command** Operates USAF bombers (active and Air National Guard and Air Force Reserve Command gained); USAF’s continental United States (CONUS) based (active and gained) fighter and attack, reconnaissance, battle management, and command and control aircraft and intelligence and surveillance systems. Provides combat airpower to warfighting commands.
- **Air Education and Training Command** Recruits, trains, and educates professional, expeditionary-minded airmen to sustain the combat capability of America’s Air Force. Provides basic military training, initial and advanced technical training, flying training, and professional military and degree-granting professional Education. Conducts joint, medical service, readiness, and Air Force security assistance training.
- **Air Force Materiel Command** AFMC delivers war-winning expeditionary capabilities to the warfighter through development and transition of technology, professional acquisition management, exacting test and evaluation, and world-class sustainment of all Air Force weapon systems. From cradle-to-grave, AFMC provides the work force and infrastructure necessary to ensure the United States remains the world's most respected Air and Space Force.
- **Air Force Space Command** Operates and tests USAF intercontinental ballistic missile forces for U.S. Strategic Command (STRATCOM); missile warning radars, sensors, and satellites; national space-launch facilities and operational boosters; worldwide space surveillance radars and optical systems; worldwide space environmental systems; position, navigation, and timing systems. Provides command and control for DoD satellites; missile warning and space weather support to DoD. Produces and acquires advanced space systems.

- **Air Force Special Operations Command** Provides Air Force special operations and combat search and rescue (CSAR) forces for worldwide deployment and assignment to regional unified commands. Tasked for seven mission areas: shaping the battlefield; information operations; precision engagement; special operations force (SOF) mobility; agile combat support; aerospace interface; and personnel recovery/recovery operations.
- **Air Mobility Command** Provides rapid global mobility and sustainment through tactical and strategic airlift and aerial refueling for US armed forces. Provides special duty and operational support aircraft and global humanitarian support. Performs peacetime and wartime aeromedical evacuation missions.

Within the MAJCOMs there are additional organizations that contain HSI practitioners and SMEs, many of which are located in the headquarters. These organzations can include safety, engineering, requirements, manpower and personnel, and logistics offices. AFMC, which leads much of the acquisition for the Air Force, also includes the following organizations useful for collaborative efforts:

- Aeronautical Systems Center – Develops, acquires, modernizes, and sustains aerospace systems
- Acquisition Environmental, Safety and Health
- Air Armament Center – Responsible for development, acquisition, testing and deployment of conventional and nuclear air-delivered weapons. Applies advanced technology, engineering and budgeting efficiencies across the entire product life cycle to provide superior combat capability.
- Air Force Flight Test Center – Conducts and supports research, development, test and evaluation of both manned and unmanned aerospace vehicles.
- Air Force Research Laboratory – Leads the discovery, development and integration of warfighting technologies for our aerospace forces. Conducts basic research and develops and transitions new technologies for Air Force weapon systems and their supporting infrastructure; and ensures responsive technical support to time-urgent problems.
- Electronic Systems Center – Develops and acquires systems that combine computers, radars, information displays, and communications gear.

2.2.2.2 Other Air Force Organizations

Some direct reporting units and forward operating agencies that have HSI functional subject matter expertise can also be beneficial in collaborative relationships. As an HSI practitioner it is important to know of available reachback capabilities within the Air Force. Some of these organizations are:

- Air Force Agency for Modeling Simulations (AFAMS) – Training
- Air Force Center for Environmental Excellence (AFCEE) – Environment
- Air Force Manpower Agency (AFMA) – Manpower
- Air Force Occupational Measurements Squadron (AFOMS) – Manpower and Training
- Air Force Test and Evaluation Command (AFOTEC) – Measurable HSI Requirements
- Air Force Personnel Center (AFPC) – Personnel
- Air Force Personnel Operating Agency (AFPOA) – Personnel
- Air Force Safety Center (AFSC) – Safety

2.2.2.3 Non-Air Force Collaborations

Army MANPRINT Directorate. Establishes policies and procedures for Army Regulation (AR) 602-2, Manpower and Personnel Integration in the System Acquisition Process; and to exercise primary staff responsibilities for the Soldier Oriented Research and Development (SORD-PT) program.

Navy NAVSEA HSI Directorate. Provides the Navy Enterprise with the policy, process, tools and people to develop war-fighting capabilities that maximize human performance and minimize life cycle cost. Ensures human requirements are accurate, affordable, achievable and stable Navy Human Performance Centers. Optimizes Naval warfighting performance by applying the Human Performance Systems Model (HPSM) and the Science of Learning (SL) to all facets of Naval operations, while focusing on performance improvement: identifying and removing all factors that could prevent a sailor or a team, a unit or an organization from achieving its highest level of performance.

FAA - Human Factors Research and Engineering Division. Provides scientific and technical support for the civil aviation human factors research program and for human factors applications in acquisition, certification, regulation, and standards. Develops and assures implementation of human factors policies, regulations, programs, and procedures which promote the safety and productivity of the national airspace system. Formulates and manages the aviation human factors research program and provides human factors support to acquisition and regulatory activities.

NASA Human Factors Research and Technology Division. Advances human-centered design and operations of complex aerospace systems through analysis, experimentation and modeling of human performance and human-automation interaction to make dramatic improvements in safety, efficiency and mission success.

3. Economic Impacts of Human Systems Integration

3.1 Return on Investment [1]

The users of modern weapon systems expect products that can be used safely and effectively. They also expect that the development community has addressed user needs and capacities as intrinsic to system effectiveness. These expectations may not be realized without a unified and integrated HSI effort. This requires an investment of time, financial resources, and personnel resources.

In trying to achieve system performance as specified in capability documents, the program manager may adopt a short-term focus on the need to stay on schedule and within the acquisition budget. The results of this management approach can be varied, as illustrated in Figure 4. The result may be an on-budget but sub-optimal weapon system that cannot be fielded safely and effectively without costly fixes and retrofits.

[1] All of the statistical information in this section is evidential, but not yet proven. One source for a small portion of this information is in the 2004 AFSAB Report. For statistical updates, please contact the 711th HPW/HPO (see Appendix VI).

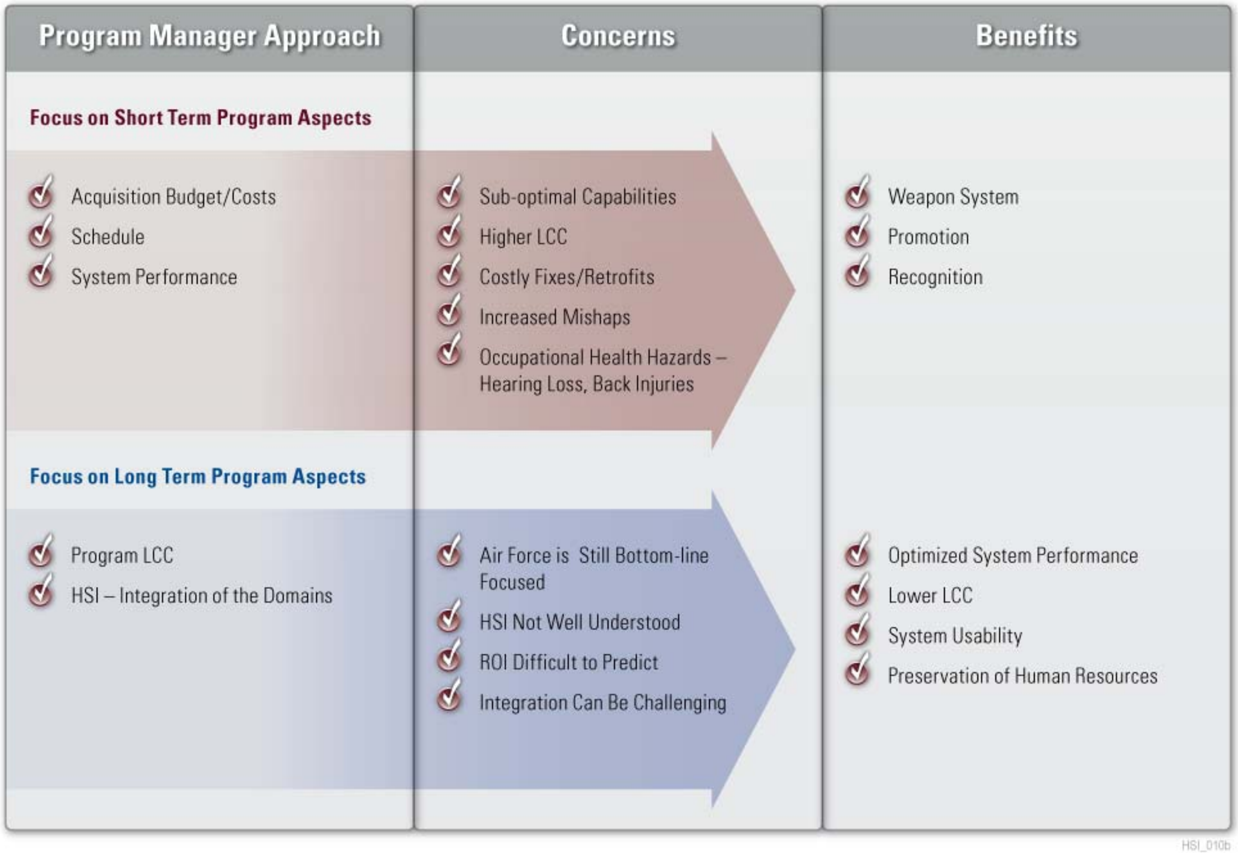

Figure 4: Short Term vs. Long Term Program Focus

> The Committee on Armed Services House of Representatives (HASC) Report (2005) expresses that program results can be achieved by an approach that focuses on long-term cost reduction. By applying a robust HSI program early in system development and acquisition, the program manager can maximize overall ROI in several important ways. Implementation of effective HSI practices and concentration on reducing overall life cycle budget will tend to optimize system performance, reduce LCCs, provide more usable systems, and minimize occupational health hazards and opportunities for mishaps (p. 150).

The types of ROIs mentioned in the HASC Report are possible because a large percentage of LCCs are attributable to HSI. Because human performance exerts such a significant effect on system effectiveness, the only question is whether HSI will be paid for most affordably in advance, or at much greater expense after a newly fielded system reveals significant problems. The earlier an HSI investment can be made, the greater will be its return. The longer one waits to implement HSI, the more negative impact will be shown on total LCC. However, always remember that there will be benefits of incorporating HSI at any point in the design maturity, as long as it preceeds the final design. Generally, fifty percent (and sometimes more) of LCC is already locked in by milestone B. By milestone C, the opportunity to have a meaningful effect on LCC is nearly gone.

Figure 5 illustrates the opportunities for return on an HSI investment over a program's life cycle.

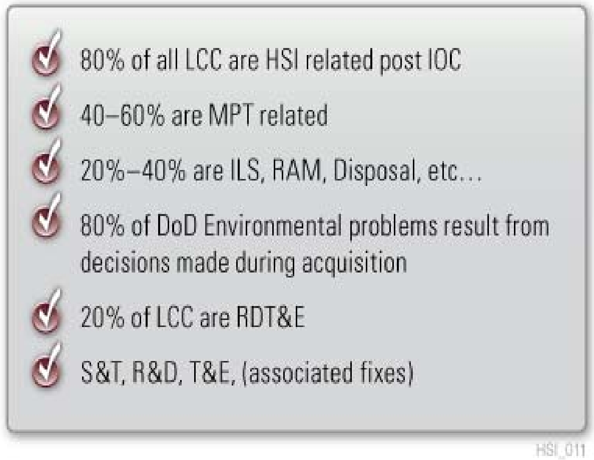

Figure 5: Targets of Opportunity for HSI

For example, 80% of all LCCs are HSI related and are incurred beyond Initial Operational Capability (IOC). Attention to the HSI domains during concept refinement and technology development phases can positively affect 80% of LCC. Attention to HSI within manpower, personnel, and training can impact 40 – 60% of LCC (Figure 6). Research, development, testing and evaluation (RDT&E) account for 20% of LCC, and so provide an additional target of opportunity to save money.

Figure 6: ROI Calculation Equation

Some key opportunities for return on investment are:

- Analysis of Alternatives (AoAs), Tradeoff studies, HSI tool use – design optimization
- Design for production, reliability, availability, maintainability, and total systems performance
- Design tradeoffs to reduce hardware/software changes during RDT&E
- Task analysis, functional analyses and allocations – workload reduction
- Design simulation & emulation – reduction of cost to prepare for test and evaluation
- Full mission simulation – optimize system for test, facilitate successful test
- Eliminate major portion of hardware and software design changes required prior to Full Operational Capability (FOC)

3.2 Investment in Human Systems Integration [2]

HSI is quickly gaining respect as an affordable and viable discipline. The Army, Navy, National Aeronautics and Space Administration (NASA), Federal Aviation Administration (FAA), and private industry have gained considerable experience in making the investment required to perform quality HSI from start to finish as part of their acquisition programs. The resulting value ranges from 2-4.2% of total system acquisition cost (RDT&E) and includes studies, analyses, assessments, domain tradeoffs, tool applications, modeling and simulations, HSI testing, and other activities (Figure 7).

HSI = RDT&E x .02
(Range 2% to 4.2%)

HSI_012

Figure 7: HSI Calculation Equation

According to MIL-HDBK 46855A (1999), illustrating values of HSI are best demonstrated by the positive and negative results of HSI activities. The benefits require money and time to reap the overall savings, increased total system performance, safety, and user satisfaction. The problems that occur from the lack of HSI within a system usualy can result from system shortcomings that require costly redesign, produce substandard system performance, or trigger system failures endangering life and equipment. Some problems are able to be resolved, but can also be more costly after the fact (p. 32-41). There are many success stories and lessons learned in section 5.3 of this reference. The amount of research done on the benefits and costs of investing in HSI attests to the necessity of early implementation before a destructive situation takes place.

Integration is the key to meaningful savings through HSI. Optimal integration requires high-level coordination among domain owners, facilitated by an HSI Team working within the HPTs and IPTs to obtain optimum solutions.

The HSI Team is ideally comprised of a minimum of one Subject Matter Expert (SME) from each domain, acquisition, and systems engineering. While the ideal team may not be achieved, having multiple SME's who are at least familiar with each of the domains may be sufficient. A HSI team lead should also be chosen among the group to keep the collaborations on track during brainstorming and decision making sessions.

By working very diligently within the HSI arena, experts in human factors, crew systems, safety, and other relevant fields can prevent the need for later hardware and software modifications, reducing the "fly and fix" or "test and fix" difficulties that have historically plagued the system acquisition process. The Air Force's longstanding experience with crew systems and cockpits can provide significant assistance in this effort. A classic example of effective HSI is presented by the Low Altitude Navigation and Targeting Infrared for Night (LANTIRN) Case Study. For more information concerning the lessons learned from this example case study, please contact the 711th HPW/HPO (Appendix VI).

Figure 8 depicts the dilemma that may be faced by a program manager. A program manager's decisions affect LCCs and mission capabilities which may not be realized until decades later. These critical LCCs are bulked into the areas that can be most affected by HSI during the program acquisition.

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[2] All of the statistical information in this section is evidential, but not yet proven. For statistical updates, please contact the 711th HPW/HPO (found in Appendix VI).

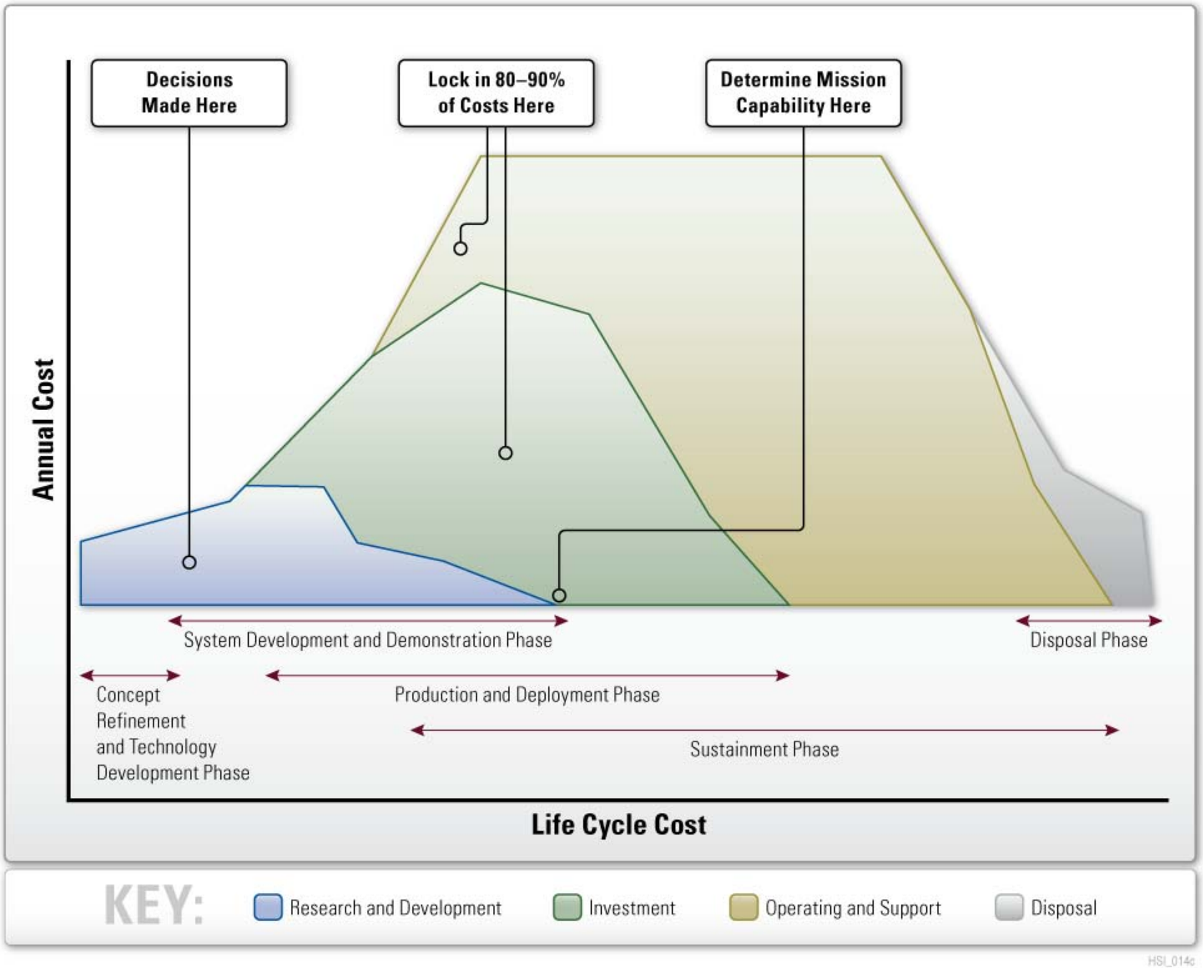

Figure 8: Life Cycle Cost Distribution

The problem of rising LCC and impact on research and development monies is depicted in Figure 9 (Defense News Magazine, 1995). This indicates that 80% of LCC are growing and pulling under the research and development available resources. In order to deal with this critical issue, the Air Force has come to grips rapidly with the need for reduction of total ownership costs. In March of 2005, the Air Force published the Life Cycle Management Plan (LCMP) Guide, which presents key points for preparing and coordinating the process for LCMPs. This guide points to HSI as one of the last strategies still available to reduce total ownership costs or LCC (p. 3).

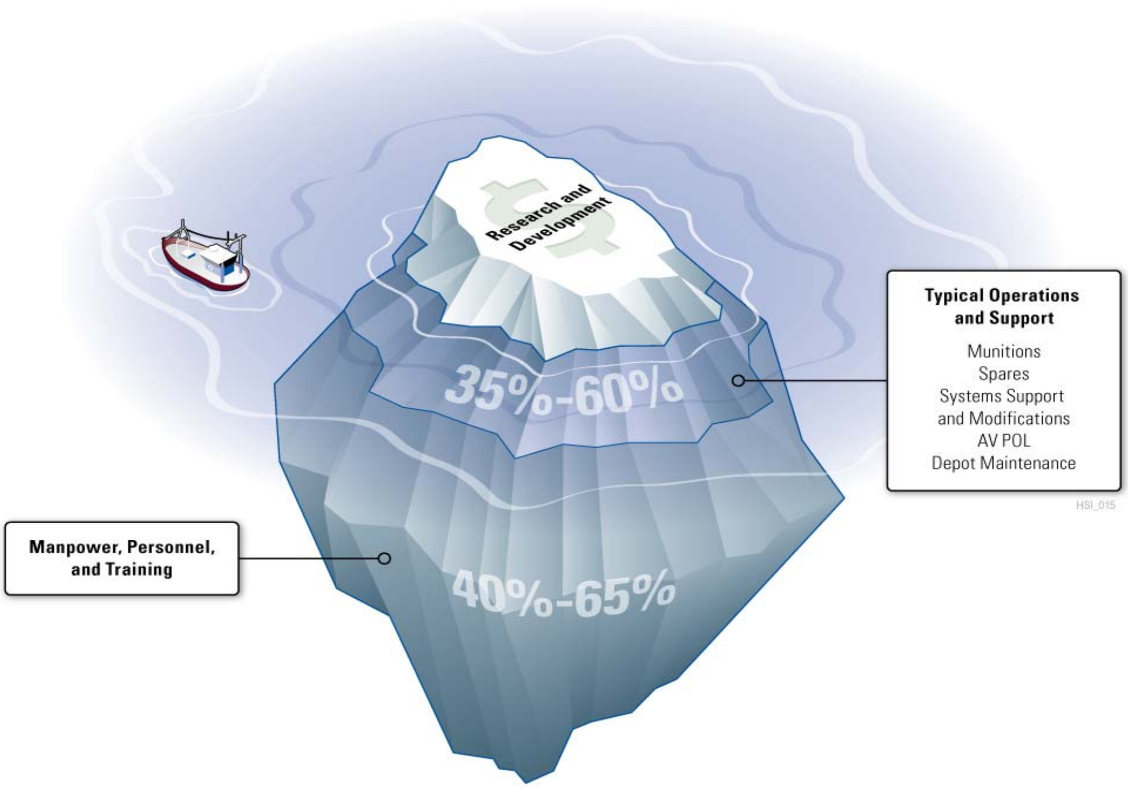

Figure 9: Where does the money go?

In justifying the value of HSI to the PM, the PEO or the defense acquisition board (DAB), the best course of action is to follow the practices laid out in this handbook. A case for HSI can also be built by using other assets, such as the Human Systems Integration Community of Practice (CoP) website (https://wwwd.my.af.mil/afknprod/ASPs/CoP/ClosedCoP.asp?Filter=HP-HS-01), and the senior level HSI policy office (AFHSIO).

GENERAL GUIDELINES: HSI Investment

- ✓ Identify targets for LCC optimization and focus
- ✓ Work closely with teams and program management to identify HSI high value areas that may impact critical programmatics, especially performance
- ✓ Begin planning for tradeoff assessments between and within HSI domains
- ✓ Plan HSI investment and work very closely with teams and SMEs to identify best investment options
- ✓ Identify the data you need to justify HSI and calculate ROI (APB, LCCE, Cost Avoidance, CBA)

3.2.1 Calculating HSI costs and ROI

In order to effectively implement an HSI Plan, the cost calculation needs to be carefully considered. The main focus is to understand the pros and cons of implementing HSI early in the system design process. The next step is to calculate your HSI investment costs using the guidelines presented above.

SYSTEMS ACQUISITION GOAL:

Develop best overall value solution over a system's life cycle to meet operational and maintainer requirements defined by the user

An example of high return on investment for HSI practices is the T800 (General Electric) engine tool kit made by Snap-On. This kit reduced the predecessor complete engine tool kit from 134 to 31 tools and the crew chief tool kit to 6 common off the shelf tools that fit in a roll-up case that can be carried in the crew chief's pocket. This is a significant reduction for a complex 1400 HP Turbine Engine. This approach met or exceeded specifications in all tests, and was proved employing untrained high school students using only the published manuals. (Handbook of Human Systems Engineering, Booher 2005).

Used properly, calculation of ROI with data already collected will allow the program manager to address LCCs. Systems engineers and HSI experts can recommend specific tools, techniques and other aids to validate costs, benefits and economic analyses as needed to determine an ROI attributable to HSI.

Here are three great HSI success stories, from the AFHSI Report to the Joint HSI Steering Group, that can be referred to when understanding the ROI for the new system. This first example shows that even though immediate resluts are not observed, long-term success can still be appreciated:

> A fighter jet employed HSI analyses, simulation, and other tools to address the cockpit/crew station, human factors, safety, survivability, and a three domain analysis of Manpower, Personnel and Training to shape the maintenance support structure. Actual HSI investment and return on that investment were conducted by the program manager and his staff. The aircraft recently achieved Initial Operational Capability and is an example of how long it takes to actually see the results of HSI efforts that were begun around 1993. (Drawbaugh, 2007, p. 5)

The second example is a manpower example that shows a monetary savings of the life cycle cost:

> An effective manpower analysis resulted in a decision to automate several tasks that previously required a flight engineer. The result was to reduce the crew complement by one. The overall

> manpower savings for the AF was 2,916 with additional savings in training for these personnel. Life cycle cost savings estimated in excess of $3 billion. (SAB Report October 2004). (Drawbaugh, 2007, p. 5)

The final example shows how Work Breakdown Structure (WBS) can make a monetary difference:

> The Program Manager elevated Crew Station and HSI-related elements to the Work Breakdown Structure Level III for the first time ever. These actions resulted in:
>
> - Maintenance Air Force Specialty Code structure studies using a maintenance simulator with a projected savings of $335 million.
> - Proposed Air Combat Command maintenance organization restructure with a potential savings of $442 million.
>
> The fighter jet was placed in service in 2005. This was the first opportunity to validate extensive HSI work that was done from 1992-1996. Life cycle cost savings in maintenance manpower and support costs may go on to exceed $4 billion. (Drawbaugh, 2007, p. 7)

How are life cycle cost savings estimated or calculated? Figure 10 depicts LCC distribution (from Figure 8, above) to identify LCC savings opportunities. HSI Team members and subject matter experts (SMEs) should consider predecessor problems, successes, models, and data to support calculations and predictions. Certainly, HSI design goals and measurable specifications and requirements can be developed and placed into the HSI Plan and moved into critical documents such as the Initial Capabilities Document (ICD), Capability Development Document (CDD), Capability Production Document (CPD) and Request for Proposals (RFP). The result should be a validated LCC savings estimate or calculation.

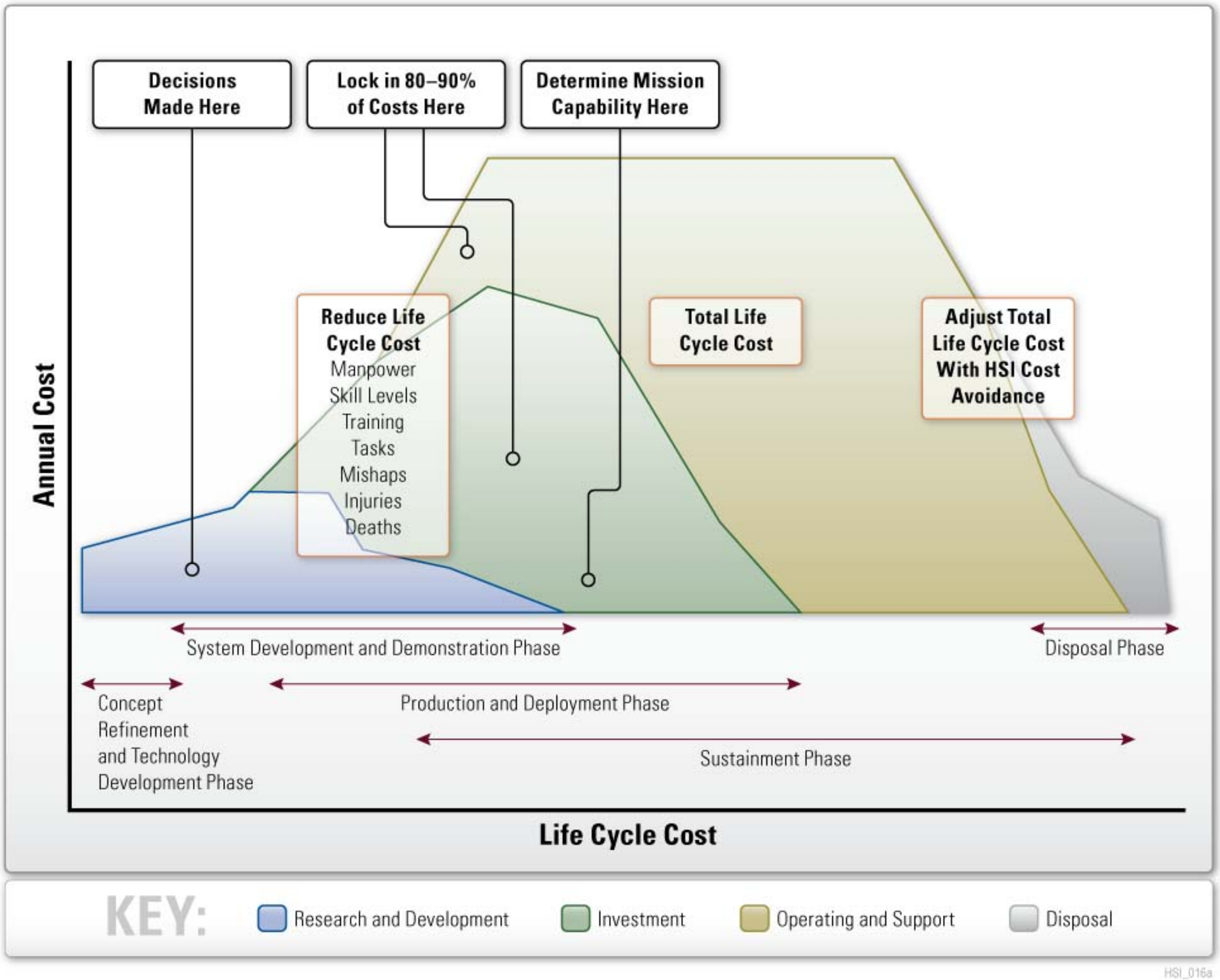

Figure 10: Life Cycle Cost Savings

The best way to use the domains of manpower, personnel, training, human factors engineering, survivability, habitability, environment, safety and occupational health is in an integrated fashion. The DoD has recognized this and its directives point to quality execution of HSI. Current initiatives, studies, opportunities and payoffs indicate the need for HSI as an integrated approach to stemming the tide of wasted resources.

Positive ROI for HSI is well-documented (Nielson 1993, Bias and Mayhew, 1994), IMPACTs (1982-1996), MANPRINT (1984-2005), NAVSEA(2003-2005), NASA(2000-2005), FAA(1999-2005). Table 3 provides a checklist for HSI practitioners at all levels to develop ROI within the acquisition process. Notice that in the left column there are action items for HSI practicitioners, while the right hand column is the checklist that assists in accomplishing the action item.

Table 3: Considerations for Developing & Calculating ROI for HSI

Considerations for Developing & Calculating ROI for HSI	
Help PM and Systems Engineering Team	• Develop HSI Plan • Conduct tradeoffs within and between HSI domains • Identify potential tangible and intangible HSI savings • Help develop acquisition program baseline (APB), manpower estimate report (MER), initial life cycle cost estimate (LCCE.) • Help refine LCCEs and MERs and cost benefit analysis (CBA) • Task Domain Leads capture and report investment & savings (time, cost, performance – tangible and intangible)
Use AFHSI Process (handbook, Cap Guide, Process Checklist, HPT, IPT, Systems Engineering)	• Recommend / Tool Use and Analyses • Develop HSI reqmts. (ICD, CDD, CPD) • Fight to keep HSI in requirements documents • Identify potential HSI KPP/KSAs • Help develop RFP
Help Produce SOW, RFP, SOOs, TEMP	• Get HSI critical issues written at WBS III • Assess contractors HSI plan and requirements • Capture Contractor proposal for HSI Investment
Capture data to document ROI from HSI investment	• Use contractor HSI tradeoff data • Evaluate revised LCCs for HSI savings • Get SME estimates of intangibles • Use data produced to support LCMP & HSIP • Capture investment & savings totals from team members
Estimate LCC savings / avoidance due to HSI	• Estimate MISHAP reduction savings from HSI • Calculate actual Personnel Cost Savings • Estimate Footprint (RAM & ILS) savings • HFE contributions – Saved fixes & test time (hardware & software) • Test enhancements and savings • Operational capability enhancements • ESOH savings ▪ Survivability / habitability savings & intangibles
ROI calculations – Inputs (time, cost, performance – tangible & intangible)	• LCCE tradeoffs - (per LCMP - using CBA/EA tools) • LCC avoidance from HSI (tangible & intangible) • Other savings (block changes, software OFPs, RDT&E) • HSI investment cost (budget should be 2-4% of RD&TE costs) • Do the Math (below)
(Actual Savings + LCC Avoidance + Intangibles) ÷ HSI Costs = ROI	

To reach a cost vs.benefit estimate for HSI, three areas should be considered: 1) program cost, 2) schedule, and 3) system total performance. There are two ways to estimate the cost of an HSI intervention:

- Draw analogies to similar situations, case studies, and personal experience
- Apply expert judgment to identify likelihood and impact of risks

It is important to consider that different stakeholders may receive different estimates of benefit. Three categories exist within these benefits:

- Monetary (e.g., costs to provide training)
- Actions converted to monetary worth
  (e.g., time to train warfighters, labor amounts for students/instructors)
- Quantifiable but stakeholders not interested in money
  (e.g., warfighter morale, accident rates)

Many different non-monetary factors also need to be considered. These may include safety, user attitudes, reliability, maintainability, usability, situational awareness, integrated systems and reduced complexity. Two other references that may be helpful in researching HSI costs and benefits are: www.usability.gov and www.eurocontrol.int

3.3 HSI in Trade-Off Studies

Instituting HSI requirements in weapon system development and acquisition programs should lead to the inclusion of HSI domains and considerations in trade-off studies. HSI issues that have been sacrificed or ignored during system design, for example, can be addressed through other domains later in the life cycle.

> Analysis performed by the SAB HSI Study (2004), one key issue to recognize is that “trade-offs” of usability requirements can be made during the systems engineering process. For example, poor attention to good HFE, perhaps motivated by acquisition budget/schedule constraints, can lead to systems with poor usability. Higher levels of manpower would then be needed to achieve operational effectiveness (thereby increasing downstream Operations and Maintenance costs) and thus compensate for the “trade-off” of good HFE (p. 5).

Starting early in the acquisition process, continuous cost, schedule, and performance trade-off analyses can help to achieve cost and schedule reductions. The Defense Acquisition Guidebook (2005) encourages Program Managers to treat the difference between attribute objective and related threshhold as “trade space”:

> Cost, schedule, and performance may be traded within the “trade space” between the objective and the threshold without obtaining Milestone Decision Authority approval. Trade-offs outside the trade space (i.e. decisions that result in acquisition program parameter changes) require approval of both the Milestone Decision Authority and the capability needs approval authority. Validated key performance parameters may not be traded-off without approval by the validation authority. (section 2.1.2)

Trade-offs are not unique to HSI, but trading human issues against equipment issues can be tricky. HSI practitioners should consider general guidelines as follows:

GENERAL GUIDELINES: Trade-Off Studies

- ✓ Do not let the human aspects get overshadowed by technology needs
- ✓ Be explicit regarding the consequences -- monetary and life cycle -- of planned trade-offs so that good decisions can be made
- ✓ Work with the user on all trade-off decisions

4. HSI Planning and Execution

HSI should be a clearly identified section within the System Engineering Plan (SEP) or as a stand-alone document in an HSI Plan (HSIP).

In order to manage HSI throughout the life cycle of a program, a comprehensive HSIP or HSI portion of the SEP should include strategies to address issues related to the development of HSI specifications.

> DoDD 5000.1(2003) states the following: Considerations for developing the HSI portion of the System Engineering Plan (SEP) must include 'Total Systems Approach'. The program manager shall be the single point of accountability for accomplishing program objectives for total life cycle systems management including sustainment. The PM shall apply human systems integration to optimize total system performance (hardware, software, and human), operational effectiveness, and suitability, survivability, safety, and affordability. PMs shall consider supportability, life cycle costs , performance, and schedule comparable in making program decisions. Planning for Operation and Support and the estimation of total ownership costs shall begin as early as possible. Supportability, a key component of performance, shall be considered throughout the system life cycle (E1.29).

The backbone of the Air Force HSI Program is the SEP and the HSIP within it. The HSI portion of the SEP satisfies DoDI 5000.2 requirements for a HSI program. The HSIP is written by the HSI Team to address issues resulting from HSI assessments of predecessor systems and/or previous system spirals and increments.

> Based on information from the United Kingdom Ministry of Defense (UK MoDAF) Human Factors Integration (HFI) Guide (2001): There should be an [HSI] section in the project management plan for each phase, typically supported by reference out to a more detailed [HSI] plan. Effective [HSI] relies on good communication across technical areas and organizations, with regular access to user representatives (subject matter experts and hands-on users). (p. 29)

This information gives the insight of where HSI should be added and what the effectiveness results are. This information also upholds the similarities between our DoD 5000 series and guides from other nation's Air Force programs. The HSIP exists to develop sound, human-centered requirements from the functional analyses performed during pre-Milestone A activities (see Figure 11).

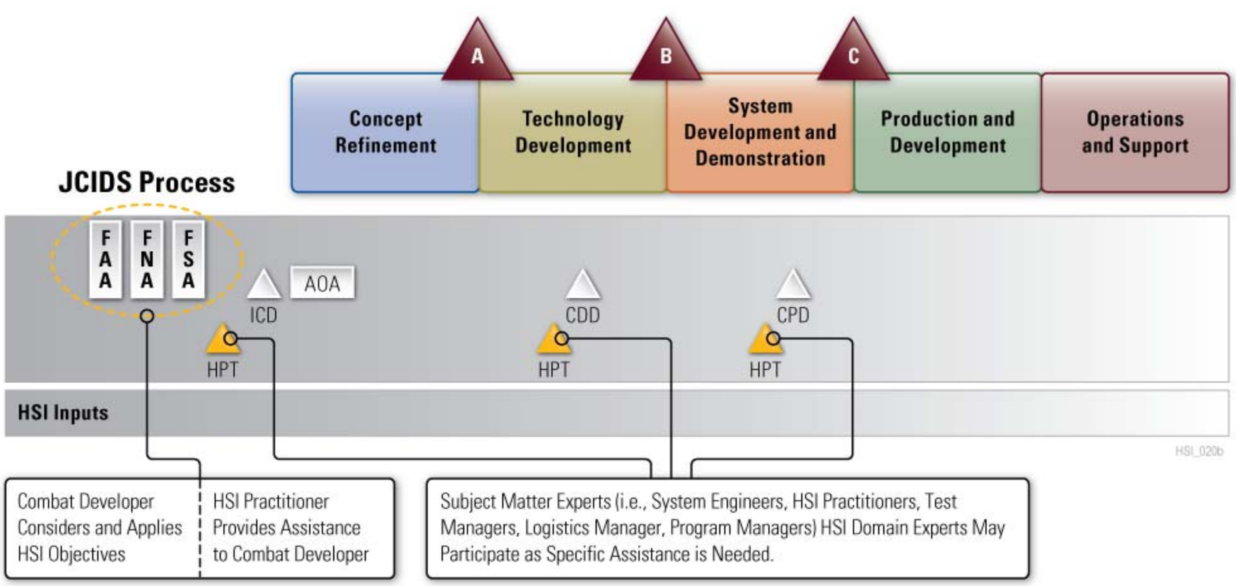

Figure 11: HSI integration within the Acquisition Process

4.1 HUMAN SYSTEM INTEGRATION PLAN OVERVIEW

All of the services have found that HSI needs to be an integrated part of the systems engineering process in the programs where it is implemented. The HSIP is best submitted as an evolutionary and continuous product in conjunction with the SEP and as a part of the LCMP and/or capability document. A HSIP can be integrated into existing documentation or developed as a stand-alone document. The HSIP is the management tool used to plan, manage, and implement HSI in the program. Because each system is unique, individual programs will naturally emphasize some domain areas more than others. HSIP content will depend upon the type and category of the weapon system.

DoDI 5000.2 instructs, "The HSI plan should be implemented early in the acquisition process to optimize total system performance, minimize total ownership costs, and ensure that the system is built to accommodate user characteristics, who will operate, maintain, and support the system" (section E7). This essential plan is used to identify HSI issues and recommend resolutions for obtaining the desired capability as identified by the requirements and specifications documented in ICDs, CDDs, and CPDs. If a full-blown HSIP is not warranted, a systematic approach should be developed and documented to plan and execute HSI activities within the SEP. For example, an aircraft engine upgrade will directly impact operator training and may even require a new skill level for qualified maintenance personnel. Depending upon the new capability associated with the upgrade, it may not require changes in manpower or the physical conditions of the work environment. The SEP should be updated in keeping with these considerations (see Appendix I, HSI Plan).

The results of functional analyses help to determine specific weapon system requirements and constraints. Ensuing risk analyses, issue identifications, and mitigation strategies contribute to the the HSIP crossflow consideration process into other important sections of the capabilities documents (see Figure 12). Final materiel recommendations, system requirements and integration needs, system attributes and affordability analysis should all be based in part upon HSIP findings.

The HSIP should also be tailored to the scope and size of the weapon system program. The plan should support HSI throughout the life cycle of the system, taking into consideration program needs from concept to disposal. The HSIP should be updated and refined annually with the SEP to account for evolving risks and improvement initiatives. If it is not possible to update yearly, it should at least be refined prior to each Milestone Decision. If possible a full HSIP should be included as an annex in the SEP, but as previously mentioned it can be developed as a section within the SEP instead of as a stand-alone plan. It is fundamentally important to the HSI practicitioners to develop an HSI Plan or an HSI strategy for the succes of the system. However, one of these HSI choices would be more useful as integrated pieces of the SEP.

The HSIP should support each phase of the life cycle (concept refinement, technology development, system development and demonstration, production and deployment, and operations and support; see HSI Plan Supports the Life Cycle Phases, Figure 12). Figure 12 illustrates each phase and related actions for HSI practitioners. This is not a comprehensive depiction, but is intended to summarize highlights for best practices.

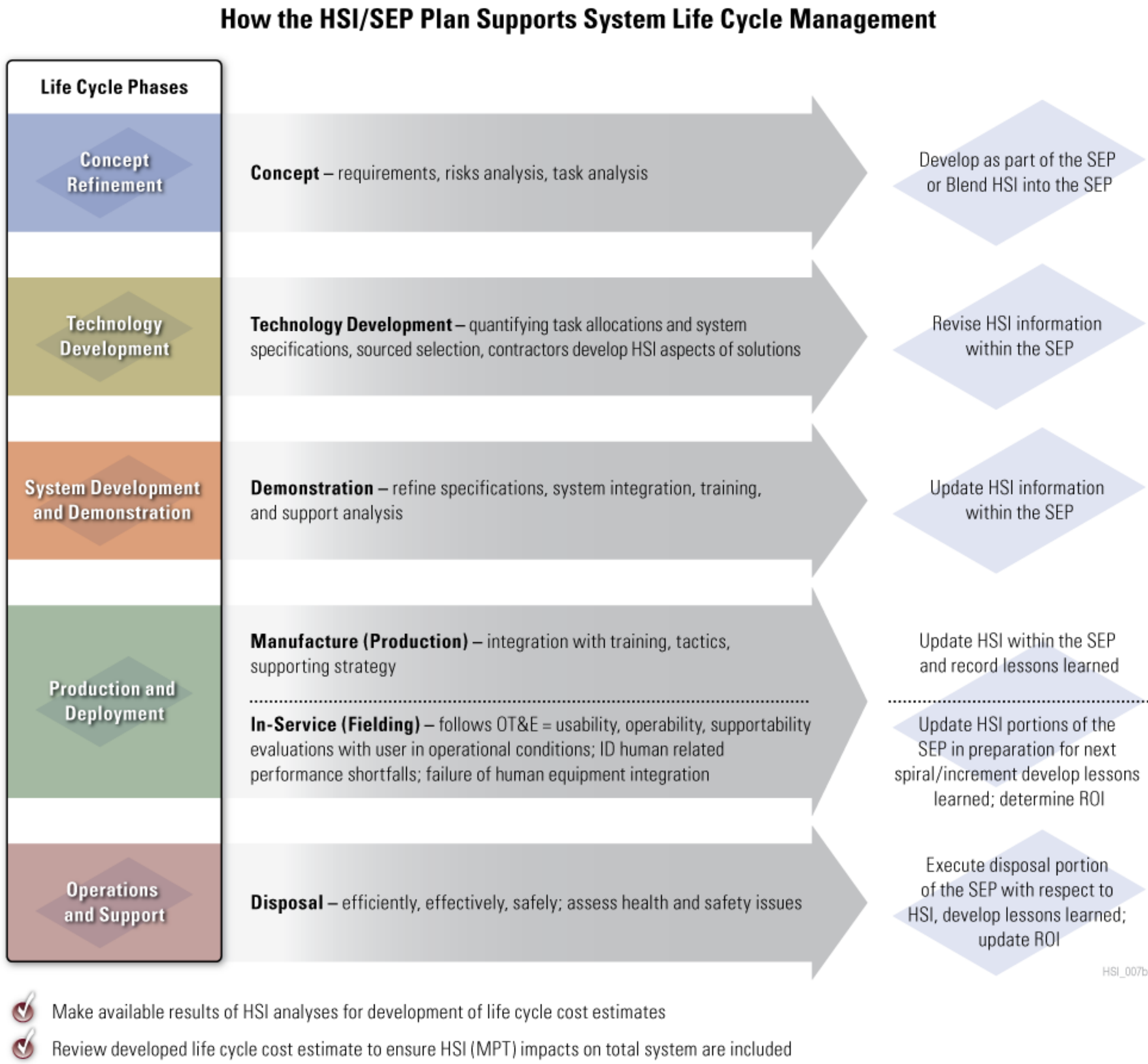

Figure 12: How the SEP/HSI Plan Supports System Lifecycle

GENERAL GUIDELINES: HSIP

- ✓ **Concept Refinement Phase** – Develop the HSIP based upon the results of functional analyses and derived human-centered requirements.
- ✓ **Technology Development Phase** – Revise HSIP to reflect results of human, hardware, and software task allocation determination, system specifications, and source selection strategies and results.
- ✓ **System Development and Demonstration Phase** – Identify potential human-related shortfalls and failures in human-machine integration. Develop and execute mitigation strategies. Update HSI Plan to include latest system specifications, integration strategy, analyses of training and support requirements.
- ✓ **Production and Deployment Phase** – Update HSIP to address issues related to system integration with training, tactics, and support strategies. After OT&E, incorporate results of evaluations regarding usability, operability, and supportability of the system. Ensure testing is accomplished by operational users in operating conditions. Identify human-related shortfalls and failures in human-machine integration. After the Plan is updated, document lessons learned to prepare for the next spiral, increment, or next-generation system. This phase also provides an opportunity to calculate potential return on investment (ROI) of HSI iniatives.
- ✓ **Operations and Support Phase** – This phase realizes the execution of plans derived during the development and acquisition of the system (e.g. training plan, disposal plan, manpower, personnel, survivability, etc.). This is another opportunity to collect data (e.g. habitability, usability, training, environment, safety, occupational health issues, etc.), calulate ROI, and document lessons learned.

4.2 HUMAN SYSTEMS INTEGRATION PLAN TEAM

A systematic approach to developing the HSIP and executing HSI activities is imperative to ensure its implementation. The HSI Team, which resides in the program office, is responsible for writing the HSIP. Any assistance that the HSI team may need while writing the HSIP, it can be acquired from either the 711th HPW/HPO or AFHSIO (Appendix VI). While no individual may possess expertise in all HSI domains, it is essential that the team responsible for developing the HSIP have at least a working knowledge of each domain area. This is especially important as programs begin to consider tradeoffs in the acquisition process. The HSI Team is needed to ensure the most effective, efficient, and affordable design possible through tradeoff studies within and between the HSI domains and system platform (see HSI Team Responsibilities, Appendix II).

The HSI team should be comprised of SMEs in HSI-related and acquisition disciplines as determined by system-specific and/or situation-specific needs In the formation of Integrated Product (IPTs) HSI should be an important consideration. Additionally domain experts should participate in the IPT. The Chief Engineer and HSI lead need to be assigned and identified as an integral part of the IPT, this ensures HSI is considered during system development. When a program does not have the resources, the Program manager should access outside assistance for these efforts.

The HSI Team is needed to identify, resolve, and track HSI issues. These efforts should be documented in the HSIP as the acquisition program progresses. Some HSI Team responsibilities include:

- Identify high-cost drivers that increase LCC and/or decrease system performance
- Identify HSI constraints and requirements for capability documents
- Develop mitigation strategies
- Serve on source selection teams and most IPT's

- Draft RFPs with HSI considerations
- Review relevant system documents
- Identify and suggest insertion of Manpower KPPs
- Identify/suggest measurable, human-centered KPPs, KSAs, and other metrics
- Develop/Review/Update HSIP for Milestone Decision Reviews (MDRs)

4.3 The Recommended Approach to an HSI Plan

As previously mentioned, if a full-blown HSIP is not warranted, a systematic approach should still be developed and documented to plan and execute HSI activities. The development of an HSIP is discussed, along with an HSIc Process Checklist Tool should be used in conjunction with each other in order to effectively implement HSI into a system. The important thing to remember about the HSIP is that it is written at the program level and it can also be a part of the Systems Engineering Plan (SEP). While this document can also be a stand-alone, it can be integrated with increased ability if it is inclueded in the SEP.

The main initial focus should be to determine whether a full or abbreviated HSIP is needed. For example, if a program involves significant changes in manpower, AFSC structure, training, or new human-centered technology, then a full HSIP should be initiated if possible. However, if the program is similar to a predecessor system in all of the aforementioned respects, then an abbreviated HSI section within the SEP may be sufficient. For most systems, a full HSIP is effective either to fully utilize the new components of an updated system or excentuate the strengths of the new system. By incorporating an HSIP, the system will have the opportunity to run smoother, more efficiently, and will essentially decrease the overall cost of the system over time. The HSIP should start from the top by including HSI in each of the domains. The HSI team can give intuitive insight into this by lending their expertise of the weak HSI areas for each domain.

The HSI Process Checklist assists the HSI Team lead in his or her effort to assemble a program's HSI effort. As soon as the HSI Team lead assumes responsibility for a weapon system development and acquisition program, the checklist should be initiated and documented in the HSI planning.
The checklist will lead the HSI Team through identifying baselines for, and integration of, HSI domains. Each activity is considered to be accomplished when all action items (boxes in column 1 and questions in column 2) are satisfied.

Table 4: HSI Process Checklist

HSI PROCESS CHECKLIST		
☐	**Determine scope of planning effort and appoint HSI Lead**	In order to perform this activity: • Use the HSI Database, review functional analyses, coordinate with user [and Air Force Research Labs(AFRL) if advanced concept technology demonstrations (ACTD) involved] and analyze preceeding programs to support determination of projected HSI effort.

HSI PROCESS CHECKLIST		
☐	**Initiate HSI Planning Activities** (*HSI Lead executes the remainder of this checklist*) ☐ Coordinate with PM ☐ Coordinate with the 711 HPW/HPO ☐ Develop a meeting schedule ☐ Develop planning assumptions	In order to perform this activity: • Have you established goals for the first meeting? • Have you coordinated for external support that may be required? • Have you reviewed the AFHSI handbook
☐	**Form HSI Team** ☐ Determine weapon system requirements, HSI constraints, and HSI requirements ☐ Assign HSI domain analysis leads ☐ Coordinate follow-on meetings ☐ Initiate meeting notification	In order to perform this activity: • Review program supporting documentation: functional analyses, Analysis of Alternatives (AoA), draft ICD if available • Is there a predecessor system with representative components to use as a baseline? • Have you established realistic goals to be met prior to the next meeting?
☐	**Draft HSI Plan**	In order to perform this activity: • Review AFHSI handbook
☐	**Define Manpower Baseline** ☐ Coordinate lead and support responsibilities ☐ Develop predecessor AFSC list ☐ Identify Manpower high drivers, constraints, requirements, and risks ☐ Develop Manpower baseline	In order to perform this activity: • Have you included consideration of: operators, maintainers, sustainers and trainers and contractor support personnel for the life of the system? • Has a Manpower Estimate Report (MER) been accomplished? ☐ Document and crossflow issues to the HSIP.

HSI PROCESS CHECKLIST		
	Define Training Baseline ☐ Coordinate lead and support responsibilities Operator / Maintainer ☐ Training and user task analysis ☐ SME identification and analysis ☐ Identify training high drivers, constraints, requirements, and risks ☐ Consolidate and develop training constraints by AFSC ☐ Document and crossflow issues to the HSIP	In order to perform this activity: • Have you identified all affected Air Force Specialty Codes (AFSCs)? • Have you identified the source of positions? • Are other MAJCOMs with affected AFSCs represented? • Are occupational surveys available for listed AFSCs? • Are there operator maintenance and software specifics available? ☐ Document and crossflow issues to the HSIP.
	Define Human Factors Baseline ☐ Coordinate lead and support responsibilities ☐ Identify system design high drivers, constraints, requirements, and risks ☐ Identify man-machine interfaces and make inputs into the system design to attain specifications	In order to perform this activity: • Obtain results of functional analysis. • Understand task allocations between hardware, software, and human. • Have you included a human factors engineering representative on the HSI Team? • Have you coordinated your analysis with the systems engineer? ☐ Document and crossflow issues to the HSIP.
	Define Personnel Baseline ☐ Coordinate lead and support responsibilities ☐ AFSC analyst ☐ Identify personnel high drivers, constraints, requirements, and risks	In order to perform this activity: • Have you identified all affected AFSCs? • Have you identified the source of positions? • Have you included a personnel representative on the HSI Team? • Have you coordinated your analysis with AFPC? ☐ Document and crossflow issues to the HSIP.

HSI PROCESS CHECKLIST		
	Define Environment, Safety and Occupational Health (ESOH) Baseline ☐ Coordinate lead and support responsibilities ☐ ESOH data collection ☐ SME identification and analysis ☐ Identify ESOH high drivers, constraints, requirements, and risks	In order to perform this activity: • Is there a predecessor system with representative components to use as a baseline? • Have you requested safety lessons learned from the Air Force Safety Center • Have enviroment, safety and occupational health representatives been included in the IPT? • Has safety issues for each system scenario been identified? Mitigate with program office after this data has been collected. ☐ Document and crossflow issues to the HSIP.
	Define Survivability Baseline ☐ Coordinate lead and support responsibilities ☐ Survivability data collection ☐ SME identification and analysis ☐ Identify survivability high drivers, constraints, requirements, and risks	In order to perform this activity: • Is there a predecessor system with representative components to use as a baseline? • Have survivability representatives been included in the IPT? • Identify worst case scenarios and provide reinforcement training. ☐ Document and crossflow issues to the HSIP.
	Define Habitability Baseline ☐ Coordinate lead and support responsibilities ☐ Habitability data collection ☐ SME identification and analysis ☐ Identify habitability high drivers, constraints, requirements, and risks	In order to perform this activity: • Is there a predecessor system with representative components to use as a baseline? • Have habitability representatives been included in the IPT? • Idenfity length of mission determination issues (i.e. movement, food, and sleep arrangements Document and crossflow issues to the HSIP.

HSI PROCESS CHECKLIST		
☐	**Integration** ☐ Integrate total system performance characteristics ☐ Address HSI in relevant portions of formal plans, test, and evaluation documents ☐ Integrate constraints and requiremetns for logistics support, program resources and training plans ☐ Conduct inter-HSI domain trade-offs and identify interactions with other major system and subsystem issues ☐ Formulate plans to perform HSI assessments on hardware/software revisions that add/delete/defer capability not addressed in the capability documents.	In order to perform this activity: • Has the total system approach (hardware, software, human) been considered? • Have all prior analytical steps been completed? • Are all program relevant HSI domains represented? • Are Measures of Effectiveness associated with HSI domains? ☐ Document and crossflow issues to the HSIP.

Update HSI Plan

5. HSI in the Defense Acquisition Management Framework

The primary foci of AF HSI are to recognize and give weight to HSI considerations, identify human performance needs and constraints, and develop HSI requirements. Earlier in this document, we have addressed opportunities to recognize HSI needs/constraints during requirements development. In this section, opportunities to recognize and manage HSI while drafting capability documents, specifically the ICD and CDD, prior to Milestone B of the Defense Acquisition Management Framework (see Figure 13) will be considered.

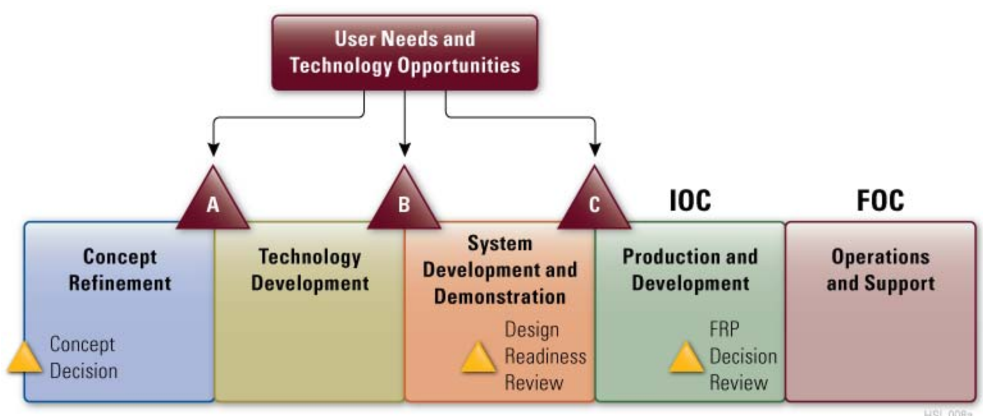

Figure 13: Defense Acquisition Management Framework

The Human Factors Integration Guide (UK Ministry of Defence, 2001), says: "[HSI] must begin in Concept phase, with some analysis of human issues related to the acquisition of the proposed capability, and assessment of the associated risks and requirements of possible options. The technique to help do this is known as Early Human Factors Analysis (EHFA). The issues identified by EHFA drive detailed planning of [HSI] tasks for Assessment phase, as well as any in-Concept-phase activities. The [HSI] objective in concept is to ensure that the outputs submitted at initial gate take account of any human-related issues that could seriously affect the ability to meet the project's objectives."

This applies to all outputs, including:

- Requirements - User Requirements Document, possibly draft System Requirements Document and Statements of Work (SoW) to accompany invitations to tender for work during assessment.
- Plans - costed plan for Assessment, through Life Cycle Management Plan, Test and Evaluation Master Plan and contribution to specialist plans such as Safety and ILS.
- Support for the Business Case assessment, with impact of human costs and performance on the Concept of Assessment. (section 3.3, p. 20)

Many of the concepts that UK MoDAF uses are closely paralleled to information regarding HSI in the DoD 5000 series along with concepts in the MIL-HDBK's and MIL-STD's.

5.1 HSI Requirements Development

The Air Force Instruction 10-601 (2006) states "Human Systems Integration includes the integrated and comprehensive analysis, design and assessment of requirements, concepts and resources for system manpower, personnel, training, safety and occupational health, habitability, personnel survivability and human factors engineering" (pg. 54).

HSI domains currently exist as independent disciplines, and may be compartmentalized and practiced by separate agencies at various times. However, taken together these domains define human interaction with systems that impact operational effectiveness. For this reason, HSI endeavors to bring these domains together for analysis (see Figure 14) under a common knowledge base to identify and address interdependencies and tradeoffs that may be required.
HSI considerations can become requirements only if they are considered during pre-system functional analyses with their resulting performance parameters expressed in quantitative terms. HSI can also be inserted in the CPD, CDD, and other documents as well, upholding the idea that it is never too later to consider HSI. In other words, HSI requirements should be expressed as all other requirements are addressed in capability documents, embedded within the design, and with associated key performance parameters (KPP) and key system attributes (KSA). This allows HSI requirements to become measurable, which is necessary for effective implementation within the acquistion system lifecycle.

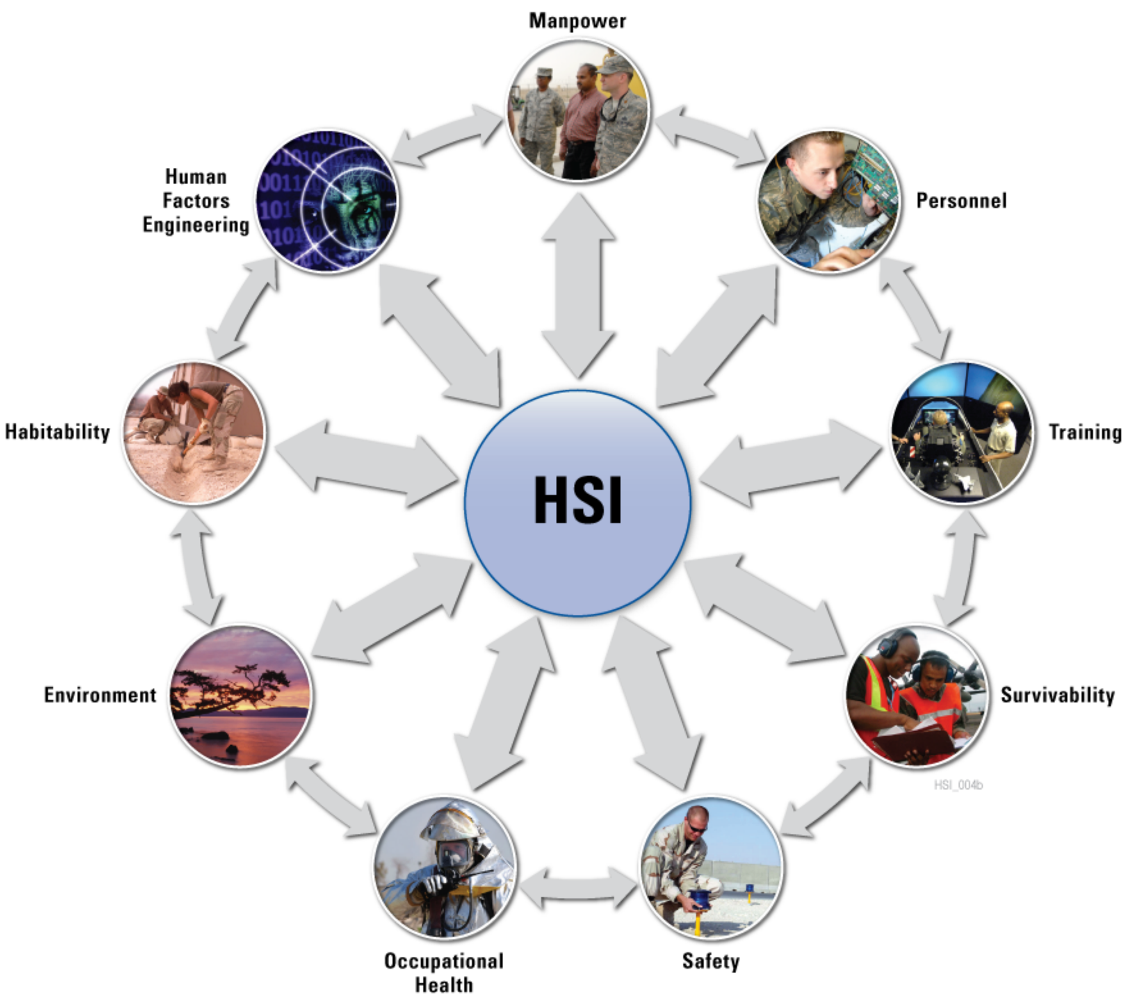

Figure 14: HSI Integrates the Domains

Requirements are derived from the operational user's identification of gaps in current capability. These gaps can be filled through changes in doctrine, manpower, training, materiel solutions and DOTMLPF. Regardless of how requirements are met, it is essential that the final solution address the user's need by the most effective, safe, and affordable means possible. HSI ensures safer, more cost-effective, and more operationally capable and viable weapon systems. Without effective HSI, systems fall victim to costly retrofits, unsafe operations, and inflated life-cycle costs.

> According to the Defense Acquisition Guide Book (2005), both DoD Directive 5000.1, *The Defense Acquisition System*, and DoD Instruction 5000.2, *Operation of the Defense Acquisition System*, make reference to Lifecycle cost and total ownership cost. This section of the Guidebook explains the meaning of each these terms. The terms are similar in concept, but significantly different in scope and intent. For a defense acquisition program, Lifecycle cost consists of research and development costs, investment costs, operating and support costs, and disposal costs over the entire Lifecycle. These costs include not only the direct costs of the acquisition program, but also include indirect costs that would be logically attributed to the program. The concept of total ownership cost is related, but broader in scope. Total ownership cost consists of the elements of Lifecycle cost, as well as other infrastructure or business process costs not necessarily attributable to the program. Subsequent sections more carefully define and describe these concepts. (section 3.1)

The *AFHSI Development Guide* presents capability based requirements for HSI in greater detail. Air Force Instruction (AFI) 10-601 (2006) states that, “Air Force Human Systems Integration (HSI) concerns are addressed in all capabilities-based development documents” (p.22). Capabilities-based requirements are developed during JCIDS, specifically the pre-Milestone A activities of the Defense Acquisition Management Framework. Many processes and analyses feed into requirements development.These include functional area, needs, and specifications analyses; HPT inputs; AF/XOR’s Requirements Strategy Reviews; and draft capabilities documents. Figure 15 depicts analyses feeding into the capabilities-based requirements for system development and where user needs can be inserted.

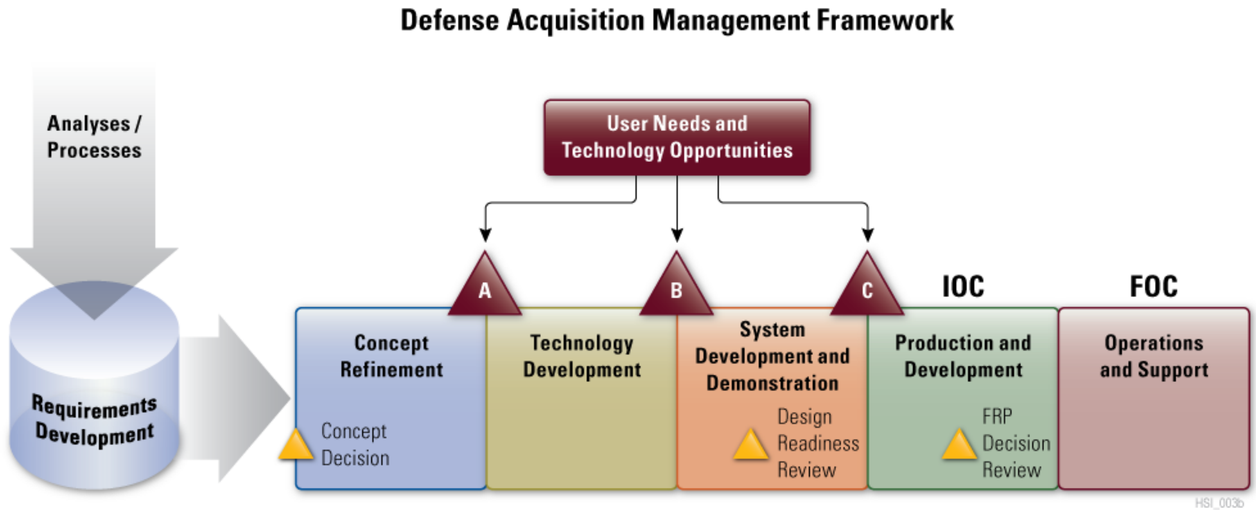

Figure 15: Analyses Feed Capabilities Based Requirements for System Development

Capabilities-based requirements drive HSI requirements. An accurate representation of human performance and requirements can potentially increase weapon system effectiveness, reduce life cycle costs, and optimize affordability. For example, manpower accounts for 40% - 60% of Operations and Maintenance LCCs. Additionally, the human operator may contribute to as much as 70% of potential variability in a system. Attention to HSI considerations must be focused on early, before final system designs are in place to prevent redesign. Special focus should be attributed to HSI during functional analysis and task allocation among the human, hardware, and software.

In summary, effective HSI can result in increased weapon system safety, reduced LCC, and optimized weapon system performance. HSI can directly contribute to mitigating program risks and staying within life cycle fiscal goals. As is true for all design consideration and program processes, HSI should be considered early in system design. Unfortunately, HSI is often viewed as optional and so is frequently the first design process eliminated when a program suffers budget cuts. Too often, such decisions are more costly in the long run. For numerous reasons including risk mitigation, it is clear that HSI is essential to successful programs.

5.2 Capability Documents

HSI parameters and requirements in the ICD, CDD, and CPD are based upon and consistent with the user representative’s strategic goals and strategies and are addressed throughout the capabilities, requirements, and acquisition processes during the entire life-cycle of the system. The ICD contains the key boundary conditions of an evolving capability – these conditions include all of the HSI domains. Key boundries are critical conditions that impact mission capabilities and total LCC. The CDD details the key specifications, including human-centered specifications, to which the system must be developed.

> The Defense Acquisition Guidebook (2005) addresses the HSI domains of the system engineering process:
> **HSI in the Capabilities Documents:** The Initial Capabilities Document should describe the key boundary conditions and operational environments that impact how the system is employed to satisfy the mission need. Key boundary conditions include critical manpower, personnel, training, safety, occupational health, human factors, habitability, and survivability factors that have a major impact on system performance and Lifecycle costs. The Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel and Facilities (DOTMLPF) considerations and implications section of the Initial Capabilities Document should discuss all relevant domains of HSI. HSI capabilities in the Capability Development Document should be specified in measurable, testable, performance-based language that is specific to the system and mission performance. (section 6.4.3, p. 253)

"DOTMLPF includes analysis of the entire life cycle, including the sustainment; environment, safety, and occupational health (ESOH); and all human systems integration (HSI) domains." (CJCSI 3170.01F, 2007, p. B-1)

Writing measurable and testable performance-based specifications for human aspects of the system is crucial to program success. Action officers should reference the AF HSI Capabilities Based Requirements Development Guide (2008) for instruction in writing, and examples of specific, measurable, human-related specifications.

It is important to try and identify or define measurable HSI requirements. Objective measurements are preferred for test and evaluation. However, if subjective information is required to resolve measures during test and evaluation then the test organizations will utilize appropriate tools and techniques to obtain the data required.

> According to the CJCSI 3170.01F (2007) Joint Capabilities Integration and Development System: The CDD and CPD state the operational and support-related performance attributes of a system that provide the desired capability required by the warfighter, attributes so significant that they must be verified by testing and evaluation. Operational testing will assess the operational effectiveness and suitability of the system and its ability to meet the production threshold values. (p. A-8)

5.2.1 The Concept Refinement Phase (pre-milestone A)

The draft CDD is completed during the Concept Refinement Phase of the Defense Acquisition Management Framework. It is in this document that KPP thresholds and objectives are identified (typically each system has eight or fewer KPPs). KPPs capture the minimum operational effectiveness and suitability attributes needed to achieve overall desired capability. Concept Refinement Phase decisions also include risk assessment of new concepts and technology, commercial-off-the-shelf (COTS) functionality, and trade-off opportunities. Requirements in the CDD provide the foundation for the RFPs and testing plans. The HSI Action Officer or HSI Team lead must attend CDD meetings so that HSI is considered in these decisions. Additionally, the HSI Manpower SME should ensure that manpower will not increase as a result of decisions regarding technology development strategy; or, if manpower must increase, the HSI Team should ensure the HSIP addresses the issue.

GENERAL GUIDELINES: Concept Refinement Phase

- ✓ Attend CDD meetings so that HSI is considered in the Concept Refinement Phase decisions
- ✓ Domain SMEs - ensure that decisions regarding technology development strategy are addressed. Ensure the HSI Team addresses the issues for each individual domain in the HSIP

5.2.2 Requests for Proposal (RFP)

The RFP is a prime opportunity to ensure HSI considerations become mainstays of the system development and acquisition program. For instance, the HSI Team could use the RFP as a means to require in the SOW for offerers to substantiate HSI claims as part of their proposal.. Proven claims can then be established as system specifications for the program, much of this information can come from the CDD. The HSI Team might also require that a contractor develop an HSIP which should include plans for test and evaluation, and usability. In any event, these items should become major criteria for source selection and be assessed during program reviews.

GENERAL GUIDELINES: RFP

- ✓ Require in SOW/SPEC for offerers to substantiate HSI claims as part of their proposal
- ✓ Require contractor to develop an HSIP, including plans for test and evaluation, and usability

5.2.3 The Technology Development Phase (pre-milestone B)

During the Technology Development Phase , efforts should be made to reduce any risks associated with technology development and to determine the technology to be integrated.

The TEMP should address usability issues to ensure that the system is tested and evaluated using typical users in relevant environments. The ME can provide sufficient justification to establish a manpower KPP as well as data for developing life cycle budgets. Additionally, Cost Benefit Analysis and Determination tasks provide input for calculating ROI in product quality, manpower, training, supportability, etc.

GENERAL GUIDELINES: Technology Development Phase

- ✓ Insert human-centered KPP and/or measurable, specific human-centered KSAs

The CJCSI 3170.01F (2007) document states: The process to identify capability gaps and potential materiel and non-materiel solutions must be supported by a robust analytical process that objectively considers a range of operating, maintenance, sustainment, and acquisition approaches and incorporates innovative practices -- including best commercial practices, HSI, systems engineering

> (including safety and software engineering), collaborative environments, modeling and simulation, and electronic business solutions.
> (p. B-2)

At the point of the CDD, it is very important to establish a HSI KPP or, at the very least, to specify measurable, specific human-centered KSAs. At this milestone, the HPT moves to an IPT. The TEMP and ME, which are key areas of interest for HSI, should be completed.

> In section 6.5.2. of the Defense Acquisition Guidebook, Manpower Estimates shall address manpower affordability in terms of military end strength (including force structure and student end strength) and civilian work years beginning at Milestone B. Consistent with DoD Directive 5000.1, DoD Components shall plan programs based on realistic projections of the dollars and manpower likely to be available in future years. When major manpower increases are required to support the program, or major manpower shortfalls exist, they shall be identified as risks in the Manpower Estimate, and addressed in the risk assessment section of the Acquisition Strategy. Program risks that result from manpower shortfalls should be addressed in terms of their impact on readiness, operational availability, or reduced combat capability (p. 257).

5.2.4 System Development and Demonstration Phase (pre-milestone C)

The CPD is developed during the System Development and Demonstration Phase. HSI practitioners need to ensure identified risks and mitigation strategies are reflected in the CPD. During this phase, Initial and Operational Test and Evaluation occur to identify system deficiencies and capabilities. The contractor is only responsible for resolving system performance issues up to the level of performance mandated by the contract. Performance issues not identified in the contract can require costly rework, redesign, or other fixes at the expense of the program. (Such reworks are often human-related, the result of poor HSI planning or none at all.) The Operations and Support segment of the System Development and Demonstration Phase provides an opportunity to capture lessons learned and prepare for HSI-related modifications and improvements.

<u>GENERAL GUIDELINES: System Development and Demonstration Phase</u>

- ✓ Ensure identified risks and mitigation strategies are in CPD
- ✓ Capture lessons learned and prepare for next spiral, increment, or modification

5.2.4.1 Incremental Acquisition

Incremental Acquisition is the development strategy implemented when a desired capability is identified, but end-state requirements are not known at program initiation. These requirements are refined through demonstration and risk management. There is continuous user feedback with each increment to provide the user with the best possible capability. Requirements for future increments depend on feedback from users and technology maturation. (DoDI 5000.2, 2003, section 3.3.2.1)

Incremental acquisition does not negate the need for an HSIP. In fact, incremental development requires just as much planning for risk mitigation as any other acquisition program does. The Program Manager along with the HSI Team should evaluate the first technical phase demonstration for HSI considerations as early as possible. Risks should be evaluated in terms of manpower to operate, maintain, and repair; tasks too difficult to perform; and embedded training, safety, health, and survivability risks. Continue this practice with each consecutive spiral, implementing mitigation strategies as necessary.

GENERAL GUIDELINES: Incremental Acquisition

- ✓ Evaluate the first technical incremental demonstration for HSI considerations as early as possible
- ✓ Continue this practice with each consecutive increment and implement mitigation strategies as necessary
- ✓ Each consecutive increment and implement mitigation strategies as necessary

5.3 Methods for Facilitating Requirements Development

One of the first steps in systems acquisition is the validation of a legitimate capability gap. Through Functional Area Analyses (FAA), Functional Need Analyses (FNA), and Functional Solution Analyses (FSA), users identify a requirement or set of requirements. If it becomes apparent that a materiel solution is necessary to satisfy the requirement, the next vital step is to define the specifications that the system must meet. Here the HSI practitioner must be knowledgeable about the intended users of the system, its intended operational environment, results of the functional analyses, decided task allocation of the system (human, software, hardware), and the make-up of the program management team.

5.3.1 Existing Means of Influencing Requirements Development

To ensure that HSI requirements are appropriately and sufficiently considered for system design, development, and fielding, the HSI Team must participate in drafting or shaping capability documents. The 711 HPW/HPO can provide additional assistance if needed. Manuals and documentation that exists within the acquisition lifecycle are good sources for HSI requirements development. The AFHSI Capabilities Based Requirements Development Guide considers how numerous other resources can be used. For example:

- Functional Area Analysis (FAA) includes the role operators, maintainers, and support personnel play in the operational tasks identified, and what human performance standards are needed to achieve the military objective.
- Functional Needs Analysis (FNA) produces a list of the personnel inventory gaps or shortcomings that require solutions.
- Functional Solution Analysis (FSA) includes analyses of all HSI domains that may solve and/or mitigate the capability gaps and the HSI implications of designing, developing, fielding and sustainment.
- Analysis of Alternatives (AoA) compares and evaluates materiel options and includes the contribution and/or limitation that HSI issues have on meeting the identified capability gap. It considers HSI impacts on cost, schedule, and performance pertaining to each of the alternatives, opportunites for trade-offs between performance, costs, and schedules.
- Human-Centered KPP Development ensures measurable HSI requirements in capabilities documents to develop human-centered KPPs and KSAs.
- Manpower KPP Development is a series of questions to assist HSI practitioners in developing Manpower KPPs. The implementation of a Manpower KPP on every CDD encourages options that maximize technology use in reducing MPT requirements and total ownership costs.

- Using the RFP to Establish Specifications to support HSI claims with analytical measures using government-approved HSI tools. An offeror could answer with a demonstrated analysis using IMPRINT or MPT-DSS. The demonstration inherently produces a specification that can be used for the contract.

GENERAL GUIDELINES: Requirements

- ✓ Use HSI Process Checklist, and AFHSI handbooks to unify your team
- ✓ Develop human-centered KPPs, KSAs, and specifications
    - o Determine objectives and thresholds for all human-systems requirements
- ✓ Work closely with HPTs and IPTs to identify, establish and refine/update constraints and requirements in all the HSI domains that:
    - o Could impact system design and capability
    - o Will achieve effective human-system interfaces
- ✓ Draft and then update the HSI plan

5.3.2 HPT and IPT Participation

DoD acquisition policy stresses the importance of HSI as a key consideration for IPT formation. It is the policy of AFHSI that this extends to HPT participation as well. HSI requirements and human-centered performance metrics development during pre-Milestone A activities are undeniably important to successful weapons system program development. The HSI Action Officer and HSI Team lead are responsible to develop a plan and a dynamic to support these objectives. Credibility, visibility, and trust for HSI can be facilitated by frequent communication with system designers, engineers, testers, and developers, and by training the HSI Team properly to participate in HPT/IPT . According to the United Kingdom Ministry of Defence (2001), "It is important to remember that HSI cannot be conducted in isolation. It is dependent upon the other individuals who have a stake in the aspects of system capability, and therefore, have a stake in HSI" (p. 8).

Full integration of HSI within operational Integrated Product Team. The HSI team members must be fully aware of the required material solution capabilities and the organizational structure of their program, understand the schedule of events, and determine up front, how they will participate in the SE and ILS processes in order to ensure HSI requirements are met and the human is fully considered by addressing the following technical domains:

- Manpower (quantity and quality of personnel required)
- Personnel (requirements for recruiting, retaining, assigning, and supporting personnel throughout their career)
- Training (techniques for providing needed Knowledge, Skills and Abilities to the crew member)
- Human Factors Engineering (design of human-machine interfaces in accordance with the requirements, capabilities, and limitations of the human)
- Habitability (including concerns for quality of life)
- Personnel Survivability (requirements for protection and safeguards)
- Environmental, Safety, and Occupational Health (requirements to reduce hazards and in doing so, minimize the risk of injury or death to personnel and damage to the system

According to the United Kingdom Ministry of Defence (MoD) (2001), prior to an IPT, key processes for HSI should have been considered. These processes should consist of:

- Identifying the issues – the driving process
- Supporting analysis – necessary to underpin decisions and plans
- Coordination – essential to avoid duplication
- Contribution to project outputs – how is value added

The MoD's HFI Guide also states that the conclusions from these processes should be integrated into the IPT. These integrations in many cases have already been initiated, in some form, by the HSI working group. Therefore, the HFI Guide recommends, "The IPT must therefore build the relationship with the collaboration working group, and in particular the [lead], while at the same time progressively taking over and building up support tasks such as running the [HSI] working group, generating requirements database… during [c]oncept phase of a large project, the IPT might use industry support for exploratory studies. This can provide access to industry [HSI] expertise on a 'customer's friend' basis. In any case, potential equipment contractors should be engaged in dialogues with the IPT, providing an opportunity to build relationships with their respective [HSI] teams."

GENERAL GUIDELINES: HPT/IPT Participation

- ✓ Coordinate with appropriate points of contact for program management, systems engineering, training, fielding, program scheduling, testing, logistics, and documentation
- ✓ Determine individual functional responsibilities for HSI
- ✓ Explain AFHSI and its importance to the team
- ✓ Share schedules and check against program schedule to coordinate program component due dates and deconflict meetings
- ✓ Attend informal and formal meetings as feasible (i.e. HPT, IPT, process reviews, T&E IPTs, design reviews)
- ✓ Conduct AFHSI meetings with the HSI team and key stakeholders
    - Assess overall HSI status of the system
    - Manage the HSI Plan (see HSI Plan Template, Appendix II)
- ✓ Facilitate responsive risk and issue management
- ✓ Share information as often as is constructive with program managers and IPT POCs

5.4 TECHNOLOGY TRANSITION AND INSERTION

The current process for technology transition and insertion is inconsistent. The funds that are expended during the transition from old to new technology unfortnately has an impact of the overall system because it is considered to be wasteful. The sustainment of old technology until new technolgy is learned and accepted wastes time, capability and funding due to supporting multiple technologies when only one is necessary. The following paragraphs give some examples and identifications of the ways to get around capability losses.

Solve weak transition woes. The most consistent and rapid means of technology transition occurs when S&T program efforts are directly mapped to warfighter needs, such as for Advanced Concept Technology Demonstrations (ACTD) and Advanced Technology Demonstrations (ATD) when S&T initiatives are already sponsored by a user. Another avenue of transition is dependent upon contractors marketing and selling technology. The least consistent means of transition occurs when labs initiate research and development first, and then attempt to transition the technology to the warfighter. Transition may fail as the result of disagreement or miscommunication concerning its relevance to warfighter needs.

Assist with Requirements Writing. In the absence of ATDs, ACTDs and other transition vehicles, 711 HPW/HPO provides guidance, insights, and recommendations to the user regarding HSI-centered technologies. Users often need assistance to translate needs and operational gaps into technical requirements. Arming the user with up-to-date information on existing technology to solve capability gaps is fundamental to weapons procurement philosophy that is needed for this translation. With the assistance of AFRL and 711 HPW/HPO, the user can write HSI requirements and drive human-centered specifications (e.g., KPPs and KSAs) for the system that is being considered.

- **Key Performance Parameters**: Major drivers of operational performance
- **Key System Attributes:** Secondary drivers of operational performance
- **Measures of Effectiveness:** Quantify mission-essential tasks

The practice of HFE Assessments during development and acquisition will help to keep the researchers involved in the program beyond its S&T phases. This mirrors the Army's effort to keep the Army Research Lab (ARL) involved through MANPRINT Assessments, which provide the lab an opportunity to update information regarding technology solutions (MANPRINT Handbook, 2005, Ch.6) Weapon systems should be evolutionary in nature throughout the acquisition process.

Some HSI S&T initiatives (e.g., Decision Aids and Net-centric Operations) are components of many other efforts. These should be watched and shepherded to ensure that HSI-related decisions can be answered collaboratively and with attention to warfighter needs. Since AFRL and 711 HPW/HPO have combined, they can make significant decisions in this area, along with offering perspectives based upon requirements development work and knowledge gathered from HPT and IPT participation.

ATDs and ACTDs aim to accelerate the maturation and/or integration of advanced technologies for the user. Therefore, HSI issues raised in ATDs and ACTDs should be assessed in much the same way as in weapon system development and acquisition programs. The HSI S&T Assessment checklist (Appendix III) provides a general, top-level guide for assessing HSI in ACTDs and ATDs before entering the DoD acquisition process.

By assessing HSI issues before technology enters the acquisition process, there is greater opportunity to foresee and address possible future problems with usability, maintainability, supportability, and reliability. At this stage, adjustments can be made at less expense. It is important to assess these overall considerations:

- Identify what user needs the technology must support, as well as the proposed system(s) within which it will be integrated
- Assess if human performance capabilities are considered
- Determine if human performance capabilities are being evaluated in the demonstration, and if the criteria are suitable and adequate to evaluate HSI issues
- Identify potential end users of the technology and determine their expectations and proposed operational concepts
- Identify specific deficiencies, if any, from predecessor systems that need to be addressed
- Anticipate issues that may "spin off" from the demonstration that may need further review

GENERAL GUIDELINES: Technology Transition

- ✓ Obtain baseline of human performance with the equipment in its current context of use
- ✓ Predict performance degradation or enhancement due to the proposed changed context of use
- ✓ Identify the need for modifications, additional items, changes to other systems, procedural work arounds, modified training or additional skills needed to guarantee the required performance of the human component of the proposed equipment
- ✓ Identify feasibility of any required changes to the organization and manning needed to ensure adequate performance of the human component
- ✓ Estimate the integration costs

Once identified, these HSI concerns should be referred to domain-relevant SMEs who can help to develop resolution and mitigation strategies. The 711 HPW/HPO will assist assessors with locating suitable domain experts for collaboration on assessments. In addition, more detailed checklists also exist for each of the domains normally used to support acquisition programs. These checklists are available through the 711 HPW/HPO and may provide further help on specific issues within particular domains.

5.5 HSI Focus on Commercial-off-the-Shelf Products

Program managers are encouraged to use COTS products whenever possible to save time and money. There is a common misperception that the use of COTS eliminates the need for HSI. Rather, COTS content increases the need for HSI assessment and risk mitigation. The greater the proposed Off-the-Shelf content (COTS – Commercial Off The Shelf, or GOTS - Government Off The Shelf) – the more important it is for HSI to inform the equipment selection decision. Otherwise, cheap COTS equipment may incur the risk of high human-related costs and/or poor overall system performance.

> According to the Air Force SAB 2004 Study on Human Systems Integration in Air Force Weapon System Development and Acquisition (see Figure 16):
> Many if not most COTS products actually embody insufficient human-system interfaces. COTS products are not designed to reduce human workload and often do not meet human factors guidelines or standards. Thus, when used they may induce any number of human errors. Traditionally, COTS developers have not invested in good interface design because they had no requirement or incentive to do so. Furthermore, using a variety of COTS products together creates an additional problem: each COTS product may have a very different interface and new user errors can develop. Nonstandardization of interfaces is a well-known hazard for increasing the probability of human error in performing actions or interpreting information. The human interface of COTS products is not customized for the unique operational needs of the Air Force, including the critical nature of many tasks. (p. 24)

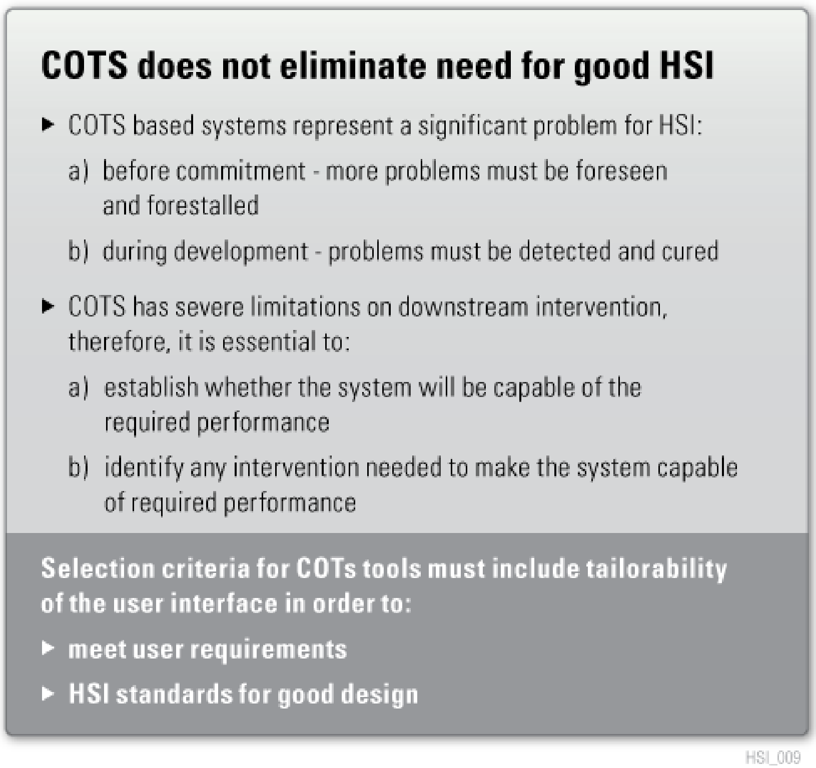

Figure 16: Scientific Advisory Board (2004) HSI Study: COTS Findings Summary

In order to avoid the risks inherent to COTS, the HSI Team must identify all human-related issues prior to product selection. Ideally, AFHSI considerations should be incorporated into market research of what is currently available in the commercial marketplace or in use by other agencies and programs. The HSI Point of Contact (POC) should carefully evaluate any information provided by industry, and ensure that HSI issues and risks are fully understood when making decisions about the system.

5.6 Ensuring Usability of Systems

Optimally usable systems result from successful management of equipment integration with human components. Early testing and evaluation is essential to ensure appropriate system usability. Key documents (e.g., HSIP, TEMP, and Development, Test and Evaluation/Operational Test and Evaluation (DT&E/OT&E) Plans) should include appropriate language to ensure proper usability evaluation. These documents should mandate that the system is tested and evaluated by typical users – operators, maintainers, support personnel, and trainers – at appropriate times during system development. Careful supervision of this process is recommended to avoid re-design merely to suit what users are accustomed to, and to improve designs for usability.

Measures of Effectiveness (MOEs), Measures of Performance (MOPs) and Measures of Suitability (MOSs) used for deriving desired system specifications should include the warfighter as part of the system. It is not enough to run models and simulations in order to drive the system to simply “fit” the operator. Rather, the user should be able to operate and maintain the system.

Knowledge derived from testing and evaluating usability can be extremely helpful in the development of system training. Evaluations of usability should continue through fielding, and periodically throughout the acquisition life cycle to ensure continued benefits in real-world applications and settings.

GENERAL GUIDELINES: Usability

- ✓ Test and evaluate the system as early as possible
- ✓ Ensure that HSIP, TEMP, and DT&E/OT&E Plans mandate testing and evaluation by typical users (operators, maintainers, support personnel, and trainers)
- ✓ Use knowledge derived from testing and usability evaluation for system training development
- ✓ Continue evaluations of usability through fielding and periodically throughout the life cycle

5.7 Training Program Development

Often, training plans are created after designs are determined and rigid. Considering training during earlier concept phases will tend to facilitate more effective training. The main take away message about training is to remember that training is not a crutch for poor system design. The HSI team can boost training considerations early by following general guidelines as shown below.

GENERAL GUIDELINES: Training

- ✓ Training SME should have results of early functional analysis such as human task allocations
- ✓ Include training resources in all Assessments
- ✓ Analyze KSA’s of personnel
- ✓ Implement operator maintenance training
- ✓ Consider embedded training during design

6. Resources for HSI

HSI implementation is supported by a variety of acquistion principles and processes, generic tools, and methods applicable to HSI. The HSI practitioner must be familiar with available methods, able to refer to them, and able to employ them in HSI program application.

> Application does not have to be glamorous or expensive. It must be pertinent, affordable and answer some simple questions and meet some useful standards.
> "The first step is to identify the right class of tool ...then, a search for currently available tools is performed (perhaps through one of the on line tool databases referenced earlier) to develop a list of candidates." (Booher, 2003)

Some initial sort criteria that can assist in finding and determining the appropriate tools for such use are:

Table 5: Tool Criteria

Original Purpose	Reliability	Validity	Realistic Resource Requirements	Output Format
Degree of Accuracy	Software Compatibility	Degree of Accuracy	Level of Resolution	System Compatibility
	Verification and Validation	Information Availability / Format	Cost	

6.1 HSI Specifications

Little data and few commercial standards exist to assist the development of HSI specifications. However, this should not diminish the effort to develop specific, measurable, human-centered specifications for use in capability documents. The information presented below is intended to support this effort by guidance drawn from military literature and work breakdown structure. It is strongly recommended that HSI practitioners also review the HSI Capabilities Based Requirements Development Guide.

Military Handbook and Standards. This guide recommends the practice of using the following Military Standards (MIL-STDs) 1472 , 3009, and 1787, and Military

The following documents are now encouraged for use in government contracts, but they are not required; industry contractors often use them as HSI guides during system development. The use of these document varies between contracts and can be called out for use in a contract, but it is not required that every contract follow these particular documents

MIL-STD 1472 – Human Engineering. This standard establishes general human engineering design criteria for military systems, subsystems, equipment and facilities.

MIL-STD 3009 – Interface Standard for Lighting, Aircraft, Night Vision Imaging System (NVIS) Compatible. This standard provides the definition and interface criteria for NVIS compatibility dealing only with interface and performance requirements and no longer lighting system design requirements.

MIL-STD 1787 – Aircraft Display Symbology. This standard describes symbols, symbol formats and information content for electro-optical displays that provide aircrew members with information for takeoff, navigation, terrain following/avoidance, weapon delivery, and landing.

MIL-HDBK 46855 – Human Engineering Program Process and Procedures. This handbook describes the application of human engineering to the development and acquisition of military systems, equipment and facilities, including work accomplished by a contractor or subcontractor in conducting a human engineering effort integrated with the total system engineering and development effort.

MIL-HDBK-1908 – Definitions of Human Factors Terms. This handbook defines terms frequently used in human factors standardization documents by providing common meanings of such terms to ensure that they will be interpreted consistently and in the manner intended.

Another resource that is unique to the space spectrum is the Space Command Style Guide, the SMC Commander's Policy on HSI (2006), and SMC Systems Engineering Handbook, Version 3 (2005). This can be used with space systems to incorporate HSI into those unique situations.

Joint Service Specification Guides (JSSG) provide an excellent framework for HSI requirements flow-down for air systems. The JSSGs contain sample language and lessons learned that may be helpful to developing performance-based specifications in contracts for new system development and upgrades or modifications.
JSSG-2000A, for example, can assist government and contractor personnel in developing specifications for air systems. The guide contains extensive guidance for completing the template, numbers and types of personnel required to operate the system, and human engineering performance requirements. While the JSSGs apply only to air systems, they provide a good starting point for other "crewed" systems.

Work Breakdown Structure (WBS) Level II and III. Systems engineering lies at WBS level II, therefore should be funded. The 2004 SAB HSI study uncovered a consensus among government and industry to establish Crew Systems at Level III in the WBS in hopes of instituting HSI awareness and processes. Since HSI is supposed to be a part of SE, a portion of the funding should go to warfighter effectiveness. The INCOSE Handbook (Version 3, 2007) currently argues that 10% is an optimum slice of the acquisition budget for SE, however it would be ideal for 30-40% of the budget should be dedicated to the operator, since they are the ones manning the system. MIL-HDBK 881A, WBS for Defense Materiel Items, 30 Jul 05, provides guidance to industry and government in extending contract work breakdown structures. It aims to achieve consistent application of the WBS for all programmatic needs, including performance, cost, schedule, risk, etc. In short, WBS activities segregate materiel items into component parts and tasks that need to be accomplished. This is a forcing mechanism for planning the management and technical responsibilities for these tasks. WBS Level III ensures a sufficient and highly desired amount of detail in task breakdown without unnecessarily constraining the contractor's ability to define or manage program resources.

Establishing Crew Systems to WBS Level III supports crew-centered designs in which the warfighter becomes the explicit focus of the design. It also fosters effective crew systems, providing better situational awareness through superior integration. The program should also consider establishing HSI tasks in the WBS Level III. Therefore, the HSI Team and AFHSI POC should:

GENERAL GUIDELINES: HSI Specifications

- ✓ Recommend that Program Managers prepare a WBS to Level III for Crew Systems and HSI
- ✓ Request contractors elevate Crew Systems and HSI to WBS Level III in RFPs
- ✓ Recommend that HSI experts be consulted on identified task allocation and level of task decomposition appropriate for WBS Level III

6.2 Existing and Emerging HSI Tools

Key HSI tools and methodologies have been identified, evaluated and are recommended for use in conjunction with the AF Systems Engineering (SE) process within the Defense Acquisition, Technology and Logistics Lifecycle Management Framework. The best source for review of these tools is within the Human Systems Integration and System Engineering Tool Report which will be published by the Defense Technical Information Center (DTIC). This information was compiled 1) to provide a top-level review of existing/emerging Systems Engineering (SE) tools that are currently being used in the field, and 2) to determine what existing/emerging HSI tools can be incorporated into the systems engineering process during each phase of the acquisition cycle.

Tables 6 and 7 are a selective sampling of tools and methods from the draft Human Systems Integration and Systems Engineering Tool Report. The exhaustive listings are available from DTIC at their website, www.dtic.mil , and it is updated biannually. Table 6 includes websites that contain varying amounts of related information. Table 7 includes references to additional information, including technical reports, books, and papers.

HSI tools and methods are defined as any tool or procedure that is used to collect human-centric data, perform HSI measurements, or model human capabilities. These tools are typically used to collect and analyze information that will assist in designing systems that require human interface in any of the Air Force HSI domain areas. SE tools include software applications and processes that are used in Air Force systems engineering. These may vary in their overall capability, but should be capable of tracking design requirements, collecting and storing requirements data, and performing analysis.

Selection of tools and methods will depend on program constraints, including phase of program development, relevant domain, and other constraints that are out of the control of the HSI staff.

Table 6: Tools and Methods Website

Reference	Website	Comments
Directory of Design Support Methods (DDSM)	http://www.dtic.mil/dtiicasd/ddsm/tools.html	Managed by DTIC San Diego office. Comprehensive description of many HSI tools. Contains obsolete tools list.
FAA Tools Database	http://www2.hf.faa.gov/workbenchtools	Contains listings of tools by subject matter. Includes data collection method and points of contact.
FAA Tools Database	http://www.hf.faa.gov/hfmaint	Lists tools by FAA acquisition phases (not necessarily just for maintenance.)
Mitre Site for Mental Models	http://mentalmodels.mitre.org/cog_eng/ce_sys_eng_phases_matrix.htm	Lists tools and methods used for cognitive engineering. Categorizes them by Systems Engineering phase
HSI Program Online Review Tool (PORT)-NAVSEA		This site is not currently active.
Army MANPRINT Handbook (May 2005)	http://www.manprint.army.mil/home/references/documents/pdfs/mpthandbook.pdf	Tools chapter lists 10 tools used by Army MANPRINT practioners
Navy Human Performance Center	https://www.spider.hpc.navy.mil/	This site has HSI checklists, links to other HSI organizations, and information on several tools.
Proceedings of the Design: Tools and Techniques Subgroup of the DoD Technical Advisory Group (TAG)	http://hfetag.dtic.mil/dtt.html	Data contained in TAG presentations.

Table 7: Tools and Methods References

Technical Report, Book or Paper	*Reference*	*Author(s)*	*Research Sponsor (if applicable)*
Human System Integration Support Tools with Links to DoD Systems Acquisition Phases	Technical Report, AFRL-RH-WP-SR-2008-0002	Lila Laux, PhD, Ronald L. Small, Susan G. Archer, Alion MA&D Operation, 4949 Pearl East Circle,	
Environment, Safety and Occupational Health (ESOH) in Acquisition		None provided.	Office of the Deputy Under Sec Def for Installations and Environment in cooperation with the Office of the Deputy Under SecDef or Acquisition and Technology
Tools to Support Human Factors and Systems Engineering Interaction During Early Analysis (Presented at the 2006 IEEE Aerospace Conference)	IEEE Issue 4-11 March 2006	Thronesbery, C; Mailin, JT, Holden, K; Smith, DP	
	Publisher: Wiley, 2003	(ed) Booher, H.	
Handbook of Human Factors and Ergonomic Methods	Publisher: CRC Press, 2005	(ed) Stanton, N., Hedge, A., Brookhuis, K., Salas, E., and Hedreick, H.	

6.3 Domain Specific Resources

The applicability of tools to particular HSI domains will depend primarily upon the type of system and what initial HSI assessments are done during the early stages of system development.

In the **HF domain,** as shown in AFI 63-101 (2005) tools generally fall into five main classes or categories: 1) time and motion analysis; 2) link analysis and operational sequence diagrams; 3) task analysis, function allocation and workload analysis; 4) accident and incident analyses; and 5) field study, survey and usability analysis. If human operators are used as subjects, determining and documenting the level of risk (exempt, minimal risk, greater than minimal risk) must be done and annotated/acted upon appropriately, through an Institutional Review Board if necessary (p. 49)

In the **Manpower, Personnel, and Training domains**, tools focus on tradeoffs and relationships within and between each of the three domains. These tradeoffs deal with the associated LCCs that apply to the proposed operations and sustainment concepts of the system. Manpower, personnel, and training account for the lion's share of total system costs. Therefore, it is critical to carefully look at tradeoffs very early in the life cycle of a system. The Armed Services have taken different MPT analysis tracks based on their own unique operations, maintenance, sustainment, training, replenishment and systems support. Some recent collaborations indicate a movement of MPT analyses toward a common tool set, which may be due to an increase in computer technologies and human performance modeling.

Also from the AFI 63-101 (2005), in the **Environment, Safety and Occupational Health domains**, different specialties apply different tools and tool sets to focus on system and personnel safety; environment and occupational health hazards; and the prediction and elimination of these hazards. The objective of HSI is to optimize interfaces between the user(s), the system, and the environment within which the user operates the system. It is inherent within this integration that the avoidance of unnecessary mishap potentials, eliminating or minimizing occupational health hazards, mediating personnel stressors, protecting the environment, and preserving the long term operational capability and quality of life of our users, maintainers and support personnel be considered (p.49). Hence, ESOH tools are primarily intended to identify potential hazards, characterize and eliminate risks, recommend protective designs or equipment, and define potential requirements for ESOH hazard remediation measures. Many of these tools focus on risk assessment.

In the **Survivability domain**, the HSI practitioner must deal with the operator and the equipment in an almost inseparable manner. The survivability of either may not ensure the survivability of the other. Tools must be able to predict the effectiveness of protective measures and must also support casualty assessments. This can be challengingand so will require involvement of experts from each of domain. Experts should join with intended equipment/system users to develop survivability issues that need to be addressed by any tool or model. Weapons Effects based models and Operational Requirements Casualty Assessment tools are currently in use.

The Habitability domain is the least robust in its tool application. This domain must address several key elements, including acoustic energy, biological hazards, chemical hazards, oxygen deficiency and ventilation, pressure changes, radiation (both non-ionizing and ionizing), shock, temperature stress, trauma and vibration. Hazard, mishap and survivability analyses are the most common tools used in this domain.

HSI tools will continue to grow in their number, efficiency and applicability.

6.4 HSI Educational Resources and Opportunities

Numerous educational opportunities are now available in continuing education, professional development, HSI and advanced degree programs. The best source for a complete review of these opportunities can be found at www.hsicourses.com.
This site contains a baseline of existing and proposed HSI education and training opportunities within military and civilian universities. Another good resource is the Human Factors and Ergonomics Society Graduate Directory (http://www.hfes.org/WEB/Students/grad_programs.html).

Source books and texts offer another resource for information about training. There is no single text that directly addresses many of the HSI specialized topics. However, several texts do address HSI as a whole a few examples are the following:

Ergonomic Design for People at Work, Eastman Kodak Company
Handbook of Human Factors, Gavriel Salvendy
Handbook of Human Systems Integration, Harold R. Booher
Handbook of Occupational Health and Safety, Lawrence Slote
Handbook of Training Evaluation and Measurement, 3rd Edition, Jack J. Philips, Ph.D
Human Factors in Engineering and Design, 7th Edition, Mark Sanders and Ernest J. McCormick
Human Performance Measures Handbook, Valerie J. Gawron
Level I Ergonomics Methodology Guide for Maintenance/Inspection Work Areas, AFIOH
Mosby's Handbook of Physiology and Anatomy, Kevin T. Patton and Gary A. Thibodeau
System Safety Analysis Handbook, 2nd Edition, System Safety Society
System Safety for the 21st Century, Richard A. Stephans

Since there is a lot of information that goes in to incorporating HSI within a program, a basic overview of HSI program goals and tasks are located in Appendix IV. This maps out five main goals and they are broken down into 4 task levels to signify the order from high to low priority. These tables can help implemnt HSI over the lifetime of a system in very basic terms.

We hope that this handbook can help understand the basics of what HSI is, why it is important, and how HSI fits into the System Acquisition Process. If there are any questions or concerns about HSI and how it can help you and the system design during the acquisition process, please use the contact information in Appendix VI for assistance.

7. Conclusion

HSI is integral to program development. It provides benefits throughout the system life-cycle, from initial implementation to retirement. The HSI Handbook provides guidance for how, when, and why to incorporate HSI into a program and its relationship with systems acquisition. It is important to integrate human concerns into the system design early in the development process. In doing so LCCs are significantly lowered, which can increase financial savings and decrease potential safety concerns.

It is important for the HSI team to include SMEs from all pertinent domains when using the HSI checklists and working with the IPT. As the HSIP is often integrated into the SEP a good working relationship and understanding of HSI by the program's systems engineer is integral to effective implementation of HSI. Resources for tools and collaboration are provided in the Handbook to provide additional opportunities to the HSI practitioner. Key to HSI is the focus around the human element in a weapons system.

Appendix I: HSI Plan Outline

HUMAN SYSTEMS INTEGRATION PLAN (HSIP)

for

<SYSTEM NAME>

<Date, Version #>

Signature Block Prior to MS A

<Signed by Primary Operating Command MAJCOM Requirements Office HSI POC>

NAME

Rank/Grade

Title

Organization

Command

Signature Block at MS A and after SPO Formation

<Signed by AFMC Program Manager>

NAME

Rank/Grade

Title

Organization

Command

Part I: EXECUTIVE SUMMARY

Part II: INTRODUCTION

- A. System Overview
- B. HSIP Objectives and Strategy

Part III: HSI RISK IDENTIFICATION AND MANAGEMENT

- A. HSI Constraints and Requirements
    1. Manpower
    2. Personnel
    3. Training
    4. Human Factors
    5. Environment, Safety & Occupational Health
    6. Habitability
    7. Survivability
- B. HSI Risk Analysis
    1. Manpower
    2. Personnel
    3. Training
    4. Human Factors
    5. Environment, Safety, & Occupational Health
    6. Habitability
    7. Survivability
- C. HSI Issue Tracking
    1. Summary and status of issue
    2. Proposed solution (mitigation strategy)

Part IV: HSI Execution

- A. Program Milestone Chart/Schedule
- B. HSI Integration Activities
- C. Contractor HSI Program

Part V: APPENDICES

- A. Points of Contact (Performance Team & HSI Practitioners)
- B. HSIP Issue Sheets
- C. Results of Functional Analyses (FAA, FNA, FSA)
- D. Trade-Off Studies

EXAMPLE HSIP ISSUE SHEET

Program Name:

Issue #:

Date:

1. Status: Indicate whether Open (unresolved) or Closed (resolved). If Closed, enter date.
2. Issue: State issue and impact on program if unresolved.
3. Source of Issue and Date Identified: Name the Organization that identified the issue and date identified.
4. Responsible Organization: Identify name of Organization(s) assigned responsibility for the issue.
5. Requirements Reference: Identify requirements source document for the issue (e.g. FNA, AoA, ICD, CDD, CPD)
6. HSI domains Affected: Indicate affected element(s)

   M: _______ P: _______ T: _______ HF: _______ ESOH: _______ Sv: _______ Ha: ______
7. Proposed Solution(s): Describe proposed solutions. Discuss the benefits and disadvantages.
8. Source(s) of Information: List sources pertinent to the issue or that may assist with resolution.
9. Schedule of Issue Resolution: Provide a time frame for resolving the issue and for expected interim results.
10. Final Resolution of Issue: Discuss the solution. Provides dates for completed actions.
11. Other Comments:

Appendix II: Outline of HSI Team Responsibilities

The HSI Team identifies, resolves, and tracks HSI issues as the acquisition program progresses. Issues must be kept current and should be documented in a Human Systems Integration Plan. Responsibilities include the following tasks:

a. Identify high cost drivers that increase life cycle costs and/or decrease system performance. Use constraints, requirements, and lessons learned as the baseline.

b. Track issues as they arise and communicate status to the HSI Team.

c. Identify HSI constraints and requirements for capability documents.

d. Develop mitigation strategies

e. Respond to systems engineering and integration activities that impact HSI.

f. Respond to HSI domains that present major HSI issues

g. Serve on source selection teams

h. Review relevant system documents to include but not limited to: Systems Engineering Plan (SEP), System Training Plan (STP), Test and Evaluation Master Plan (TEMP) and related reports, Manpower Estimate (ME), Analysis of Alternatives (AoA) and functional analyses, and Life Cycle Management Plan (LCMP).

i. Draft RFPs with HSI considerations. Require contractors demonstrate HSI claims using government approved tools.

j. Identify and suggest insertion of Manpower Key Performance Parameter (KPP).

k. Identify and suggest measurable, human-centered KPPs, Key System Attributes (KSAs), and other metrics.

l. Provide inputs to Models and Simulations.

m. Ensure MOEs and MOPs include the operator as part of the system.

n. Ensure T&E validates HSI requirements as having been or not been accomplished; and OT&E evaluates system using typical users.

o. Develop/Review/Update HSIP for Milestone Decision Reviews (MDRs).

Appendix III: HSI S&T Assessment Checklist

Manpower Issues and Concerns for Capabilities Documents
Will existing and forecast manpower levels support the technology / systems?
Will existing or projected manpower mix (military, civilian, contractors) have to change significantly?
Personnel Issues and Concerns for Capabilities Documents
Will new skill sets, knowledge bases, and abilities be required to support the capability from all aspects?
Will unique experience levels or pay grades be required?
Are skill sets, knowledge base, and abilities required by the new capability projected to be available?
Are new AFSCs required? Can we merge AFSCs, Will we have asset / resource pool to draw on?
Training Issues and Concerns
Will human performance limits be approached - will unique training / training systems be required?
Do we have the capability to train to IOC? How do we train the trainers?
Will we have the capability to provide maintenance/operations training?
Will deployment/employment of the new capability change tactics and decision-making?
Will changes in individual or team training be required to address tactics or decision-making?
Will the solution change who is to be trained? (Active Duty, Reserve, Guard, Civilian, Contractor)
Will the solution change who is to conduct training and where? (Government, Contractor)
Will solution impact the timing, cost or method of the training? (Duration, Availability, type)?
Human Factors Engineering Issues and Concerns - all personnel
Does the solution present any significant challenges, implications or constraints in the following
Work/living space (storage, cleaning, maintenance, etc.)
System or display integrations; Operability/Maintainability; Anthropometry/Ergonomics
Does solution require a new system interface or modification to existing interfaces?
Is special gear required that may impact task performance? Are tasks/missions less or more difficult?
Does solution require additional tasks -physical, cognitive, psychological? Is workload manageable?
Will specific performance thresholds/objectives impact mission outcome?
ESOH Issues and Concerns - all personnel, not just crew members
Will personnel be exposed to new hazards? New materials, chemicals or compounds, environments?

Does the solution introduce new ESOH risks - physical, emotional, cognitive, psychological?
Have ESOH risks of the current technology /systems been identified? Are they reduced or increased?
ESOH Issues and Concerns - all personnel, not just crew members
Will unique Warnings, Cautions or notes be required - operators & maintainers?
Will failure modes create unique risks of loss of material or life?
Will new protective equipment, procedures or technologies required?
Survivability Issues
Does technology introduce a new threat? Change egress systems requirements?
Is the system signature (visible, electromagnetic, etc.) similar to potential threat vehicles?
Is the system signature more likely to be detected by unfriendly forces? Infrared or other?
Does the system present a unique or highly recognizable signature (visual, thermal, etc.)?
Does the solution require a change in attack and attack prevention measures?
Does the system provide adequate crew protection from Directed Energy weapons such as lasers and RF weapons and sub-systems?
Habitability Issues
Anthropometrics: Any body size / system accommodation issues?
Environments (natural & induced) -Acoustics-Personal Communication-Mission Communication -
Personnel Safety: -alarms-warnings-safety equipment-first aid-electrical hazards-food-water-lavatory sys.
Health Management: -food-water-lavatory-fatigue-comfort-circulation-shower-privacy-exercise
Architecture: -lighting-workspace design-power access-labeling & coding-ventilation
Trash & Waste:-availability-adequacy-accessibility-interference-general housekeeping
Maintenance & tools: -procedures - feasibility-demands-capability-frequency-diagnostics-repairs
Protective clothing: -donning, doffing-adequacy-comfort-availability-stowage
Cultural / Gender Issues

Appendix IV: HSI Program Goals and Task Tables

Goal: 1. Recommendations for good HSI are enforced in weapon system programs			
Task Level 1	Task Level 2	Task Level 3	Task Level 4
HPT/IPT Participation	Write measurable HSI Requirements	Build HSI Team (HSI POCs (MAJCOM, AFRL, etc)	
		Identify HSI Requirements during JCIDS process	
		Draft ICDs	
		Ensure HSI considered during functional analyses (FAA, FNA, FSA)	
		Ensure functional analyses results are used towards developing HSI metrics, KPPs and KSAs in CDDs	
		Perform Human Factors assessments	
		Trade studies	Analyze HSI in regards to program trade offs
	Source selection criteria/RFPs/system specs		
	Draft HSI Plan as a part of Systems Engineering Plan	Build HSI Team	SME for each relevant domain for that program
		Identify and document HSI risks, constraints, requirements, issues	CDD, ICD, CPD, PMD, RFP, contract, system specifications SEMP, TEMP, SAMP, PSMP, MER, SSP, STP PESHE
		Participate in source selection and developing criteria	
		Ensure HSI a part of trade studies and not dropped altogether	

Goal: 1. Recommendations for good HSI are enforced in weapon system programs			
Task Level 1	Task Level 2	Task Level 3	Task Level 4
	Tackle Spiral Acquisition	Ensure trained HSI "expert" available to programs on a daily basis	Maintain robust HSI Plan
		Ensure HSI not left out of the loop on programs that are quick to field systems (i.e. UAV)	
Find HSI needs (see HSI Engagement Process	Initiate HSI engagement	Air Force 711th HPW/HPO website	
		Identify HSI SME to work on project	
	Begin work initiatives immediately		
	Pull documents from system	CDD, ICD, CPD, PMD, RFP, contract, system specifications SEMP, TEMP, SAMP, PSMP, MER, SSP, STP PESHE	
Comment on capability documents	Manpower Estimate Reports inputs to determine manpower KPPs		
	Ensure OT&E feedback on HSI issues gets addressed		
	Participate in weapon system working groups, PDR, CDR	HSI Assessments	
Participate in Program Milestone Reviews	Participate in Milestone Decision Reviews	Documentation reviews	
	Participate in Milestone Decision Reviews DAB review	Development Test	
		Operational Test	

Goal: 1. Recommendations for good HSI are enforced in weapon system programs			
Task Level 1	Task Level 2	Task Level 3	Task Level 4
	Become member of organizations that function on PMRs at the various levels		

Goal: 2. Institutionalized HSI program			
Task Level 1	Task Level 2	Task Level 3	Task Level 4
Assess tasks and goals	Determine different levels of effort and supportability	Risk assessment	
		Levels of resource allocation	
Objectives (responsibilities)	Supporting organization	Metrics	
	Executing organization	Metrics	
Program buy-in strategy	Stakeholder analysis	Execute strategy	
Identify the HSI experts (who/where?)	Human factors	Engineers, scientists, physiologists, researchers	DR, AFMA, AFRL, Contracted work
	System Engineers		
	AQ (PMs, SPOs)		
	Domain Reps		
	Requirements writers	DR, AFRL	
	T&E Assessors (OT/DT)		
	Operators		
	Educators		
Policy	Program Directive and Instruction	AFMC Level	
	Integrate HSI into existing policy	Environment, Safety, Occupational Health, training, AQ, MAJCOMs, XO, XI, DP, IE, SE, TE, SG, system engineering, IL	
		OSD/CJCS	
		Space	
		Identify policy metrics	

Goal: 2. Institutionalized HSI program			
Task Level 1	Task Level 2	Task Level 3	Task Level 4
	IG Inspection policies		
	Documents	PD, Instruction, Policy Letters, Vision Statement, Mission Statements	
Process In Place	HSI Plan	HSI Assessments	Test and evaluation
			Manpower Estimate Reports
		Metrics	
	Other HSI Assessments	Programs in Fielding and Sustainment Phases	
		Programs preparing for next spiral	
		Programs preparing for next increment or modification	
		Programs involving COTS or NDI	
		Metrics	
	Board of Advisors		
	Requirements writing	HSI Capabilities Based Requirements Development Guidebook	Metrics
	HPT/IPT Support	SME identification	
		HSI Team	
	ORM	Risk tracking	
	Manpower Estimate Reports		
	Reviews	Red Team Reviews	HSWAG semi-annually
			Peer reviews from AQ/user community
	Accident investigation board participation		
	Documents and Tools	Air Force Human Systems Integration Handbook, Training Courses	Other tools
Train HSI professionals and spread HSI awareness wherever needed	Short term training implementation	Develop training courses: short and long courses	AFMC Organizations
			AQ (61, 62, 63) Users

Goal: 2. Institutionalized HSI program			
Task Level 1	Task Level 2	Task Level 3	Task Level 4
	Long term training implementation	AFIT, PME, NPGS, Academia, OJT	HAF/SAF (32, 36, 38, 43, 48)
			Domain Reps
			AQ (61, 62, 63) Users
			AFMC Organizations
			HAF/SAF (32, 36, 38, 43, 48)
			OSD/CJCS
Tool Development	Internal	Air Force Human Systems Integration Handbook, Req writing, etc.	
	External	IMPRINT, etc.	Database of tools
Organization	Advocate	Vision	
		Mission Statements	
		Approve tasks	
		Strategic Planning	HSI organization
			Points of contacts
	Executing Organization	Process owner (HPW/HPO)	
	Supporting Organizations	AFRL	
		Product Centers	
		MAJCOMs (users)	
	Staffing	POM	
Funding	Determine budget	DHP POM	
		Line POM	
	Establish Program Element Code (PEC)		
	Search for outside funding		
	Develop Program Decision Memo		
	Determine type of USAF funding		
	Determine project costs		

Goal: 3. HSI Expertise in the Air Force			
Task Level 1	Task Level 2	Task Level 3	Task Level 4
Manage experts	Develop database in an effort to access experts on an as needed basis		
Develop experts	Professionals, users, S&T, awareness	E-learning	
		On-site, OJT, PME	
Manage/facilitate USAF HSI Community of Practice	On-line development	Shared workspace, library, weblinks	
	Provide HSI experts membership to COP		
	Share knowledge (wisdom exchange)		
Involvement in Working Groups	Program specific	Environmental, system safety, Occupational Health, HSI, test plan working group	
	Universal	MANPRINT workshop, DoD HFE TAG, HSI Symposium (USN sponsored), USAF Board of Advisors	
Integrated Product Teams (program specific)	ID experts to serve		
High Performance Teams	ID experts to serve		

Goal: 4. Strong Human-Centered S&T Culture			
Task Level 1	Task Level 2	Task Level 3	Task Level 4
HSI Assessments on ACTDs, NDI, COTS	Ensure HSI considerations embedded in new technology		
AFRL/User collaboration	Technical risk assessments		
	New technology requirements writing		
	Establish communications (transparent efforts)		
	Technology transition		
AFRL/HPW/SG collaboration	Bridge HF and HSI technology gaps	HSI Roadmap	SG modernization panel (FAWG) à HSI S&T projects funding
	Technical risk assessments		
	New technology requirements writing		
	Establish communications (transparent efforts)		
	Technology transition		
Technology development	HSI specific		
	HSI funded		

Goal: 5. Full Operational Capability (HSI applied AF-wide in all programs)			
Task Level 1	Task Level 2	Task Level 3	Task Level 4
AO assigned to each program	AF 711th HPW/HPO website	Return on investment	Field, cost-savings, life-savings, effectiveness
	HSI Plans and HSI Teams		
Mishap analysis with HSI focus	Assess area/level of engagements		
	HFACS		
Ensure AFMC HSI office functioning	Collaboration		
Inspections	Assess organizations' processes	Maturity Index, 6 Sigma, Carnegie Mellon	
	Red team reviews and self inspections		
	IG		
Tools developed, available, and in use			

Appendix V: Policy Letter Examples

Subj: HUMAN SYSTEMS INTEGRATION (HSI) IN FUNCTIONAL CAPABILITY ANALYSES AND THE INITIAL CAPABILITIES DOCMENT (ICD)

Ref: (a) CJCSI 3170.01D
(b) CJCSM 3170.01
(c) AFI 10-601

1. Under recent transformational acquisition policy found in references (a) and (b), High Performance Teams must develop a comprehensive Initial Capabilities Document (ICD). The ICD must include precise language that documents adequate consideration of Human Systems Integration (HSI). Reference (a) and (c) requires that an integrated DOTMLPF (Doctrine, Organization, Training, Materiel, Leadership, Personnel, and Facilities) analyses be conducted, and all non-materiel implications of a proposed materiel solution be considered. Reference (a) also stresses that early functional capabilities analyses are to be collaborative in nature to ensure potential materiel and non-materiel solutions are developed in an integrated fashion. As such, these DOTMLPF analyses and assessments must incorporate all HSI domains (Manpower, Personnel, Training, Human Factors, Environment, Safety, and Occupational Health (ESOH), Survivability, and Habitability).

2. a. Analyses conducted as part of the Joint Capabilities Integration Development System (JCIDS) must address all HSI domains. For example:

(1) The Functional Area Analysis (FAA) should include consideration for the role operators, maintainers, and support personnel play in the operational tasks identified, and what human performance standards are needed to achieve the military objective.

(2) The Functional Needs Analysis (FNA) should assess the ability of the current and projected joint capabilities and personnel inventory to accomplish the tasks identified in the FAA to the designated human performance standards. The FNA should produce as an output a list of the personnel inventory gaps or shortcomings that require solutions.

(3) The Functional Solution Analysis (FSA) should include analysis of all HSI domains that may solve and/or mitigate the capability gaps and the HSI implications of designing, developing, fielding and sustainment. The analysis may provide rationale as to why non-materiel options are inadequate, infeasible, or undesirable. This, along with the AoA and the Technology Development Strategy, provide the basis for the ICD that identifies a need for a materiel solution.

(4) The Analysis of Alternatives (AoA) should include in the comparison and evaluation of materiel options the contribution and/or limitation that HSI issues such as manpower, personnel and training have on meeting the identified capability gap. The AoA should consider HSI impacts on cost, schedule, and performance pertaining to each of the alternatives. It identifies opportunities for trade-offs between performance, costs, and schedules, as well. Specific issues to consider: interfaces, tech development, COTS, previously designed systems, etc.

b. The results of these early HSI analyses should be included in the ICD format as per references (b) and (c). Specifically:

(1) Section 6.a (DOTLPF Analyses) should explain if changes in manpower, personnel and training concepts, or accomplishment of minor human factors engineering modifications to existing capabilities could enhance current system performance enough to meet the capability gap. Discussion of supporting analyses and reasons why changes in DOTLPF/HSI will not satisfy the need should be more specific.

(2) HSI constraints that impact concept feasibility, total system performance and affordability should be included in Section 7b of the ICD as key boundary conditions of the AoA.

(3) Section 7c of the ICD should describe the DOTMLPF implications and constraints to include all of the HSI domains. Examples of HSI implications and constraints may include: end-strength limitations for manpower, affordability of developing knowledge, skills,

abilities and training not currently available in the Air Force; manpower minimums and appropriate mix (military, civilian, and contractor); joint manning options; the appropriate level and acceptable risk of automating critical functions; and environmental regulations and workspace safety compliance requirements.

3. Members of my staff were closely involved in formulating the DOTMLPF and HSI portions of the recent DoD 5000 and CJCS 3170 series guidance, and fully understand the underlying intent. They can be of great value in early consultation during ICD preparation. My point of contact on this matter is ___________________, 711 HSW/HPO, ___________ or _________@brooks.af.mil.

MEMORANDUM FOR

Subj: HUMAN SYSTEMS INTEGRATION (HSI) IN FUNCTIONAL CAPABILITY ANALYSIS AND THE CAPABILITIES DEVELOPMENT DOCUMENT/CAPABILITIES PRODUCTION DOCUMENT (CDD/CPD)

Ref: (a) CJCSI 3170.01D
CJCSM 3170.01
AFI 10-601

1. Under recent transformational acquisition policy found in references (a), (b) and (c), High Performance Teams must develop comprehensive Capabilities Development Documents (CDD) and Capabilities Production Documents (CPD). The CDD/CPD must include precise language that documents appropriate Human Systems Integration (HSI) requirements. Reference (a) and (c) requires that the CDD/CPD include a description of the DOTMLPF (Doctrine, Organization, Training, Materiel, Leadership, Personnel and Facilities) implications and constraints. These DOTMLPF impacts and constraints must incorporate all HSI domains (Manpower, Personnel, Training, Human Factors, Environment, Safety, and Occupational Health (ESOH), Survivability, and Habitability).

2.a. HSI shall be addressed in Sections 6c, 13, 14, and 15 of the CDD/CPD.

(1) Section 6c of CDD/CPD summarizes specified Key Performance Parameters (KPP) and additional performance attributes in threshold-objective format. Manpower may be a key performance parameter for selected systems as jointly determined by the MAJCOM sponsor and the Manpower sponsor (AF/DP). MAJCOM sponsors should assume a default consideration for the manpower KPP unless they obtain prior agreement with AF/DP. Manpower thresholds and objectives shall be established so as to encourage options that maximize the use of technology in reducing manpower, personnel, and training (MPT) requirements and total ownership costs. Manpower KPPs are inserted verbatim into the performance section of the Acquisition Program Baseline (APB).

(2) Section 13 of the CDD/CPD summarizes the DOTMLPF implications, to include all the HSI domains, associated with fielding the system. This section should provide a short description of the HSI issues and operational concerns regarding implementation of the materiel solution. This section should describe the environment, safety and occupational health (ESOH) requirements, and the environmental compliance expectations and associated costs.

(3) Section 14 of the CDD/CPD summarizes capabilities-oriented, performance-based HSI requirements that drive design, cost, and/or risk. HSI requirements should be specific and explicit in identifying the human performance contribution required to ensure total system performance and mission success. HSI requirements should include thresholds and objectives and identify the measures of effectiveness (MOE). Statements describing analyses that lead to specific human performance requirements should be avoided unless the level of fidelity of the CONOPS, program, or technology is lacking. These analyses should be conducted as part of the capabilities effort similar to any other system component. When fidelity is lacking, Section 14 should contain broad constraints for the HSI requirements so that future revisions of the CDD will represent a refinement of the requirements and not the addition of new requirements. HSI requirements should address, but are not limited to:

(a) Broad manpower constraints for the maximum number and appropriate mix (military, civilian, and contractor) of operators, maintainers, trainers and contract personnel.

(b) Manpower factors that impact system design (e.g. utilization rates, pilot-to-seat ratios, maintenance concepts).

(c) Identification of required knowledge, skills, and abilities KSA), aptitudes and physical characteristics of operators, maintainers, and support personnel.

(d) Requirements for the training support package and logistics (e.g. technical documentation, simulators, training devices, new learning techniques, simulation technology, embedded training); requirements for individual, collective and joint training for operators, maintainers and support personnel.

(e) Human performance requirements that contribute to total system performance and mission success; the cognitive, sensory and physical requirements of the operators, maintainers and support personnel.

(f) Environment, safety and occupational health (ESOH) requirements that will eliminate, reduce and mitigate the potential for injury, illness or disability and death of the operators, maintainers and support personnel.

(g) System requirements that reduce the risk and prevent or increase the odds of surviving fratricide, personal detection or targeting, or confinement within an attacked entity. Examples include egress from confined spaces, location of berthing and mess facilities, ejection seats and assisted breathing devices.

(h) Personnel support service requirements such as berthing and personal stowage, food service, medical, lavoritories, recreational and lounge spaces; ambient environment requirements (e.g. noise, lighting, heating, air conditioning and ventilation (HVAC)).

(i) Attributes that affect design, cost, and risk drivers, including environmental quality and safety issues regarding hazards of electromagnetic radiation to ordnance (HERO) should be addressed.

3. Members of my staff were closely involved in formulating the DOTMLPF and HSI portions of the recent DoD 5000 and CJCS 3170 series guidance, and fully understand the underlying intent. They can be of great value in early consultation during ICD preparation. My point of contact on this matter is ___________________, 711 HSW/PEC, ___________ or _________@brooks.af.mil.

Appendix VI: HUMAN SYSTEMS INTEGRATION ORGANIZATIONS WITHIN THE AIR FORCE

A. 711 HUMAN PERFORMANCE WING (711 HPW) DIRECTORATE OF HUMAN PERFORMANCE INTEGRATION (HP) HUMAN PERFORMANCE OPTIMIZATION DIVISION (HPO)

711 HPW/HP Mission: To integrate human performance sustainment, optimization and enhancement through the application of operational knowledge and evidence-based human systems integration (HSI); to ensure an overwhelmingly effective USAF warfighter through the integration of people and technology for total systems performance; to be the USAF human performance and HSI lead execution agent to DoD, Air Staff, MAJCOMs, system program offices, science and technology, and acquisition, logistics, and test centers.

711 HPW/HPO advances human-centered design in the acquisition of weapons systems to maximize total system performance and reduce life cycle costs; facilitates HSI process implementation during weapons systems acquisition across the Air Force enterprise areas of aeronautical, C4ISR, munitions, and space/missile; consults with High Performance Teams, Program Managers, Systems Engineers, and Integrated Product Teams to execute HSI.

Location and Organizational Contact Information
711 HPW/HPO
2485 Gillingham Dr
Brooks City-Base, Texas 78235

Telephone:
DSN: 240-4457
Commercial: (210) 536-4457

Email: 711hpw.hp.hsi.workflow@brooks.af.mil

B. AIR FORCE HUMAN SYSTEMS INTEGRATION OFFICE (AFHSIO)

AFHSIO Vision: Integrate Air Force people and technology to ensure total systems performance to support Air Force missions at affordable life cycle costs.

Mission: Ensure all Air Force warfighting systems are designed, built, operated, and sustained in a manner that optimizes total system performance at every Warfighter level.

Goal: Optimize Warfighter capability and sustain readiness through integrating HSI processes into the Integrated Acquisition, Technology, and Logistics Life Cycle Management Framework to equip and sustain the Warfighter; institutionalize HSI as the way of doing business to increase total systems performance and to ensure affordable life cycle costs; sustain HSI through collaboration with partners in OSD, AF, sister services, industry, and academia; improve HSI processes through metrics, feedback, and lessons learned.

Location and Organizational Contact Information
AFHSIO
5201 Leesburg Pike
Skyline 3, Suite 1401
Falls Church, VA 22041

Telephone:
DSN: 761-6300
Commercial: (703) 681-6300

Email: HSI.workflow@pentagon.af.mil

C. Request for Feedback and Comments

This is considered a living document, which means that although every effort has been made to make it usable comprehensive and up to date, we acknowledge that the acquisition and JCIDS process continues to evolve and changes will need to be made maintain currency. User feedback in the form of corrections or improvements is encouraged. Comments can be made at any time by contacting the 711 HPW/HPO or AFHSIO.

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Appendix VIII: Glossary

Analysis of Alternatives (AoA)—The evaluation of the operational effectiveness and estimated costs of alternative systems to meet a mission capability. The analysis assesses the advantages and disadvantages of alternatives being considered to satisfy capabilities, including the sensitivity of each alternative to possible changes in key assumptions or variables.

Capability—The ability to achieve a desired effect under specified standards and conditions through combinations of means and ways to perform a set of tasks. It is defined by an operational user and expressed in broad operational terms in the format of a joint capabilities document, initial capabilities document or a joint Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, and Facilities (DOTMLPF) change recommendation. In the case of materiel proposals, the definition will progressively evolve to DOTMLPF performance attributes identified in the capability development document and the capability production document.

Capability Development Document (CDD) – A document that captures the information necessary to develop a proposed program(s), normally using an evolutionary acquisition strategy. The CDD outlines an affordable increment of militarily useful, logistically supportable and technically mature capability.

Capability Gaps – Those synergistic resources that are unavailable, but potentially attainable to the operational user for effective task execution. These resources may come from the entire range of DOTMLPF solutions.

Capability Production Document (CPD) – A document that addresses the production elements specific to a single increment of an acquisition program.

Environment—Water, air, land, space, and cyberspace. In the context of HSI, Environment is important in that it affects concepts of operation and the requirements to protect systems from the environment and the environment from the systems operations, sustainment and disposal. *(One of the Human Systems Integration (HSI) domains – this domain is treated differently in each of the three services and ownership of expertise and processes that deal with environment are varied. In the case of HSI the domain owner is considered to be SAF/IE with significant shared responsibilities in SAF/AQ, AF/SG and A4/7))*

Functional Area Analysis (FAA)—An FAA identifies the operational tasks, conditions and standards needed to achieve military objectives. It uses the national strategies, the family of Joint Operations Concepts (JOpsC), Integrated Architectures (as available), Air Force CONOPS, and the Universal Joint Task List as input. Its output is the tasks to be reviewed in the follow-on functional needs analysis. The FAA includes cross-capability and cross-system analysis in identifying operational tasks, conditions and standards. The FAA should be conducted as a collaborative effort.

Functional Needs Analysis (FNA)—It assesses the ability of the current and programmed joint capabilities to accomplish the tasks that the FAA identified, under the full range of operating conditions and to the designated standards. Using the tasks identified in the FAA as primary input, the FNA produces as output a list of capability gaps/shortfalls that require solutions, and indicates the time frame in which those solutions are needed. The sponsor leads the FNA.

Functional Solution Analysis (FSA)—It is an operationally based assessment of all potential DOTMLPF approaches to solving (or mitigating) one or more of the capability gaps/shortfalls identified in the FNA. On the basis of the capability needs, potential solutions are identified, including (in order of priority) integrated DOTMLPF changes that leverage existing materiel capabilities; product improvements to existing materiel or facilities; adoption of interagency or foreign materiel solutions; and finally, initiation of new materiel programs. Identified capability gaps/shortfalls or redundancies (excess to the gap/shortfall) establish the basis for developing materiel approaches in ICD and/or DOTMLPF approaches through CJCSI 3180.01, *Joint Requirements Oversight Council (JROC) Programmatic Processes for Joint Experimentation and Joint Resource Change Recommendations*.

Habitability—Factors of living and working conditions that are necessary to sustain the morale, safety, health, and comfort of the user population that contribute directly to personnel effectiveness and mission accomplishment, and often preclude recruitment and retention problems. *(One of the Human Systems Integration (HSI) domains – this domain is a recent addition to HSI and ownership of processes and expertise that addresses the domain is varied. In the case of HSI the domain owner is considered to be SAF/IE with significant shared participation by AF/SG and A4/7)*

Human Factors Engineering—The comprehensive integration of human capabilities and limitations (cognitive, physical, sensory, and team dynamic) into systems design, to optimize human interfaces to facilitate human performance in training operation, maintenance, support and sustainment of a system. *(One of the Human Systems Integration (HSI) domains – this domain is the prime integrating domain and the domain owner is considered to be SAF/AQ with domain expertise primarily vested in AFRL and AFMC engineering communities)*

HSI practitioners—Individual(s) working to ensure that HSI is properly applied to satisfy human requirements in the acquisition of systems. An HSI practitioner may have knowledge, skills and abilities in one or many of the domains and processes used in HSI. These include (but are not limited to): Program Management, Systems Engineering, Human Factors Engineering, Applied Behavioral Science, Experimental Psychology, Science and Engineering Specialties, ESOH specialties, Aerospace Physiology, MPT specialties.

Human Systems Integration (HSI)—The integrated and comprehensive analysis, design, and assessment of requirements, concepts, and resources for system manpower, personnel, environment, training, safety, occupational health, habitability, personnel survivability, and human factors engineering. (AFI 63-101, 2008 draft, glossary)

Initial Capabilities Document (ICD) – Documents the need for a materiel approach to a specific capability gap derived from an initial analysis of materiel approaches executed by the operational user and, as required, an independent analysis of materiel alternatives. It defines the capability gap in terms of the functional area, the relevant range of military operations, desired effects and time. The ICD summarizes the results of the DOTMLPF analysis and describes why nonmateriel changes alone have been judged inadequate in fully providing the capability.

Joint Capabilities Integration and Development (JCIDS) – A component of the Integrated Defense Acquisition, Technology & Logistics Life Cycle Management Framework. The DoD's system for articulating stakeholder capabilities needs. These needs are reflected in a series of progressively more detailed documents (ICD, CDD, CPD) that support the acquisition process.

Key Performance Parameter (KPP)—Those attributes or characteristics of a system that are considered critical or essential to the development of an effective military capability and those attributes that make a significant contribution to the key characteristics as defined in the Family of Joint Operations Concepts. Failure to meet a KPP attribute may result in restructuring of the initiative.

Key System Attribute (KSA)—An attribute or characteristic considered essential for an effective military capability during an increment. KSAs provide decision makers with an additional level of capability prioritization below the KPP level. Generally, KSAs are the top 8 to 10 attributes that are considered as potential KPPs but do not meet full KPP criteria.

Manpower—The number and mix of personnel (military, civilian, and contractor) authorized and available to train, operate, maintain, and support each system. In the classic HSI context these are the "spaces" that must be identified, authorized and funded. *(One of the Human Systems Integration (HSI) domains – the domain owner is considered to be SAF/MR with domain expertise primarily vested in AF A/1, AFOMS and AFPC)*l

Occupational Health—The consideration of design features that minimize risk of injury, acute and/or chronic illness, or disability, and/or reduce job performance of personnel who operate, maintain, or support the system. *(One of the Human Systems Integration (HSI) domains – the domain owner is considered to be AF/SG with shared responsibilities throughout the ESOH communities and expertise primarily vested in AFIOH)*

Operator—An operational command or agency that employs acquired systems for the benefit of users. Operators may also be users.

Personnel—The human aptitudes, skills, and knowledge, experience levels, and abilities required to operate, maintain, and support a system at the time it is fielded. In the HSI context, these are the "faces" that go into the authorized spaces. . *(One of the Human Systems Integration (HSI) domains – the domain owner is considered to be SAF/MR with domain expertise primarily vested in AF A/1, AFOMS and AFPC)*

Program Manager (PM)—As used in this instruction applies collectively to System Program Director, Product Group Manager, Single Manager, or acquisition program manager. The PM is the designated individual with responsibility for and authority to accomplish program objectives for development, production, and sustainment to meet the user's operational needs. The PM shall be accountable for credible cost, schedule, and performance reporting to the MDA.

Safety—The application of systems engineering and systems management in conducting hazard, safety and risk analysis in system design and development to ensure that all systems, subsystems, and their interfaces operate effectively, without sustaining failures or jeopardizing the safety and health of operators, maintainers, and the system mission. *(One of the Human Systems Integration (HSI) domains – the domain owner is considered to be AF/SE with domain expertise vested in AF/SE the Air Force Safety Center and the field level trained flight, ground, traffic, weapons, and system safety experts.)*

Sustainment – Sustainment includes supply, maintenance, transportation, sustaining engineering, data management, configuration management, manpower, personnel capability, training, habitability, survivability, environment, safety (including explosives safety), occupational health, protection of critical program information, anti-tamper provisions, and Information Technology (IT), to include National Security Systems (NSS), supportability and interoperability functions. (MANPRINT Handbook, p17)

Systems Engineering—An interdisciplinary approach encompassing the entire set of scientific, technical, and management efforts needed to conceive, evolve, verify, deploy, and support an integrated and life cycle balanced set of system solutions that satisfy customer needs. Systems engineering, through technical and management processes, addresses architectures; requirements development; design; technical management; test and evaluation; verification and validation; operational safety, suitability, and effectiveness (OSS&E); environment, safety, and occupational health (system safety); and human systems integration. These fundamental elements must be accomplished on all development, acquisition, and sustainment activities to develop a relevant technical knowledge base that is matured, maintained, and transferred in a disciplined manner. (AFI 63-101, 2008 draft, glossary)

Survivability—The ability of a system, including its operators, maintainers and sustainers to withstand the risk of damage, injury, loss of mission capability or destruction. Survivability includes the elements of susceptibility, vulnerability, and recoverability. As such, survivability is an important contributor to operational effectiveness and suitability. A survivability assessment should be conducted for all systems under Operational Test & Evaluation (OT&E) oversight that may be exposed to threat weapons in a combat environment, whether or not the program is designated for Live Fire Test & Evaluation (LFT&E) oversight. (For example, unmanned vehicles are not required to undergo survivability LFT&E under 10 USC 2366, but should be assessed for survivability.) The assessment may identify issues to be addressed by testing. The Developmental Test & Evaluation (DT&E), OT&E, and LFT&E strategies should be integrated so that the full spectrum of system survivability is assessed in a consistent manner. The Critical Operational Issues should include the issues to be addressed in the OT&E evaluation of survivability. Personnel survivability must be addressed for systems under LFT&E oversight (10 USC 2366) and should be integrated into the overall system evaluation of survivability conducted under OT&E. *(One of the Human Systems Integration (HSI) domains – domain ownership is not clear cut. In the Army the Survivability Lethality Directorate (SLAD) of the Army Research Laboratory has significant expertise. PL108-375 requires a survivability KPP for all "Covered" systems. The DAG clearly notes that it is not limited to just personnel survivability, but addresses system survivability also. Domain ownership is most likely best assigned to SAF/AQ with significant shared responsibility with AF/TE. Expertise in the Air Force is not readily identifiable)*

Tradeoff Analyses – The system acquisition process consists of a continuous series of tradeoffs both at the macro and micro level. The critical factor is the "trade space". This is the range between objective and threshold that can be traded-off by the PM. The best time to reduce lifecycle costs is early in the acquisition process. Cost reductions should be accomplished through cost/performance tradeoff analyses conducted before an acquisition approach is finalized.

Training—the instruction and resources required providing personnel with requisite knowledge, skills, and abilities to properly operate, maintain, and support a system. Training prepares the personnel (faces) for the manpower slots (spaces) in which they are expected to capably perform. This training ranges from basic training and technical training through the more advanced professional certification, professional military education (PME) to post graduate level accredited education. *(One of the Human Systems Integration (HSI) domains – the domain owner is considered to be AETC with domain expertise primarily vested in AETC and its subordinate units and at the Using / Operating Commands)*

User—An operational command or agency that receives or will receive benefit from the acquired system. Combatant commanders and their Service component commands are the users. There may be more than one user for a system. Because the Service component commands are required to organize, equip, and train forces for the combatant commanders, they are seen as users for systems. The Chiefs of the Services and heads of other DoD components are validation and approval authorities and are not viewed as users.

Appendix IX: Acronyms

711 HPW – 711th Human Performance Wing
AAC – Air Armament Center
ACE – Air Combat Element
ACS – Agile Combat Support
ACTD – Advanced Concept Technology Demonstration
AETC – Air Education and Training Command
AF/XOR – Air Force Operational Capabilities Requirements Division
AFAMS – Air Force Agency for Modeling Simulations
AFFTC – Air Force Flight Test Center
AFHSI – Air Force Human Systems Integration
AFI – Air Force Instruction
AFIT – Air Force Institute of Technology
AFMA – Air Force Manpower Agency
AFMC – Air Force Materiel Command
AFOTEC – Air Force Operational Test and Evaluation
AFPC – Air Force Personnel Center
AFPEO – Air Force Program Executive Office
AFRL – Air Force Research Lab
AFSC – Air Force Specialty Code
AIRPRINT – Air Force Airmen Performance Integration Program
AoA – Analysis of Alternatives
ARL – Army Research Lab
ASC – Aeronautical Systems Center
ATD – Advanced Technology Demonstration
C4ISR – Command, Control, Communications, Computers, Intelligence, Surveillance, Reconnaissance
CBA – Cost Benefit Analysis
CDD – Capability Development Document
CoP – Community of Practice
COTS – Commercial-off-the-shelf Product
CPD – Capability Production Document
DAB – Defense Acquisition Board
DAG – Defense Acquisition Guide
DoD – Department of Defense
DoDD – Department of Defense Directive
DoDI – Department of Defense Instruction
DOTMLPF – Doctrinal, Organizational, Training, Materiel, Leadership, Personnel and Facilities
DT&E – Development Test and Evaluation
DTIC – Defense Technical Information Center
EA – Executive Agency
EHFA – Early Human Factors Analysis
ESC – Electronic Systems Center
ESH – Acquisition Environmental, Safety & Health
ESOH – Environment, Safety, and Occupational Health
FA – Fighter Attack
FAA – Functional Area Analysis
FAA – Federal Aviation Administration
FFRDC – Federally Funded Research and Development Center
FNA – Functional Needs Analysis
FOC – Full Operational Capability
FSA – Functional Solution Analysis

GOTS – Government Off the Shelf
GS – General Schedule
Ha – Habitability
HASC – House Armed Service Committee
HF – Human Factors
HFE – Human Factors Engineering
HFI – Human Factors Integration
HPSM – Human Performance Systems Model
HPT – High Performance Team
HQDA – Headquarters, Department of the Army
HSI – Human Systems Integration
HSIP – Human Systems Integration Plan
ICD – Initial Capability Document
ILS – Integrated Logistics Support
IMPACTS – Integrated Manpower Personnel and Training System
IMPRINT – Improved Performance Research Integration Tool
IOC – Initial Operations Capability
IOT&E – Initial and Operational Test and Evaluation
IPT – Integrated Product Team
ISR – Intelligence, Surveillance, Reconnaissance
ITEAP – Integrated Test and Evaluation & Acceptance Plan
JCIDS – Joint Capabilities Integration and Development System
JSSG – Joint Service Specification Guides
KPP – Key Performance Parameter
KSA – Key System Attribute
LCC – Life-Cycle Cost
LCCE – Life-Cycle Cost Estimate
LCMP – Life Cycle Management Plan
LRS – Longe Range Strike
M&S – Modeling and Simulation
MAJCOM – Major Command (U.S. Air Force)
MANPRINT – Manpower and Personnel Integration
MDR – Milestone Decision Review
MER – Manpower Estimate Report
MIL-HDBK – Military Handbook
MIL-STDS – Military Standards
MOB – Mobility
MoD – Ministry of Defense
MOE – Measure of Effectiveness
MOP – Measure of Performance
MPT – Manpower, Personnel, and Training
NAVSEA – Systems Engineering, Acquisition, and Personnel Integration
NBC – Nuclear, Biological, Chemical
NDI – Non Developmental Item
NPGS – Naval Post Graduate School
NVIS – Night Vision Imaging System
OSD – Office of the Secretary of Defense
OT&E – Operational Test and Evaluation
PE – Performance Enhancement Directorate
PEC – Concept of Operations Division (711 HPW/PEC)
PEO – Program Executive Officer
PER – Performance Enhancement Research Division (711 HPW/PER)
PESHE – Programmatic Environment, Safety
PEX – Warfighter Operations Division (711 HPW/PEX)
PM – Program Manager

PME – Professional Military Education
PMR – Project Management Review
POC – Point of Contact
PSMP – Product Support Management Planning
RDECOM – Research, Development, & Engineering Command
RDT&E – Research, Development, Testing, and Evaluation
RFP – Request for Proposal
ROI – Return on Investment
S&T – Science and Technology
SAB – Air Force Scientific Advisory Board
SAMP – System Acquisition Management Plan
SE – Systems Engineer
SEMP – System Engineering Management Plan
SEP – Systems Engineering Plan
SG – Surgeon General (AF/SG = Air Force Surgeon General)
SL – Science of Learning
SME – Subject Matter Expert
SOF – Special Operations Force
SOO – Statement of Objectives
SORD – Soldier Oriented Research & Development Program
SOW – Statement of Work
SPO – Special Program Office
STP – Systems Technology Program
SV – Survivability
TEMP – Test and Evaluation Master Plan
TMP – Task Management Plan
TRAC – TRADOC Analysis Center
UAV – Unmanned Aerial Vehicle
WBS – Work Breakdown Structure