Human Systems Integration Guidebook

May 2022

Office of the Deputy Director for Engineering

Office of the Under Secretary of Defense
for Research and Engineering

Washington, D.C.

Human Systems Integration Guidebook

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Human Systems Integration Guidebook Change Record

Date	Change	Rationale

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CONTENTS

Figures

Tables

1 INTRODUCTION

This guidebook addresses Human Systems Integration (HSI) in Department of Defense (DoD) acquisition. HSI supports the systems engineering and program management effort to provide integrated and comprehensive analysis, design, and assessment of requirements, concepts, and resources for seven HSI domains recognized by DoD:

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

This document provides guidance regarding all the HSI domains in a total-systems approach. Program Managers (PMs), Systems Engineers, Test and Evaluation (T&E) representatives, and Product Supportability Managers (PSMs) can use the guidebook to (1) identify and use tools, techniques, approaches, and methods (TTAMs) to infuse HSI activities into systems engineering practice and the acquisition process, and (2) understand the importance for budgeting for and leveraging Component HSI Subject Matter Experts (SMEs) and HSI practitioners to conduct HSI for a program within defense system acquisition. The guidebook explains how HSI minimizes total ownership costs (TOC) and optimizes total system performance (TSP) over the life cycle of a program. Much of this information appeared previously in the Defense Acquisition Guidebook (DAG) Chapter 5, Manpower Planning and Human Systems Integration. The DAG has been superseded by individual guides in focus areas such as this one.

This Introduction discusses the purpose of the guidebook and relevant DoD HSI policy.

Section 2, Overview of Human Systems Integration, provides the definition, goals, objectives, benefits, and return on investment of HSI; describes a total systems approach and how HSI contributes to near- and long-term program objectives; and describes how aspects of HSI relate to risk identification and mitigation to achieve desired end states.

Section 3, Integration Role across HSI Domains, describes the seven domains including their goals and objectives, and discusses the relationships between and among the domains.

Section 4, DoD HSI Domains, describes how Component HSI SMEs, HSI domain-level representatives, and HSI practitioners integrate and facilitate trade-offs among HSI domains, assimilating considerations and recommending best practices.

Section 5, HSI Tools and Methods, discusses HSI tools, techniques, approaches, and methods.

Section 6, HSI Workforce Advancement, describes tools and resources for HSI education and workforce training.

Section 7, HSI Communities of Practice, describes the HSI Community of Practice (CoP) and the Joint HSI Working Group (JHSIWG).

The guidebook also includes a glossary, acronyms, and references relating to HSI.

The purpose of HSI is to provide equal consideration of the human element along with the hardware and software processes in order to engineer a system that optimizes TSP and minimizes TOC. The PM staff, specifically the Lead Systems Engineer with HSI practitioner support, analyze requirements to optimize TSP and determine the most effective, efficient, and affordable design. The PM staff should use the analysis of the HSI domains to help determine and investigate the science and technology gaps to address all aspects of the system (hardware, software, and human).

The PM should ensure that system requirements are integrated across the HSI domains and within the total system. As the program completes work to satisfy these requirements, each HSI domain representative should anticipate and respond to changes made by other domains or that may be made within other processes or imposed by other program constraints. The PM should reflect these integration efforts in updates to the requirements, objectives, and thresholds in the Capability Development Documents (CDDs).

1.1 HSI in Statute, Policy, and Guidance

PMs and HSI stakeholders should know and understand the statutory and regulatory mandates for HSI, as these mandates provide the basis for DoD HSI policy and guidance. The Joint HSI Steering Committee addendum "Reference Manual of Congressional Language Relevant to Human Systems Integration" (JHSISC Charter, June 2020) lists HSI-related statutory, regulatory, congressional requirements, budgets and investments, and activities. The addendum is available from the DAU HSI Community of Practice (CoP) website (HSI CoP).

DoD published mandatory HSI direction to the PM in Department of Defense Directive (DoDD) 5000.01, "The Defense Acquisition System" (September 2020), DoD Instruction (DoDI) 5000.02, "Operation of the Adaptive Acquisition Framework" (January 2020), and DoDI 5000.05, "Human Systems Integration" (April 2022).

DoDD 5000.01 states:

> *"Human systems integration planning will begin in the early stages of the program life cycle. The goal will be to optimize total system performance and total ownership costs, while ensuring that the system is designed, operated, and maintained consistent with mission requirements."* (DoD Directive 5000.01)

DoDI 5000.95 states:

> *"Component capability developer or program manager will:*
>
> > *a. Plan for and implement an HSI program from initial user requirements through the program life cycle to system disposal, appropriate to the system's acquisition pathway. The goal is to: (1) Optimize total system performance; (2) Reduce total ownership costs; (3) Ensure that the system is designed to be operated, maintained, and supported while providing users with the ability to effectively complete their mission(s).*
> >
> > *b. Perform, document, and manage program and systems human-centered design considerations and readiness risks through trade-off analyses among the HSI domains. The trade-off analyses will ensure human performance data systematically informs and facilitates total system performance in both materiel and non-materiel solutions during SE activities.*
> >
> > *c. Ensure that DoD Component HSI subject matter experts (SMEs) and HSI practitioners are engaged with working groups tasked with the development and review of program documents that: (1) Manage HSI planning; (2) Report on HSI program and HSI domain level execution to the OSD and DoD Component heads assigned responsibilities in Section 2 throughout the course of the program; (3) Inform program managers on acquisition program decisions."* (DoD Instruction 5000.95)

DoD policy requires PMs to address reliability, supportability, and maintainability in the early phases of the program, with HSI as an element of both engineering and product supportability (PS). The key to a successful HSI strategy is comprehensive integration across the HSI domains and through other core acquisition and engineering processes. Programs will conduct HSI planning that includes the comprehensive integration of all human-centric requirements impacting human safety and performance, and personnel-driven ownership costs (DoD Directives; DoD Instructions).

The OUSD(R&E) Engineering of Defense Systems Guidebook (2022) and Systems Engineering Guidebook (2022) replace the former DAG Chapter 3 and include considerations relating to HSI.

Links to these and other guides are available on the OUSD(R&E) Engineering References for Program Offices web page (ENG References).

1.2 Adaptive Acquisition Framework Pathways

DoDI 5000.02 introduced the Adaptive Acquisition Framework (AAF) pathways. Acquisition programs are to follow one of six pathways, depending in part upon the urgency of the need, the maturity of the technology, and the type of system (e.g., hardware versus software) under development. HSI will continue to be relevant for any acquisition program, regardless of which pathway it follows. As the AAF pathways shift to the new acquisition authority instructions, DoD will continue to tailor HSI guidance to reflect the needs of the pathways (AAF pathways).

The 2020 DoDD 5000.01 states, "Human systems integration planning will begin in the early stages of the program life cycle." The corresponding instruction, DoDI 5000.02, states, "The AAF supports the DAS (Defense Acquisition System) with the objective of delivering effective, suitable, survivable, sustainable, and affordable solutions to the end user in a timely manner."

Efforts are under way by the DoD HSI community to define the HSI role for PMs to implement the DoDI 5000.02 within each of the AAF pathways. HSI subject matter experts (SMEs) are developing future case studies and applying lessons learned. Future updates to this guidebook will include guidance outlining the HSI role and activities pertaining to each pathway.

1.3 Best Practices

The Section 4 discussion of HSI domains highlights HSI best practices. A best practice is generally a procedure demonstrated by research and experience to produce optimal results and therefore is proposed as a standard for widespread adoption in a field. DoD best practices include techniques, guidance, and lessons learned that assist practitioners and stakeholders to successfully execute DoD policy. The processes, approaches, and methods proposed in this guidebook as best practices, including the use of TTAMs in some cases, have been peer-reviewed with oversight by the JHSIWG.

2 HUMAN SYSTEMS INTEGRATION OVERVIEW

2.1 HSI in DoD

HSI is a comprehensive, interdisciplinary management and technical approach applied to system development and integration as part of the wider systems engineering process to ensure that human performance is optimized to increase TSP and minimize total system ownership costs. The definition of HSI is the systems engineering process and program management effort that provides integrated and comprehensive analysis, design, and assessment of requirements, concepts, and resources for the seven HSI domains (manpower, personnel, training, HFE, habitability, safety and occupational health (SOH), and force protection and survivability) (DoDI 5000.95). The domains are interrelated and interdependent and must be among the primary drivers of effective, efficient, affordable, and safe system designs. HSI integrates and facilitates trade-offs among these domains and other systems engineering and design requirements but does not replace individual domain activities, responsibilities, or reporting channels (ENG HSI).

In this regard, HSI employs a tailored, total system approach addressing system components including humans, technology (hardware and software), the operational context, and the necessary interfaces among the system elements to make them all work in harmony. The total systems approach includes equipment and software as well as people who operate, maintain, and support the system (including those involved with the creation and implementation of training requirements and training devices, the operational and support infrastructure, etc.). HSI specifically addresses the human element as integral to the total system.

In today's joint environment, integration across systems of systems is necessary to achieve a fully networked joint warfighting capability. The user requires a fully networked environment that can operate efficiently and effectively across the continuum of systems—from mission planning to initial threat detection through mission completion. To fully accomplish this integration, the program office should consider HSI domains and human capabilities and constraints within analytic assumptions and system-of-systems analysis, modeling, simulation, and testing. This analysis provides opportunities for integration, synchronization, collaboration, and coordination of capabilities to meet human-centered requirements.

It is not enough to be knowledgeable in each of the HSI domains. HSI practitioners should be skilled at knowing how to leverage resources among the domains to influence the performance of the total system (Shattuck and Bellenkes 2017). When effectively integrated into all activities associated with program capability planning, development, acquisition, and sustainment activities and across all domains, HSI practitioners help to "ensure that the human component of a system enhances that system's effectiveness and minimizes TOC. Incorporating HSI early in system design promotes more successful and effective transition of capability to the Warfighter" (ENG HSI). As a result, HSI is required by DoD acquisition policy as part of the systems engineering process. Each of the seven HSI domains will be discussed further in Section 4.

2.2 HSI Benefits for Return on Investment

Practicing HSI helps ensure human considerations, such as capabilities and limitations, are incorporated into all steps during the system acquisition process. As such, the HSI practitioner supports the PM in providing the capabilities required in the projected operational environments to accomplish the assigned missions, which helps ensure that users can effectively operate systems.

When effectively integrated into system acquisition and design processes, HSI efforts should:

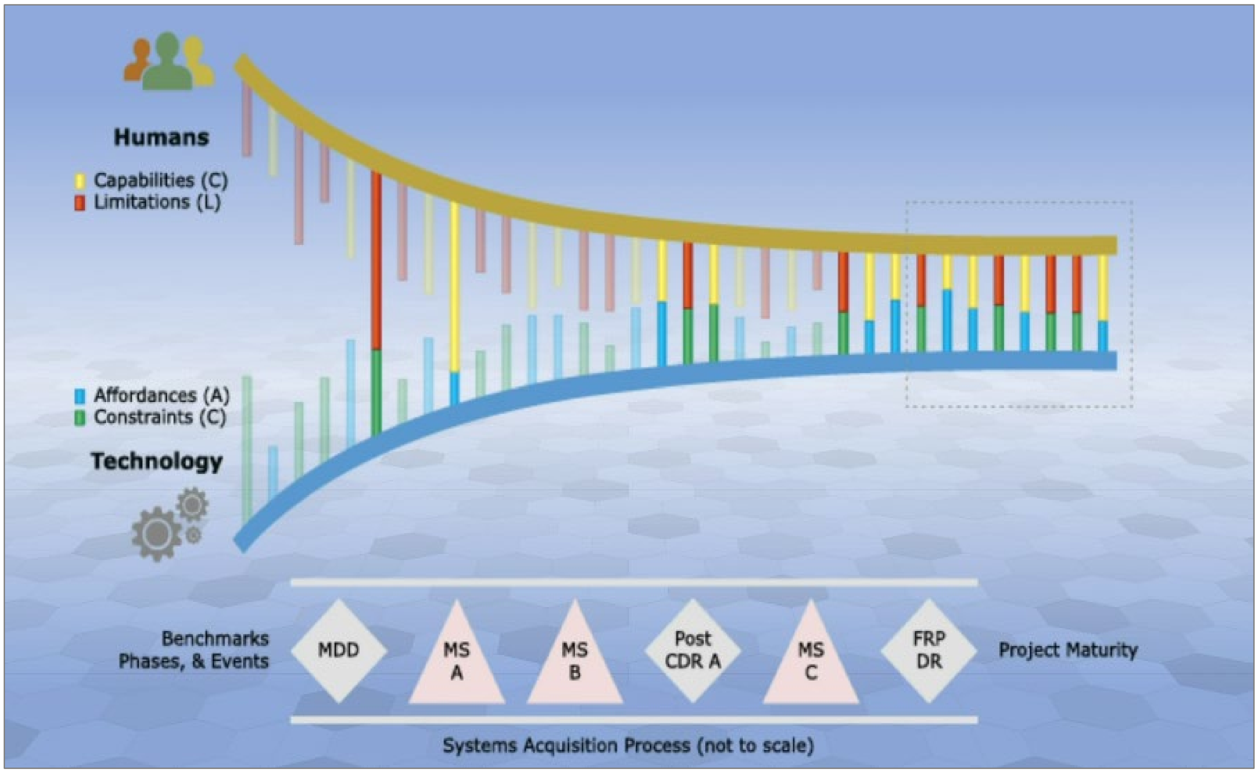
- Provide a better operational solution to the users.
- Lead to the development or improvement of all human-machine interfaces (HMI).
- Achieve required effectiveness of human performance during system testing, operation, maintenance, support, transport, demilitarization, and disposal.
- Plan and account for demands upon personnel resources, skills, training, and costs at every stage in the system life cycle.
- Ensure that overall human performance is within the knowledge, skills, and abilities (KSAs), and other attributes of the designated operators, maintainers, trainers and support personnel (i.e., users) to support mission tasking.

The payoff for using HSI in all acquisition planning is enormous. Cost benefits include improved use of manpower, reduced training costs, reduced maintenance time, and improved user acceptance, all of which decrease overall program costs. Improved operational availability and performance can result in fewer errors, and improved design trade-off decisions can reduce life cycle costs and decrease the need for redesigns and retrofits. Addressing HSI from the earliest stages of acquisition and throughout the acquisition process, regardless of acquisition pathway, can help a program realize the HSI benefits.

2.2.1 Optimizing Total System Performance

A principal benefit of integrating HSI into the acquisition process is to help ensure system users can perform their missions in a more effective, efficient, and safe manner. The HSI practitioner identifies hardware, software, and performance, requirement-based affordances and risks whereby human capabilities and limitations have the potential to impact TSP. O'Neil (2014) described "the core activity of HSI" as "the balancing of human capabilities and limitations with the affordances and constraints presented by system technology, to accomplish system objectives. What technology permits (affordances) and what it does not allow (constraints), must align with both what a human can do (capabilities) and cannot do (limitations)."

Figure 1 presents a Human-Technology Integration Model by O'Neil (2014) that illustrates how HSI contributes to optimizing total system performance throughout the acquisition process.



Source: O'Neil 2014

Figure 1. The Human-Technology Integration Model

The horizontal axis along the bottom of the diagram shows the principal way points (benchmarks, phases, and events) characterizing the Major Capability Acquisition pathway. These way points help to establish the model's context. Above this, from left to right appears to be closing the "zipper." The vertical axis to the left includes the icons representing humans and technology. The goal of the process is to achieve total system integration by combining or integrating the human and technological components. A video description for the Human-Technology Integration model is available at the DAU HSI CoP website (HSI CoP).

To attain TSP, the HSI practitioner should be able to (a) provide advocacy for HSI domain inputs (to be discussed in the following sections); (b) identify and assess the impacts of system enablers and constraints (including affordances and risks) associated with each domain; (c) collect, assess, interpret, and report on data providing the first order outcomes of said assessments; and (d) ensure these efforts will yield a product meeting or exceeding contractual system requirements.

In carrying out this process, the HSI practitioner should be certain to:

- Analyze, assess, and report on required/expected/actual system operational effectiveness, suitability, survivability, safety, and affordability throughout the acquisition process.
- Provide PMs with timely and accurate HSI-based data throughout the acquisition process, so decision makers fully understand the HSI-based capabilities and limitations of human

performance, the affordances and constraints associated with hardware and software designs, and the risks (if any) to the program that these may pose to achieving TSP.

- Ensure that PMs and Systems Engineers understand how design changes affecting one HSI domain will, in turn, affect one or more of the other domains. They should be able to ascertain the effects of these multi-domain impacts during design on TSP.
- Ensure program processes and mandatory and supporting documentation (e.g., Systems Engineering Plan) include system safety.
- Conduct upfront requirements analyses and write concise, verifiable HSI requirements.

It is imperative that HSI practitioners make certain program requirements address the human as an active system component that can and will directly impact overall TSP.

2.2.2 Optimizing Total Ownership Costs

HSI optimizes TOC by presenting viable options to decision makers with long-term cost-effectiveness. With this in mind, the HSI practitioner should develop alternative concepts for reducing life cycle cost by applying HSI. For each concept, the HSI practitioner should be able to identify major drivers of TOC and a support strategy for life cycle sustainment and continuous improvement of product affordability, reliability, and supportability, while sustaining readiness.

The HSI practitioner should plan an affordability assessment of the implications of HSI for each design concept and each support strategy. The assessment involves determining life cycle resource requirements for operational and maintenance manpower, training, personnel non-availability due to accident, expected human error rates, expected time to repair, requirements for supportability, and requirements resulting from expected system downtime. The affordability assessment should incorporate HSI with the design concepts to reveal whether design concepts encounter problems with HSI affordability factors and to recommend changes to design concepts to improve the performance of the HSI affordability factors.

2.2.3 The HSI Investment Imperative

Given the benefits of employing HSI, the HSI practitioner should ensure the PM has complete, accurate data and rationale to support investing in the manpower, temporal, fiscal, and physical resources necessary to yield positive outcomes and to ensure the investment occurs early and throughout the acquisition process. HSI practitioners have documented numerous cases in which investing in HSI allowed a program to realize cost, schedule, and performance benefits while lowering program risks and yielding safe and effective systems, at times exceeding design requirements (Liu et al. 2010; NASA HSI Handbook 2021; National Research Council Case Studies 2007). On the other hand, when PMs minimize or waive HSI-related efforts in order to invest resources in other aspects of a program, these documented lessons learned consistently show detriment to effective, suitable, and survivable system design and delivery, and increased risks to achieving TSP at the lowest TOC.

2.3 HSI throughout the Acquisition Life Cycle (Total Systems Approach)

HSI addresses the human element of the system and considers the human as integral to the system. The hardware, software, and human components of a system function together as a unit, which dictates that they be evaluated together. The HSI practitioner focuses on the human performance and effectiveness within a total systems approach as shown in Figure 2.

For a total systems approach, consider the following:

- Use a top-down approach (viewing a holistic system throughout the life cycle)
- Remember "system = hardware + software + human"
- Consider the human role in the mission along with technology development
- Assess HSI-related risk (early trend analysis, legacy system information, and known domain risk) to inform the process
- Employ HSI processes, models, and tools throughout the life cycle, whether for a commercial off-the-shelf or full development program

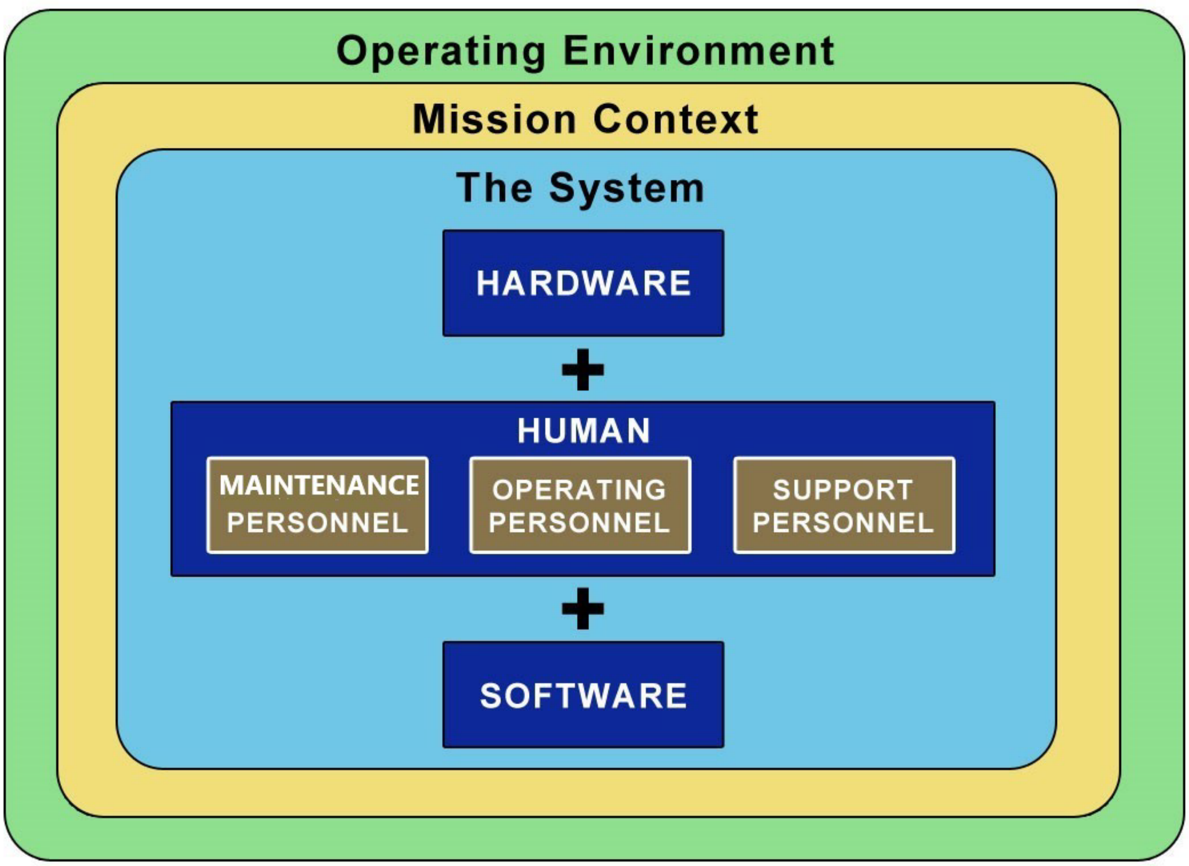


Figure 2. Total Systems Approach

The HSI practitioner role includes the following activities:

- Advise programs on the HSI process and related policies and standards
- Assist in planning solutions
- Provide input on requirements
- Advise regarding HSI-related trade-offs in design
- Assess the total system for human-related risk, and track and mitigate risks

The HSI practitioner has a role both in systems engineering and in product support to ensure consideration of the human as part of the total system throughout the acquisition life cycle, with the goal of optimizing mission effectiveness.

Often, in program reviews and design decisions, human-related considerations are not adequately addressed during system design. In this case, the process of adjusting human-system and technical requirements is called a "trade-off" analysis, and is implemented to attempt to meet cost, schedule, and performance metrics. While all of these are important metrics and considerations, the HSI practitioner should ensure the program considers the characteristics, capabilities, and limitations of the users during these trade-off decisions.

The total systems approach includes equipment and software as well as people who operate, maintain, and support the system; training requirements and training devices; and the operational and support infrastructure. Top-down HSI analysis identifies the human roles (e.g., operators, maintainers, trainers, support personnel) and the allocation of functions to human, hardware, or software. It includes three elements that focus on human capabilities and limitations in the context of mission capabilities and requirements: mission analysis, functional analysis, and task analysis. Consistent with DoDI 5000.95, the PM will address each of the HSI domains. A comprehensive integration within and across these domains is required (see Section 3).

Integrated Product and Process Development (IPPD) is a management technique that integrates all acquisition activities, starting with a capabilities definition through systems engineering, production, fielding/deployment, and operational support in order to optimize the design, manufacturing, business, and supportability processes. At the core of the IPPD technique are Integrated Product Teams (IPTs), and programs should consider HSI when forming IPTs. Systems engineering IPTs, design teams, and other IPTs that deal with human-oriented acquisition topics should include HSI representatives as members. The various HSI domain SMEs should have the opportunity to work in an integrated structure to impact the system comprehensively. Domain SMEs working different IPT structures may make significant changes/inputs to the system without fully appreciating the effects their changes may have on other domains. Only by working closely together can the HSI practitioners bring an optimum set of human interfaces to the systems engineering and acquisition processes.

HSI practitioners assist in IPPD as part of the IPTs by ensuring the HSI requirements in the Initial Capabilities Document (ICD), CDD, and Capability Production Document are based upon and consistent with the user representative's strategic goals and strategies. These requirements are addressed throughout the acquisition process, starting in the Capabilities-Based Assessment (CBA) and ICD and continuing throughout the engineering design, trade-off analysis, testing, fielding/deployment, and operational support phases.

The HSI practitioner uses performance and HSI domain issues, identified in legacy systems and through design capability risk reviews, to establish a preliminary list for risk management. HSI should evaluate and manage these issues and risks throughout the system's life cycle at a management level consistent with the hazard.

The tools, methodologies, risk-assessment and mitigations, and set of assumptions are artifacts used by the acquisition community, the functional communities, and user representatives to evaluate performance and establish performance-based metrics. These artifacts can help to assess manpower, personnel, and training requirements; measure human-in-the-loop system performance; and evaluate SOH hazards, survivability, and habitability.

The HSI practitioner should ensure that the factors the acquisition community uses to develop cost estimates are consistent with:

- Manpower and personnel documentation requirements, such as the Cost Analysis Requirements Description (CARD) and Target Audience Description (TAD)
- Training requirements reported in the DoD Component system training plans
- SOH assessment requirements and selected mitigation measures for safety and health hazards documented in the Hazard Tracking System (HTS)/Database

The HSI practitioner should ensure that the Manpower Estimates and Training Strategies reported during the acquisition milestone reviews are reflected in the manning documents, training plans, personnel rosters, and budget submissions when the systems are fielded.

2.4 HSI Planning and Risk Management

Acquisition system designs have historically been overly complex and difficult to train, learn to use and operate, and maintain. Through the principles of HSI, system designs can enable mission and program success to be easier to train, operate, and maintain; to be safe, efficient, and cost-effective; and to minimize redesign. Programs should use inputs from the HSI domains to determine and address performance impacts to all aspects of the system (hardware, software, and human).

HSI and domain-level analyses may indicate deficiencies or concerns about the combat capability of the system. Risks, issues, or opportunities (RIO) may be tied to the maintainer's ability or inability to perform discrete maintenance tasks (e.g., those contained in a set of procedures). In that case, solutions might include system redesign, procedural changes, or embedded training. Lessons learned create opportunities and ability to minimize risk early in acquisition.

General considerations for HSI planning and risk management include the following:

- When users are subject to information overload and required to integrate data from multiple sources dynamically, they risk loss of situational awareness and overall readiness.
- Common user interfaces, information sources, and system workload management can present areas of risk and should be carefully considered.
- There may be opportunity for trade-offs among HSI concerns including human performance and the program risk categories of cost, schedule, and system performance.
- With early planning and consistent HSI execution, HSI products can contribute to the mitigation of risks across the program.

2.4.1 HSI Planning

Per DoDI 5000.95, the Component capability developer or PM will "plan for and implement an HSI program from initial user requirements through the program life cycle to system disposal, appropriate to the system's acquisition pathway", or during improvement to an existing capability is first established. To satisfy the requirements of DoDI 5000.02, the PM should have a plan for HSI in place before entering Engineering and Manufacturing Development.

The PM should engage with or contract for HSI expertise (practitioners) to assist in developing an HSI approach and plan that allow for the requisite resources, activities, and manpower to satisfy data collection and analysis criteria throughout the system's acquisition phases. The PM should describe the technical and management approach for meeting HSI parameters in the capabilities documents, and identify and provide ways to manage HSI-related cost, schedule, or performance issues that could adversely affect program execution. HSI planning should address how the linkage between HSI and the domains' concerns for program execution are incorporated into the relevant PM documentation.

The PM's risk management program should address HSI risks and risk mitigation. PMs should use the HSI plan to describe the process for identifying HSI risks and the associated cost, schedule, and performance impacts and the process for developing associated risk mitigation plans. HSI-related risks should be clearly identified and included among the other risks the PM manages and documents.

The HSI plan should address potential readiness or performance risks and how these risks should be identified and mitigated. For example, skill degradation can impact combat capability and readiness. The HSI plan should call for studies to identify operations that pose the highest risk of skill decay.

The HSI plan should reference the areas of the Programmatic Environment, Safety, and Occupational Health Evaluation (PESHE) that summarizes Environment, Safety, and Occupational Health (ESOH) risk information (hazard identification, risk assessment, mitigation decisions, residual risk acceptance and evaluation of mitigation effectiveness). In addition, the program and decision makers should plan to address HSI issues at system technical reviews and milestone decision reviews. For more information, see the DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs (2017).

2.4.2 HSI Risk Identification and Mitigation

Program risks related to cost, schedule, performance, supportability, or technology can negatively affect program affordability and supportability. The PM should prepare multiple courses of action to mitigate any such negative effects on HSI objectives. For example, if the proposed system design relies heavily on new technology or software to reduce operational or support-manning requirements, the PM should be prepared with design alternatives to mitigate the unexpected impacts of technology or software to support the system.

System safety engineering hazard analyses, system safety management activities, Critical Task analyses, and Human Reliability Analysis (HRA) provide the data necessary to identify user inputs and interactions and quantify the human error associated with various human tasks in operating, maintaining, and supporting a system. HRAs are probabilistic risk assessments, also known as human error probabilities (HEPs), and are used to determine the probability that the human elements will function as intended over specified time under realistic conditions. The purpose is to quantify human-related reliability and incorporate this into the broader system reliability, availability, and maintainability (RAM), SOH issues, hazards, and risk analyses and calculations. The HRA data is a component of the procuring activity's identification, quantification, and assessment of program risk.

The Military Standard (MIL-STD) 882, DoD Standard Practice System Safety, is a key element of the larger SE process that provides a standard, generic method for the identifying, classifying, and mitigating hazards. MIL-STD 882 provides a system safety process, which informs risk identification for multiple HSI domain-level activities. For general risk management, this system safety process can still be applied to other areas of risk.

3 INTEGRATION ROLE ACROSS HSI DOMAINS

HSI practitioners are responsible for integrating and facilitating trade-offs among HSI domains, assimilating considerations, and providing recommendations. HSI domains are interrelated and interdependent, such that the HSI practitioner should consider trade-offs among the primary drivers of effective, efficient, affordable, and safe system designs. HSI trade-off analyses between and among the domains will assist PMs in the decision-making process to improve system performance, increase mission effectiveness, and reduce programmatic risk to the extent possible within program constraints. HSI activities do not replace individual domain activities, functional responsibilities, or program reporting channels.

3.1 Inter-Domain Relationships

Often, a close relationship exists between certain domains, either through common or competing requirements, overlapping activities, or risk management implications. Decisions made for one domain can affect another. In many cases, decisions are driven by the trade-off analyses of technical requirements, cost factors, programmatic constraints and the available trade space is determined. Each option considered in these analyses of alternatives should be managed with the best available information. Therefore, it is the HSI practitioner's responsibility to analyze the trade space between the domains to highlight human performance capabilities and limitations, and provide recommendations for the engineers and PMs to address technical and programmatic impacts to cost, schedule, performance, and risk reduction.

HFE SMEs are often included in Habitability and Force Protection and Survivability (FP&S) domain activities with SOH personnel. Larger, more complex systems that require facilities and support equipment in order to operate, maintain, and support the system increase the number of touch points for personnel. In many cases, trade-off studies will result between the Habitability, FP&S, and SOH domains. Safety and HFEs (or crew systems engineers) should be supported by HSI practitioners to help identify risk factors associated with complex systems where work spaces are susceptible to long-term habitability issues, health hazards, or fratricide to personnel or crew members.

The Manpower, Personnel, and Training (MPT) domains are commonly linked when considering unit or crew makeup. Staffing a crew depends on the KSAs and other attributes required to perform the necessary tasks under the expected workload, derived from the task analysis, functional allocation, and workload analysis. Based on the classification, the number of each specialty (manpower) required for each crew is determined by the expected workload and level of expertise (HFE and Personnel). The balance of desired manpower and personnel requirements with training considerations creates a large trade space, usually driven by the associated costs. The HFE activities are inputs into MPT solutions that can facilitate implementation of these domain-level interactions in the HSI management activities (HFE and MPT).

The holistic examination of HSI domains should roll up into three overarching concepts — usability, operational suitability, and sustainability:

- Usability: "Cradle-to-grave" including operations, support, sustainment, training, and disposal. This includes survivability and habitability.
- Operational Suitability: Includes utility, operability, interoperability, dependability, survivability, and habitability.
- Sustainability: Includes supportability; survivability; RAM; accessibility; dependability; interoperability; interchangeability; survivability and habitability.

3.2 Doctrine, Organization, Training, Materiel, Leadership, Personnel, Facilities, and Policy

DoD uses the Joint Capabilities Integration and Development System (JCIDS) to identify warfighter requirements, and the process has a unique relationship to the formal defense acquisition process HSI domains. According to the current JCIDS Manual (2021): "DOTmLPF-P analyses should identify and address HSI." The HSI practitioner, using the DOTmLPF-P framework along with HSI, can optimize human and system performance through materiel and non-materiel solutions. The DOTmLPF-P areas can directly map to or have an effect on various HSI domains. The HSI practitioner should consider HSI and DOTmLPF-P domains in the trade-off process to mitigate the impacts of cost, schedule, and risk on TSP. Figure 3 depicts a crosswalk example of the DOTmLPF-P and HSI interactions.

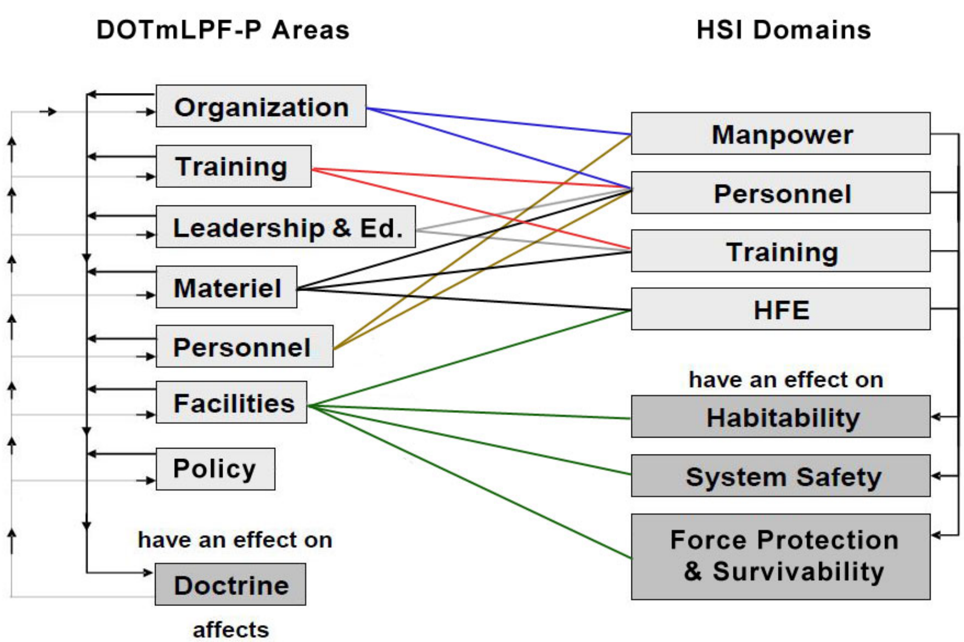


Figure 3. DOTmLPF-P and HSI Crosswalk Example

Table 1 provides a more detailed view of the example in Figure 3. Table 1 aligns each DOTmLPF-P domain with the corresponding HSI domains presented in Figure 3, including rationale for the application of each HSI domain.

Table 1. DOTmLPF-P and HSI Touch Points for Example

HSI Touch Points	Relevant Domains	Rationale
Doctrine: the way we fight (e.g., emphasizing maneuver warfare, combined air-ground campaigns)	All domains	DoD may review and revise the current doctrine to ensure it provides appropriate guidance for evolution of equipment, management, training, and procedures in the future
Organization: how we organize to fight (e.g., divisions, air wings, Marine-Air Ground Task Forces)	Manpower / Personnel	HSI concerns the manner in which management, personnel, and equipment are planned and used across the organization
Training: how we prepare to fight tactically (basic training to advanced individual training, unit training, joint exercises, etc.).	Training / Personnel	Warfighters need to be technically skilled in all facets of their jobs at specified skill levels, to fulfill their roles supporting the organization mission
Materiel: all the “stuff” necessary to equip U.S. forces that DOES NOT require a new development effort (weapons, spares, test sets, etc. that are “off the shelf” both commercially and within the government)	HFE / Personnel / Training	Human factors engineering can help determine usability for the right personnel who are appropriately trained
Leadership and education: how we prepare the command structure (squad leader to 4-star general/admiral - professional development)	Training / Personnel	Resources need to be provided and standardized to improve leadership skills and education to prepare individuals for leading units to accomplish the mission
Personnel: availability of qualified people for peacetime, wartime, and various contingency operations	Personnel / Manpower	Personnel selection, retention, and utilization impact the effectiveness of the mission
Facilities: real property, installations, and industrial facilities (e.g., government owned ammunition production facilities)	HFE / Habitability / FP&S / SOH	Real property is used for operations, maintenance, and support to provide accommodations and protection for personnel and equipment
Policy: DoD, interagency, or international policy that impacts the other seven non-materiel elements.	All domains	Policies may prevent the mission from being accomplished and affect multiple domain areas

The requirements community manager should identify touch points between the DOTmLPF-P elements and HSI domains and should assess, document, and include HSI-related considerations in the CDD during the development of system requirements for DOTmLPF-P.

4 DoD HSI Domains

The goal of HSI is not to duplicate requirements that the Services and program stakeholders own but to integrate human concerns in balance with life cycle objectives comprehensively and robustly. The effective practice of HSI requires assessing the impact of HSI domains to arrive at viable recommendations for decision makers. Combinations of the HSI domains and the additional factors of systems engineering form the trade space for including HSI in risk assessment tests and evaluations. The PM and the HSI practitioner should address all HSI domains in acquisition planning efforts.

HSI domains are interrelated; changes in system design or capabilities could improve one HSI domain and adversely affect another. For example, reducing manpower or increasing skill levels for a specific maintenance job could increase training demands because more is required of the people performing the job. Program trade-off decisions should include the impact on HSI domains/issues. The following sections describe the seven HSI domains.

4.1 Manpower Domain

Manpower is the determination of the most efficient and cost-effective mix of available, authorized, and capable people (military, civilian, and contractor support) needed to operate, maintain, repair, support, and provide training for each system being acquired. Manpower is sometimes referred to as the “spaces,” in contrast with the “faces” of the personnel domain.

4.1.1 Definition

Manpower domain is the total number of personnel or positions required to perform a specific task. Indexed by requirements including jobs lists, slots, or billets characterized by descriptions of the people required to fill them and the number of people required to operate, maintain, train, and support a system.

4.1.2 Best Practices

Manpower can be a factor in determining program affordability over the life cycle. The requirements owner should be documenting all manpower assumptions within the requirements documentation. The PM conducts a manpower estimate to identify the manpower required to operate and maintain the system for military, government, and civilian personnel.

The PM reports manpower in the Life Cycle Cost Estimate and, for ACAT I programs (statute), in the CARD to the Office of the Secretary of Defense (OSD) Cost Assessment and Program Evaluation (CAPE). For all other ACAT programs, the Program Management Office (PMO) reports manpower to Service-level manpower authorities. According to the DoD 5000 series and Service-level policies, Manpower goals and parameters shall be based on a manpower methodology that can be validated and authenticated to substantiate the estimation: (1) design options that reduce workload and are essential for ensuring program affordability are pursued and not traded off in favor of other lesser priority design features; (2) ownership costs and manpower are kept at desired levels; and (3) future-year resources designated for other higher priority programs are preserved.

Manpower factors are those job tasks, operation/maintenance rates, associated workload, and operational conditions (e.g., risk of hostile fire) that are used to determine the number and mix of military and government civilian manpower and contract support necessary to operate, maintain, support, and provide training for the system. Manpower officials contribute to the defense acquisition process by ensuring that the PM pursues engineering designs that optimize manpower and keep human resource costs at affordable levels (i.e., consistent with strategic manpower documentation and plans).

Technology-based approaches used to reduce manpower requirements and control life cycle costs should be identified in the capabilities documents early in the process. For example, the developers can work with HSI practitioners to use automation to reduce operator and maintainer tasking, to use task reallocation to reduce workload, to use material-handling equipment to reduce labor-intensive material-handling operations, and to use simulation, simulators, and embedded training to reduce the number of instructors.

The PMO manpower methodologies are used to determine the total manpower needed to operate and maintain the system or systems associated with the specific occupational requirements. The PMO needs to consult Service-level policy and conduct IPTs with Service-level equities to determine the methodology best suited to estimate the manpower.

HSI practitioners should assist PMs to review the CARD, a component of the Independent Cost Estimate (ICE), and other supporting documentation to confirm that HSI has been appropriately included in the system overview, the DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs (2017), and system operation concept. The DOTmLPF-P assessment, when properly performed by each Service’s requirements generation office(s), should identify the manpower implications that the PM needs to address.

4.2 Personnel Domain

Personnel domain characteristics are the determination, consideration, and selection of the appropriate human aptitudes and KSAOs needed for humans to properly perform job tasks and functions required for the mission. Whereas manpower refers to the “spaces,” Personnel refers to the “faces” – the actual personnel and their skill sets.

4.2.1 Definition

Personnel domain are human aptitudes (i.e., cognitive, physical, and sensory capabilities); KSAs; and experience levels needed to properly perform job tasks and required to train, operate, maintain, and sustain materiel and information systems. The full definition of KSAs and other attributes can be found in the Glossary.

4.2.2 Best Practices

Personnel domain factors are used to develop the Total Force. Characteristics include but are not limited to occupation, occupational groups, job and occupational series (i.e., military occupational specialties (MOS) or equivalent DoD Component), and job function. Personnel officials contribute to the defense acquisition process by ensuring the PM pursues engineering designs that (1) minimize personnel requirements and (2) keep the human aptitudes necessary for operation and maintenance of the equipment at levels consistent with what will be available in the user population at the time the system is fielded.

Key personnel decisions or assumptions that have a significant effect on manpower (e.g., plans for developing new, or restructuring existing, career fields) should be identified through manpower analysis. According to DoDI 1100.22, the PMO should report in Service-level training plans whether any occupations require unique KSAs and other attributes that create personnel inventory shortfalls. Inadequacy of personnel could adversely affect military readiness or sustainment of the system.

4.2.2.1 Personnel Domain Requirements

PMs should work with the personnel domain and user community to define the performance characteristics of the user population, or target audience, early in the acquisition process. The PM should work with the personnel community to establish a TAD that identifies the cognitive, physical, social, and sensory abilities (i.e., capabilities and limitations) of the users expected to be in place at the time the system is fielded. When establishing the TAD, HSI practitioners should verify whether any recruitment or retention trends could significantly alter the characteristics of the user population over the life of the system. In addition, HSI analysts should consult with the personnel community and verify whether any new personnel policies could significantly alter the scope of the user population (e.g., policy changes governing women in combat significantly changed the anthropometric requirements for occupational specialties).

To the extent possible, systems should not be designed to require cognitive, physical, or sensory skills beyond those found in the specified (target) user population. During functional analysis and allocation, tasks should be allocated to the human component consistent with the human attributes (i.e., capabilities and limitations) of the target user population to ensure compatibility, interoperability, and integration of all functional and physical interfaces. Personnel requirements should be established that are consistent with the KSAs and other attributes of the user population expected to be in place at the time the system is fielded and over the life of the program. Personnel requirements are usually stated as a percentage of the population. For example, capability documents might require “a design wherein the multivariate central 90 percent of suitably clothed and equipped males of the target user population and the multivariate central 90 percent of suitably clothed and equipped females of the target user population will be able to use and fit the system to accomplish required physical tasks under consideration" (MIL-STD-1472H). Setting specific, quantifiable personnel requirements in the capability documents assists with the establishment of test criteria in the Test and Evaluation Master Plan.

The PM assesses the KSAs and other attributes of the intended operators and maintainers to ensure that the specific military or civilian personnel possess the required KSAs and other attributes to operate, maintain, and employ the equipment or software system(s) at the Service level. When a gap is identified, the PM develops solutions to mitigate the gap by designing the system to current KSA levels or recommending an increase or additional KSAs and other attributes of the occupational series.

4.2.2.2 Personnel Domain Planning

Personnel capabilities are normally reflected as KSAs and other attributes. The availability of personnel and their KSAs and other attributes should be identified early in the acquisition process. The DoD Components have a limited inventory of personnel available, each with a finite set of cognitive, physical, and psychomotor abilities. This could affect specific system thresholds.

The PM should use the TAD as a baseline for personnel requirements assessment. The TAD should include information such as inventory, force structure, standards of grade authorizations, personnel classification (e.g., Military Occupational Code/Navy Enlisted Classification), description, biographical information, anthropometric data, physical qualifications, aptitude descriptions as measured by the Armed Services Vocational Aptitude Battery (ASVAB), task performance information, skill grade authorization, Military Physical Profile Serial System (PULHES), security clearance levels, and other related factors.

The PM should assess and compare the cognitive and physical demands of the projected system against the projected personnel supply. The PM should also determine the physical limitations of the target audience (e.g., color vision, acuity, and hearing). The PM should identify any shortfalls highlighted by these studies. Systems fielded that exceed the current KSAs and other attributes of the military or civilian job series may result in that system's failure to meet Key Performance Parameters (KPPs) or Key System Attributes, due to the design's requirements that are beyond either the cognitive or physical abilities of the intended personnel pool. This will lead to increased maintenance repair times, decreased operational availability, increase in manpower costs, repair costs, mission degradation, increased human error, and maintenance-induced failures.

The PM should determine if the new system contains any aptitude-sensitive critical tasks. If so, the PM should determine if it is likely that personnel in the target audience can perform the critical tasks of the job. The PM should consider personnel factors such as availability, recruitment, skill identifiers, promotion and assignment. The PM should consider the impact on recruiting, retention, promotions and career progression when establishing program costs, and should assess these factors during trade-off analyses. The PM should use a truly representative sample of the target population during test and evaluation (T&E) to obtain an accurate measure of system performance. A representative sample during T&E helps identify aptitude constraints that affect system use.

The assessment should account for the ASVAB testing and MOS requirements as it relates to the occupational requirements and any technology incorporated into the materiel solution that may mitigate conflicts. Service-level MOS descriptions and requirements should be assessed and amended, if required, to ensure that Military Service members and government workers will meet the expected KPPs and Key System Attributes of the materiel solution. These changes are inexorably linked to the training solutions required of the material / software solution and to the MOS producing schools.

Individual system and platform personnel requirements should be developed in collaboration with related systems throughout the Department and in various phases of the acquisition process to identify commonalities, merge requirements, and avoid duplication. The PM should consider the cumulative effects of system-of-systems, family-of-systems, and related systems integration in the development of personnel requirements.

The PM should summarize major personnel initiatives that are necessary to achieve readiness or rotation objectives or to reduce manpower or training costs, when developing the acquisition strategy. The Life Cycle Sustainment Plans (LCSPs) should address modifications to the KSAs for system users and should highlight the modifications having cost or schedule issues that could adversely impact program execution. The PM should also address actions to combine, modify or establish new MOS or additional skill indicators, or issues relating to hard-to-fill occupations if they impact the PM's ability to execute the program.

HFE is able to assist and support MPT specialists with personnel assessment activities during all phases of the acquisition life cycle. The goal is to have in place any changes to job series requirements for recruitment or hiring prior to fielding the system.

4.3 Training Domain

Training is the domain concerned with the level of learning required to adequately perform the responsibilities designated to the function assigned to the system; the instruction and development of efficient and cost-effective learning process options and applied exercises for acquiring and retaining KSAs required to complete specific tasks. Training domain characteristics develop and sustain personnel domain and team-dynamic abilities that allow users to: acquire predetermined job-relevant KSAs and other attributes; enhance user capabilities and skill proficiencies for individual, collective, and joint training; and maintain skill proficiencies. The focus of training is on the instruction of personnel to enhance their capacity to perform specific functions and tasks.

4.3.1 Definition

Training domain is the policy, processes and techniques, training aids, devices, simulators and simulations, planning, and provisioning for the training, to include equipment used to train personnel to operate, maintain, and support a system.

4.3.2 Best Practices

The PM is responsible for training and educating military and civilian personnel in support of DoD material and software acquisition programs throughout the life cycle of the acquisition. Each Service has its own Service-level training planning, reporting, implementation, and sustainment requirements that the acquisition component must provide or meet.

Training and education functional elements follow the ADDIE model (Analysis, Design, Development, Implement and Evaluation). Training domain practitioners apply four learning theories (Behaviorism, Cognitive, Social, and Constructivist) in conjunction with the ADDIE model to implement a training solution for an acquisition program.

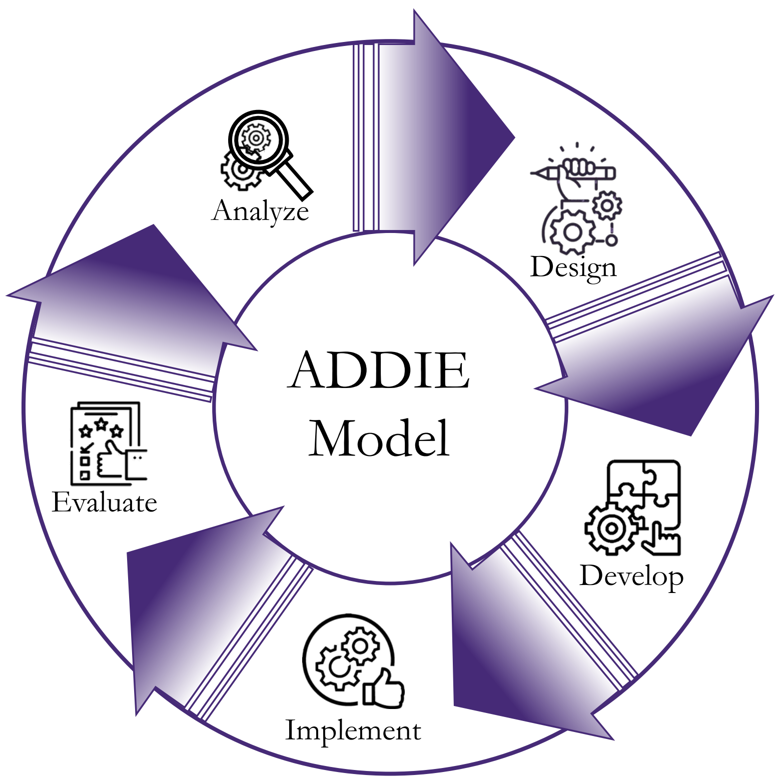


Figure 4. ADDIE Model

The goal of training and education is to make learning and skill attainment as efficient and effective as possible within the funding available for each phase of the program schedule. A program requires a skilled and educated training specialist to guide the training effort during system acquisition.

Personnel qualified to conduct and lead all phases of Instructional System Design (ISD) are certified under Instructional Systems Specialist, Office of Personnel Management (OPM) occupational series 1750. The series includes several positions, which typically involve duties described in one or more of the following nine functional categories. The examples are not intended to be restrictive or all-inclusive.

1. Occupational Analysis
2. Instructional Design
3. Instructional Materials Development
4. Training Aids and Devices
5. Instructional Services
6. Instructional Program Evaluation
7. Staff and Faculty Development
8. Tests and Measurement
9. Instructional Program Administration

The OPM 1712 Training Instruction Series also includes a range of positions involving instruction, or the administration, management, or development of programs of instruction. A position should be classified in this series if there is clear evidence that persons with training experience and knowledge of the subject being taught could satisfactorily perform the duties of the position.

Since persons in the 1712 series are capable of assisting an Instructional Systems Specialist, programs are encouraged to have both a 1750 and 1712 specialist supporting the PMO training efforts.

The DOTmLPF-P assessment from the requirements community identifies the Training implications the PMO needs to address and report.

4.3.3 Training Domain Planning

Upon receipt of the requirement; (e.g., Urgent Operational Need, CDD; CPD; Capability, Universal, or Operational Needs Statements) the PMO must begin its training planning. Each Service has its own regulatory requirements for training plans and reporting. Regardless of whether the terminology differs among the Services (US Army-STRAP, USMC-MPTP, USN-NTSP, USAF-STP), the PM should submit its applicable training plan or report to the appropriate Higher Headquarters (HHQ) responsible for reviewing and approving the PM’s training documentation. As each Service has its own requirement for training and training plans or reports and depending on the ACAT designation, the training plan may be required for key program milestones, and decisions. Identification of these reporting requirements and the PM’s schedule is vital to ensure the PM achieves successful determination by the Milestone Decision Authority.

The PM identifies the statutory and regulatory reporting of training and the mechanism each level requires. Statutory requirements for ACAT I and II programs' training requirements are reported in the CARD to OSD CAPE, exclusive of regulatory reporting to Service-level equities.

The Independent Logistics Assessment (ILA) is conducted in advance of each milestone, decision point and every 5 years or as directed. The output of the ILA is a decision criterion for the Milestone Decision Authority, combined with approved training plans/reports and other PM acquisition documents. If the PM has thoroughly executed its responsibilities and actions towards the development of its training products and strategies the program will have little risk. For areas the ILA noted as RED, the program should develop mitigation schema and report to the ILA assessor when resolved for a reassessment, and the PM should report back to the Milestone Decision Authority when all ILA issues are resolved.

As training planning is immense, complex, and multilayered, the PM must be staffed to support the development of all training products, strategies, reports, and funding. The PM will need a team of dedicated Component staff (government, military, and contractors) in support to execute all phases and facets of training planning, development, reporting, and execution throughout the life cycle.

The PMO training plans address individual or crewed training, maintainer training, system of systems training and training multiple occupations; as applicable

Training planning and execution is not confined to the acquiring phases (EMD, LRIP, Rapid Prototyping, etc.) just as there are sustainment engineering and logistics efforts, after the program is in sustainment, there are training sustainment efforts. Factors the PM has to address and recognize when the system is in sustainment include the following:

- The training effectiveness from NET and the Service-level schools
- The system being operated and maintained as designed and expected; the system KPPs and Key System Attributes being met or not
- Impacts from modifications to the system or software
- Feedback from Service stakeholders and equities (notwithstanding the PM is responsible for training throughout the life-cycle)
- System wear-out and obsolescence (i.e., bathtub curve)
- Training system (s) wear out and obsolescence
- Improvements to instructional technologies and methodologies related to the system fielded

These above items are direct inputs for continued training planning, development, execution and most importantly, funded. Cost estimating over each POM cycle for training requirements needs to be identified and submitted.

As stated previously about reporting funding in the CARD, funding for training efforts and activities is planned for each type of approbation (RDT&E, PMC, O&M, or OMMC) supporting each phase of acquisition and the PM's schedule. Identifying the activity that training efforts are supporting is vital to ensure budget requirements are met. Using the OPM-Series 1750 and 1712 is critical for forecasting training funding requirements.

Training planning factors for the PM are influenced by the acquisition strategy to procure GOTS, COTS, NDI or DI. As stated in training requirements paragraph, all the items contained in that paragraph are training planning inputs. A pitfall to avoid is overestimating an Original Equipment Manufacturer's (OEM) ability and capacity to produce training that meets (1) training requirements (KPP or Key System Attribute), (2) Service-level training requirements and expectations, and (3) user and maintainer training requirements and expectations.

PMs should not rely on the OEM to solely derive or produce U.S. Government training tasks and goals but should generate macro- and micro-level training tasks and goals, which serve five purposes:

1. Create Program-Unique Specification for both PM and OEM
2. Provide to the OEM as Government-Furnished Information
3. Apply to Contractor Surveillance Plan or Quality Assurance Surveillance Plan
4. Develop OEMs' POA&M to meet Statement of Work (SOW) and Contractor Deliverable Requirements Listing (CDRL) requirements
5. Monitor OEM spend plan and reporting of funding expenditures to PM.

The program should be deliberate and strategic in developing SOWs and CDRLs and selecting and tailoring the related training Data Items Description (DIDs). A common pitfall is to use blanket narratives and ambiguous language that can obscure the true training requirements and products the OEM is to deliver. Using boilerplate language incorrectly can cause Cost, Schedule and Performance overruns that the PM then has to address, usually requiring the Contracting Officers and Contracting Officer Representative to help resolve issues between the OEM and the U.S. Government.

The PM acquires the required level of data rights necessary for the development, reproduction and modification of data for training products for U.S. Government purposes and ensures the correct markings are documented. The lack of data rights and markings that restrict or prohibit modification and reproduction inhibits the PM and Service-level school's ability to inherently produce and sustain an organic capability.

Another planning consideration is the effect of training during Operational Tests/Assessments. ACAT I and II programs are assessed by DOT&E and Service-level test agencies. ACAT III and IV are tested by Service-level test agencies. As training is assessed for suitability, the determination by these test agencies will directly affect the program's cost, schedule, and performance. Training for Operational Testing represents the PM's New Equipment Training strategy and products for the system being tested in preparation for fielding.

SOW and CDRL development with DID selection and tailoring is best suited for the OPM 1750 and 1712 series.

The PM's training planning team participates with IPTs and working groups for Systems Engineering, HSI, Test, Product Supportability/Logistics, Cost, and OEM. The PM should apply the ADDIE process and instructional design methodologies to plan detailed training that supports the requirements. The following list includes examples of tools and methods:

- Training Aids Devices, Simulators, and Simulations
    - Driver simulators and simulations
    - Gunnery simulators and simulations
    - Flight simulators and simulations
    - Ship simulators and simulations
    - Individual or crew simulators and simulations
    - Training aids, part-task trainers, and simulations
        - Operator(s)
        - Maintainer(s)
    - Videos, Interactive Multimedia Instruction (IMI), Computer Based Training (CBT)
        - Operator(s)
        - Maintainer(s)
- Service-level training documentation and information.
    - Training Support Package (US Army)
    - Master Lesson Files (USMC)
- New Equipment Training execution
    - Live or traditional learning
    - Synchronous learning
    - Asynchronous learning
    - Combination thereof

- Training implementation within Service-level schools or sister-service schools
- Ranges, facilities, infrastructure, training and storage areas required to support NET and Service-level schools.
- Consumables, support equipment, tools, base or unit support, ammunition, and fuel requirements
- Milcon, as required to support the training requirements and products within the Service.

The application of training planning by the PM is inherently governmental, and training product development activities are reflected in the PM's Integrated Master Schedule (IMS) and Plan of Action and Milestones (POA&M).

4.3.4 Training Domain Requirements and Parameters

Development of training requirements is the responsibility of the DoD requirements owner, and that agency must identify within the requirements documentation the training and training systems to support institutional or new equipment training for the capability. This description includes KPPs or Key System Attributes the training must meet. The PM should be involved within a requirements generation process to ensure the requirements are realistic and obtainable.

The DOTmLP-F is critical for identifying or solidifying Manpower, Personnel, and Training requirements as a result of the material, software, or cyber solutions. This consideration expands beyond new equipment training, as it refers to the Service's capacity to support training within Service-level schools and gaining commands at the individual and collective levels. The DOTmLP-F assessment from the requirements community identifies the training implications the PM needs to address with the requirements and Service-level stakeholders and equities.

Trade-offs: The PMO working within an IPT of stakeholders identifies possible trade-offs if training KPPs or Key Systems Attributes (threshold/ objectives) cannot be met.

Factors that contribute to development of training requirements include the following:

- The expected performance levels of the system, concept of operations/employment, (Operational Mission Summary/Mission Profile)
- Technology Readiness Levels (TRLs) from Systems Engineering
    - TRLs are influencers in that the technology is relatively immature or developing compared with a proven technology
    - Technology is a driver in that the complexity of the technology influences the complexity of the training
    - A common pitfall is to underestimate technology and the impacts upon users and maintainers

- Logistics
  - The maturity or immaturity of Logistic Product Data is an influencer in the generation of training requirements
  - Considerations include whether manuals exist or need to be developed
  - If manuals exist, they may not be written to military requirements as industry manuals differ from military specification manuals
- Manning levels, including whether the system or platform will be operated by an individual or crew
- Maintainers, including whether one or more occupations (Personnel and Manpower) will maintain the system or platform
- System of Systems
  - If the acquisition a system of systems, it may provide multiple capabilities within or integrated onto another system
  - Training may involve multiple occupations for one system or a system of systems
- Replacing existing system/platform with holistically new system/platform
- Updating an existing system/platform with technology insertions
- Mixed fleet of system/platform with overlapping life-cycles
- Availability, Material Readiness, and Reliability metrics (KPPs)
- Facilities, ranges, training areas, including whether the system will require new or modified infrastructure to support the operational, storage, and maintenance requirements
- Affordability of training solutions required over the life-cycle, which affects the PM's Program Objective Memorandum (POM) and the Cost Analysis Requirements Document (CARD)

The training requirements should offer the PMO trade space and should be written to provide training capabilities. The writers should apply training analyses and planning to specify the training solutions and products to support the requirement.

Requirements generation must consider training users in the Live, Virtual and Constructive-Environments (LVC-E) and simulated environments (DoDD 1322.18;Army Regulation 350–38, OPNAV Instruction 1500.84; AF Policy Directive 16-10; MCO 3550.14). Requirements generation must be prepared to address and provide embedded training capability within the system or platform to be procured and fielded. LVC-E is using Training Aids, Devices, Simulators and Simulations (TADSS). These are proven instructional technologies that work synergistically but must be chosen deliberately by the PMO to achieve the desired results and meet capability requirements.

Training requirements must account for and be prepared to incorporate the system or platform into the applicable Service-level schools, or leverage sister-service schools (Inter-service Training Review Organization (ITRO)). This consideration of system or platform is also a training planning action.

When developing the training system(s), in order to achieve the expected KPPs and Key System Attributes throughout the system life cycle, the PMs must be able to provide current and relevant instructional and training methodologies TADSS to support the LVC-E learning environment.

Training requirements should be identified during the generation of program requirements documents such as CDDs and CPDs. The training requirements should be unambiguous. For example, if a training requirement cites a KPP or Key System Attribute, the requirement should include metrics against which to assess the KPP or Key System Attribute. Training requirements should support the operational and maintainability requirements of the system being fielded.

The PMO reports the cost estimating and POM request in conjunction with total life cycle costs in the CARD and budget requests. The request should secure funding that will enable the development and implementation of training for the system being fielded and contribute to the adoption, incorporation, or creation of related training within a Service's formal military MOS schools, including facilities, ranges, and infrastructure.

Training of users should achieve intended capabilities of new systems acquisition; enable joint integration, interoperability, and testing; and ensure sustainment goals over the life cycle of weapon systems. As a key component of product support and sustainment, training should be considered as one of the criteria within the Analysis of Alternatives. To facilitate timely, cost-effective and appropriate training, the program should complete the content, development, and planning of training during the earliest acquisition life-cycle phases and referenced within the Acquisition Strategy (AS), Manpower Estimate, and Acquisition Program Baseline (APB).

Per DoDI 5000.85 and DoDI 5000.87, and consistent with DoDI 5000.95, the program will develop and execute training strategies and materials, such as but not limited to a system training plan (e.g., System Training Plan (STRAP)-US Army, Manpower Personnel and Training Plan (MPTP)-USMC, Navy Training System Plan (NTSP)-USN, or System Training Plan (STP)-USAF), outlining the training strategy, manpower and personnel requirements, funding, and schedule, in accordance with the proponent and Service policy. The training strategy, curriculum, and products will be assessed during testing and evaluation/ Operational Assessments, and Limited User Events so the program can determine and finalize the New Equipment Training requirements of the system to be fielded. Lessons learned will inform plan updates.

To ensure the training is appropriate for new systems acquisition and traceable to life cycle sustainment costs estimates, training domain practitioners should use systems engineering processes to assess the impact of materiel decision trades on training and document the analysis. Training plans should identify Service joint warfighting training requirements. Training plans should be updated whenever there is a significant change in the operational system and when lessons learned, e.g., through testing and evaluation, warrant an update. Training planning and training cost estimates should be incorporated within the CARD and LCSPs.

The DOTmLPF-P is critical to identify or solidify MPT, facilities, and infrastructure to support and host training across the LVC-E. This training portfolio expands beyond New Equipment Training, as it involves the capacity of that Service to support training at unit and individual levels with the system.

The Training domain may include or employ training concepts, strategies, and tools such as computer-based and interactive courseware, simulators, and embedded training consistent with the program's Acquisition Strategy, goals, and objectives. The domain should reflect the tenets outlined in the next generation training strategy.

The acquisition program characterizes training planning, development, and execution within the CARD. Life Cycle Support Plans and Service-specific training plans and reports should be tailored to each program requirement and acquisition strategy sought within the acquisition life cycle. Either supportability or MPT IPTs will vet the activities associated with the development and staffing of LCSPs and training plans.

These training summaries capture the support traceability of planned training across acquisition and capability documents, and they include product support planning for training, training equipment, and training device acquisitions and installations. The PMO's training strategy and devices will be planned, funded, designed, and developed in parallel with the operational system to ensure that the training devices properly replicate the operational ones for optimal training outcomes.

4.4 Human Factors Engineering Domain

The PM employs HFE in the design of systems to optimize human-system performance under operational conditions; provide effective training; ensure systems can be operated, maintained, and supported by specific personnel; and ensure systems are suitable (habitable and safe with minimal SOH hazards) and survivable for both the crew and equipment in accordance with DoDI 5000.02.

HFE domain considerations include but are not limited to ergonomics, psychological principles, human behaviors, and characteristics (e.g., sensory, perceptual, mental, and physical attributes) as they relate to the design, development, test, and evaluation of systems. The integration of human characteristics and limitations into the system design, development, and evaluation criteria will support the goal of optimizing human performance during operations, maintenance, support, and training activities.

4.4.1 Definition

HFE domain is the application of knowledge about human capabilities and limitations to system or equipment design and development to achieve efficient, effective, and safe system performance at minimum cost and manpower, skill, and training demands.

MIL-STD-46855A, DoD Standard Practice, Human Engineering Requirements for Military Systems, Equipment, and Facilities, considers Human Factors Engineering (HFE) equivalent to the MIL-HDBK-1908 definition of "human engineering":

> *The application of knowledge about human capabilities and limitations to system or equipment design and development to achieve efficient, effective, and safe system performance at minimum cost and manpower, skill, and training demands. Human engineering assures that the system or equipment design, required human tasks, and work environment are compatible with the sensory, perceptual, mental, and physical attributes of the personnel who will operate, maintain, control, and support it.* (MIL-STD-46885A)

4.4.2 Best Practices

HFE plays an important role in each phase of the acquisition life cycle, including system analysis and definition, development of system requirements and design criteria, development, evaluation, and system support for reliability and maintainability in the field. The HFE practitioner should apply principles, guidelines, and criteria during development and acquisition of military systems, equipment, and facilities to integrate personnel effectively into the design of the system. The HFE effort should develop or improve all human interfaces of the system; achieve required effectiveness of human performance during system operation, maintenance, support, control, and transport; and make economical demands upon personnel resources, skills, training, and costs. The HFE effort should be well integrated with other HSI domain participation and supported by HSI practitioners, user advocates, and other functionals (i.e., acquisition program function leads) when necessary.

4.4.2.1 Human Abilities, Concerns, and Requirements

Human factors are the end-user cognitive, physical, and sensory abilities required to perform system operational, maintenance, and support job tasks. Human factors engineers contribute to the acquisition process by ensuring that the PM designs systems that capitalize on and do not exceed the abilities of the user population. The HFE community works to integrate the human characteristics of the user population into the system definition, design, development, and evaluation processes to optimize human-machine performance for operation, maintenance, and sustainment of the system.

HFE is primarily concerned with human-centered designs that are consistent with the physical, cognitive, and sensory abilities of the user population. Human-centered design concerns include:

- **Tasks/Workload –** Functions and tasks, and allocation of functions to human performance or automation based on human capabilities and limitations.
- **Information/Situation Awareness –** Information and characteristics of information that provide the human with the knowledge, understanding, and awareness of what is happening in the tactical environment and in the system.
- **Environmental Factors –** The natural and artificial environments, environmental controls, and facility designs that support optimal human performance.
- **Communication –** Provisions for team performance, cooperation, collaboration, and communication among team members and with other personnel.
- **Organizational Culture –** Job design, management structure, command authority, policies, and regulations that impact behavior.
- **Operational Factors –** Aspects of a system that support successful operation of the system such as procedures, documentation, workloads, and job aids.
- **Cognitive –** Decision rules, decision support systems, provision for maintaining situation awareness, mental models of the tactical environment, provisions for knowledge generation, cognitive skills, and attitudes and memory aids.
- **Physiological –** Human characteristics such as muscle strength and endurance in different body positions, visual acuity, tolerance to extremes of temperature, frequency range of human hearing, and tolerances to vibration.
- **System Components –** Hardware and software elements designed to enable and facilitate effective and safe human performance such as controls, displays, workstations, worksites, accesses, labels and markings, structures, steps and ladders, handholds, maintenance provisions, etc.

Cognitive requirements address the human capability to evaluate and process information. These requirements are typically stated in terms of response times and are typically established to avoid excessive cognitive workload. Operations that entail a high number of complex tasks in a short time period can result in cognitive overload and safety hazards. The capability documents should specify whether there are human-in-the-loop requirements. These could include requirements for "human in control," "manual override," or "completely autonomous operations." KSAs for users change with the increasing complexity of emerging systems. These requirements should be cross-correlated with each of the HSI domains.

Physical requirements are typically stated as anthropometric (measurements of the human body), strength and weight factors. Physical requirements are often tied to human performance, safety, and occupational health concerns. To ensure that the users can operate, maintain, and support the system, the program office should state requirements in terms of the user population. For instance, when the user requires a weapon that is “one-man portable,” weight thresholds and objectives should be based on the strength limitations of the user population and other related factors (e.g., the weight of other gear and equipment and the operational environment). It may be appropriate to require that “the system be capable of being physically maintained by a percentage of both the male and female population, inclusive of battle dress or arctic (i.e., encumbered) and Mission Oriented Protective Postures-Level 4 protective garments inside the cab,” or that “the crew station physically accommodate a percentage of the female and male population, defined by current anthropometric data (e.g., as described in a TAD), for accomplishment of the full range of mission functions.” See MIL-STD 1472 for more information on appropriate requirements for population accommodation.

Sensory requirements are typically stated as visual, olfactory (smell), or hearing factors. The CDD should identify operational considerations that affect sensory processes. For example, systems may need to operate in noisy environments due to weapons firing or on an overcast moonless night with no auxiliary illumination. Visual acuity or other sensory requirements may limit the target audience for certain specialties.

4.4.2.2 Application of Human Factors Engineering

To realize the potential of HFE contributions, HFE should be incorporated into the design process at the earliest stages of the acquisition process (i.e., during the Materiel Solution Analysis and Technology Maturation and Risk Reduction phases). HFE should be supported by inputs from the other HSI domains as well as the other SE processes. The right decisions about the human-machine interfaces (HMI) early in the design process optimize the human performance, and hence, the TSP. HFE participation continues to each succeeding acquisition phase, working trade-offs based on input from the other HSI domains and hardware and software designs and adaptations. The HFE practitioners provide expertise that includes design criteria, analysis, and modeling tools and measurement methods that help to ensure that program office design systems are operationally suitable, safe, survivable, effective, usable, and cost-effective.

In any system acquisition process, it is important to recognize the differences between the competencies (skills and knowledge) required for the various users. HFE processes lead to an understanding of the competencies needed for the job. They help identify whether requirements for KSAs and other attributes exceed what the user can provide and whether the deficiency leads to a training or operational problem. HFE tools and techniques can be used to identify the KSAs and other attributes of the target audience and account for different classes and levels of users and the need for various types of information products, training, training systems, and other aids. While it is critical to understand the information processing and net-centric requirements of the system, it is equally important to understand the factors affecting format and display of the data presented to the user to avoid cognitive overload. This consideration applies equally to the system being designed as to the systems that interface with the system. The system should not place undue workload or other stress on systems with which it must interface.

The HFE effort should be well integrated with other HSI domain activities, including but not limited to analysis, design and development, and T&E of system design.

4.4.2.3 Analysis

The HFE practitioner, in conjunction with the PM, should identify the functions to be performed by the system in achieving its mission objectives and analyze them to determine the best allocation of personnel, equipment, software, or combinations thereof. Allocated functions should be further examined to define the specific tasks to be performed to accomplish the functions. Each task should be analyzed to determine the human performance parameters; the system, equipment, and software capabilities; and the operational and environmental conditions under which the tasks are conducted. Task parameters should be quantified where possible and should be expressed in a form that permits effective studies of the human-system interfaces in relation to the total system operation. HFE high-risk areas should be identified as part of the analysis. Task analysis should include maintenance and sustainment functions performed by crew and support facilities. Analyses should be updated as required to remain current with the design effort.

HRA is a process to determine the likelihood of human error for a given task when a user is operating, maintaining, and supporting a given system. The analysis describes and quantifies both the human behavior and system design contribution to deficiencies, leading to improved mitigation strategies. The core activities supporting HRAs are: (1) Problem Definition; (2) Methodology Description; (3) Identification of Data Sources; (4) Task Analysis Results Summary; (5) Error Identification and Representation; (6) Assessment of the possible user's initiating events and response actions and identification of their effects on the system; (7) Error Management; and (8) Articulation of the HRA results in terms of Human Error Probabilities. The methodology chosen for the HRA should be described, including the approach to assessment and quantification of the human contribution to the system concept, in terms of tasks, processes, and group dynamics, as well as the rationale for the choice.

Task analysis should be conducted and results summarized to show the effects on the system of the operator's possible initiating events and response actions to identify safety and reliability critical user actions.

Human Error Analysis included in HRA or other system analyses will show the types of errors that can occur for the specific tasks identified and show a list of errors developed for errors across these tasks. Human errors may include:

- Errors of omission versus commission
- Test and maintenance errors
- Errors causing initiating events
- Procedural errors during an incident or accident

- Errors leading to inappropriate actions
- Recovery errors

Error Management describes the errors humans are capable of committing while using the system and fully explain how the system will manage and mitigate those errors.

4.4.2.4 Design and Development

The PM should apply HFE principles to the design and development of the system equipment, software, procedures, work environments, and facilities associated with all functions requiring personnel interaction. This HFE effort should convert the mission, system, and task analysis data into a detailed design and development plan to create a human-centered design that will operate within human performance capabilities and limitations, facilitate or optimize human performance in meeting system functional requirements, and accomplish the mission objectives.

4.4.2.5 Test and Evaluation

HFE and the evaluation of all HMI and user processes should be integrated into engineering design and development tests, contractor demonstrations, flight tests, acceptance tests, other development tests, and operational testing. T&E and HFE should test compliance with human-centered design requirements as early as possible. T&E should include the evaluation of maintenance and sustainment activities, as well as the dimensions and configuration of the system environment relative to the human-centered design criteria for each of the HSI domains. T&E should use findings, analyses, evaluations, design reviews, modeling, simulations, demonstrations, and other early engineering tests when planning and conducting later tests. Test planning should be directed toward verifying that the system can be operated, maintained, and supported by user personnel in its intended operational environment in accordance with the appropriate training. Test planning should also consider data needed or provided by operational T&E.

4.5 Habitability Domain

Habitability domain factors contribute directly to personnel effectiveness, overall system performance, and mission accomplishment as well as impacts personnel recruitment and retention. The habitability domain should address several key factors, including lighting, noise, temperature control, space dimensions, berthing or sleeping quarters, availability of medical care, food, and drink services, stowage, sanitation and personal hygiene facilities. These personnel needs include factors such as environmental controls, personnel services (i.e., hygiene to preserve health), and living conditions (i.e., berthing), to prevent or mitigate risk conditions that adversely impact human performance, quality of life and morale, or degrade recruitment or retention.

Habitability factors are those living and working conditions necessary to sustain the morale, safety, health, and comfort of the user population. They directly contribute to human performance (e.g., fatigue) and mission accomplishment, and often preclude recruitment and retention problems. Examples include: lighting, space, ventilation and sanitation; noise and temperature control (i.e., heating and air conditioning); religious, medical, and food services availability; and berthing, bathing, and personal hygiene. Habitability consists of those characteristics of systems, facilities (temporary and permanent), and services necessary to satisfy personnel needs. Habitability factors sustain maximum personnel effectiveness, support mission performance and prevent personnel retention problems.

The PM will "Establish requirements for the physical environment (e.g., adequate space and temperature control); as appropriate, requirements for personnel services (e.g., medical and mess) and living conditions (e.g., berthing and personal hygiene) that have a direct impact on meeting or sustaining human performance; or an adverse impact on quality of life and morale such that the warfighter capability, recruitment, or retention is degraded; Consider the cybersecurity requirements for systems supporting living and working environments or conditions that have a direct impact on operational performance, in accordance with DoDI 8500.01" (DoDI 5000.95).

4.5.1 Definition

The habitability domain is the consideration of the characteristics of systems focused on satisfying personnel needs that are dependent upon physical environment, such as berthing and hygiene.

4.5.2 Best Practices

The PM should apply Habitability domain principles, guidelines, and criteria during development and acquisition of manned systems to effectively enhance personnel working and living conditions. Crew systems engineering or HFE should develop or improve the physical environment and related personal services required to operate the system and make it habitable. The Habitability effort should be well integrated with other HSI domain participation and supported by HSI personnel, user advocates, and other functionals when necessary.

4.5.2.1 Habitability Domain Parameters and Requirements

Habitability is one of several important factors included in the overall consideration of warfighter mission readiness, elements of personnel survivability, and effective human performance. A Habitability KPP should be included for any manned system where optimal working or living conditions are critical to warfighter performance. According to the JCIDS Manual (2021), habitability requirements should be incorporated under the FP KPP for "endorsement which is applicable to all CDDs addressing manned systems, or systems designed to enhance personnel survivability."

For systems in which habitability is less critical, creating Key System Attributes or Other System Attributes for Habitability may be more appropriate. According to DoDI 5000.95, in conjunction with DoD Component HSI SMEs and HSI practitioners, the Component capability developer or PM will work with Habitability domain representatives to establish habitability requirements.

While engineers should not design the facility or service solely around optimum habitability factors, these factors cannot be systematically traded off in support of other readiness elements without eventually degrading mission performance.

4.5.2.2 Habitability Domain Planning

The PM should address habitability planning in the LCSP Section 3.1.5. Other Sustainment Considerations and should identify habitability issues that could impact personnel morale, safety, health, or comfort; degrade personnel performance or unit readiness; or result in recruitment or retention problems.

4.6 Safety and Occupational Health Domain

Ensuring the appropriate SOH efforts are integrated across disciplines and functionals, including systems engineering, T&E, and product support, minimizes the risks of acute or chronic illness, injury, disability, or death to the users.

Safety is the development of system design characteristics and procedures to minimize the risk of mishaps or accidents that cause injury or death to users; threatens the operation of the system; or causes cascading failures in other systems. System safety engineering analyses and lessons learned are used to aid in the development of safety design features to eliminate system safety hazards and to control those hazards that cannot be eliminated by incorporating design features and mitigations, such as the use of engineered devices, warning devices, signage, training, and personal protective equipment (PPE).

Safety factors that negatively impact the safe operation and survival of a system include fratricide, pressure extremes, and control of hazardous energy releases (such as mechanical, electrical, fluids under pressure, ionizing or non-ionizing radiation, fire, and explosions). Occupational health issues include noise, chemical safety, atmospheric hazards (including those associated with confined space entry and oxygen deficiency), walking and working surfaces (including work at heights), vibration, ionizing and non-ionizing radiation, and human factors issues that can create chronic disease and discomfort, such as repetitive motion disorder.

Occupational health focuses on system design features and procedures that serve to minimize the risk of injury, acute or chronic illness, and disability, and to enhance job performance of personnel who operate and maintain the system. Occupational health analyses and lessons learned are used to aid in development of design features that reduce health hazards where possible and manage health hazards that cannot be eliminated using the system safety design order of precedence in MIL-STD-882E, such as PPE, protective enclosures, warning devices, signage, and training.

4.6.1 Definition

The SOH domain is the characteristics of system design that can: eliminate or minimize the risk of acute or chronic illness, disability, injury, or death to the operators or maintainers; or damage or loss of equipment or property. These characteristics of system design also enhance job human performance and productivity of personnel who operate, maintain, or support the system in the intended operational environment.

4.6.2 Best Practices

SOH principles, guidelines, and criteria should be applied during development and acquisition of systems to effectively enhance operator, maintainer, and support personnel safety. SOH practitioners should identify the potential risks of mishaps and injuries, threats to the operation of the system, and opportunities to enhance job performance. The SOH effort should be well integrated with other HSI domain participation and supported by HSI personnel, user advocates, and other functionals when necessary.

4.6.2.1 SOH Domain Parameters and Requirements

SOH KPPs or requirements should be included for any manned system where Safety hazards have the potential to critically affect user health and performance. Per JCIDS manual (2021), “Human Systems Integration (HSI) considerations … have a major impact on system effectiveness, suitability, and survivability. The HSI SOH domain contributes to the Force Protection KPP by defining requirements for personnel and system safety.” SOH hazard parameters should address all activities inherent to the life cycle of the system, including test activity, operations, support, maintenance and final demilitarization and disposal.

SOH hazard requirements often stem from human factors issues and are typically based on lessons learned from comparable or predecessor systems. For example, both physical dimensions and weight are critical safety requirements for the accommodation of pilots in ejection-seat designs. SOH hazard thresholds are often justified in terms of human performance requirements, because, for example, extreme temperature and humidity can degrade job performance and lead to frequent or critical errors. Another methodology for specifying safety and health requirements is to specify the allowable level of risk as defined in MIL-STD-882E. The goal should always be to eliminate the hazard if possible. When it is not possible to eliminate a hazard, the PM should reduce the associated risk to the lowest acceptable level.

The PM should state SOH hazard requirements in measurable terms, whenever possible. For example, it may be appropriate to establish thresholds for the maximum level of acoustic noise, vibration, acceleration shock, blast, temperature or humidity or impact forces, etc., or “safeguards against uncontrolled variability beyond specified safe limits,” where the capability documents specify the "safe limits." The PM and Component Staff should determine requirements by reviewing military and industry standards and specifications; historical documentation on similar and legacy systems; DoD requirements (to include risk mitigation technology requirements); system performance specifications; other system design requirements and documents; applicable Federal, military, State, and local regulations; and applicable Executive Orders (EOs) and international agreements.

4.6.2.2 Human Factors Analysis and Classification System

The DoD Human Factors Analysis and Classification System (HFACS) is a framework that provides key components in understanding the contributing factors during the analysis of the human element of mishap investigations (Shappell and Wiegmann 2004). This system uses codes to identify and categorize a broad range of human errors within:

- Unsafe acts of operators (e.g., aircrew)
- Preconditions for unsafe acts
- Unsafe supervision
- Organizational influences

During a mishap investigation, investigators identify codes from various categories that relate to the events, decisions, and conditions leading to the mishap. Comprehensively identifying even second- and third-level causes are key to identifying trends that create risks, paving the way for proactive preventive measures.

The goal of HFACS is not to attribute blame but to understand the underlying operational or cultural factors that led to a mishap. Such knowledge can spur measures that help prevent future mishaps. For more information on DoD HFACS, see the Air Force Safety Center website (HFACS).

4.6.2.3 System Safety Assessment Analysis

MIL-STD-882 requires a series of hazard analyses during all phases of the acquisition process and life cycle of the system. HSI-related considerations should be included in each of those analyses, particularly Task 207, Health Hazard Analysis.

MIL-STD-882 Task 301 Safety Assessment Report (SAR) is a comprehensive evaluation and assessment of the status of SOH hazards and their associated risks in advance of test or operation of a system, before the next contract phase, or at contract completion. This SAR addresses hazards that were identified and eliminated, and specific mitigation measures to reduce the risks of hazards that could not be eliminated through design. The SAR is a compilation of the results of all hazard analyses performed, hazards identified and included in the HTS, and the measures taken to eliminate or mitigate risks, including SOH risks. SOH risk information is maintained in the HTS, and the system model and may be documented in other program-related documents (e.g., Hazard Action Records (HARs), Safety Releases, PESHE).

4.6.2.4 Health Hazard Analysis

MIL-STD 882E, Task 207, requires the program to perform and document a Health Hazard Analysis (HHA) to identify human health hazards, to evaluate proposed hazardous materials and processes using such materials, and to propose measures to eliminate the hazards or reduce the associated risks when the hazards cannot be eliminated. The practitioner should conduct HHAs during each phase of the acquisition process, beginning with a review of issues related to predecessor systems. During early stages of the acquisition process, sufficient information may not always be available to develop a complete HHA. As additional information becomes available, the program should refine and update initial analyses to identify health hazards, assess the risks to determine how to mitigate the risks, formally accept the residual risks, and monitor the effectiveness of the mitigation measures. The health hazard risk information should be maintained in the HTS and the system model and may be documented in other program-related documents (e.g., HARs, Safety Releases, PESHE). Health hazard assessments should include cost avoidance figures to support trade-off analysis. An HHA typically addresses nine health hazard categories:

1. Acoustical Energy – The potential energy that transmits through the air and interacts with the body to cause hearing loss or damage to internal organs.
2. Biological Substances – An infectious substance generally capable of causing permanent disability or life-threatening or fatal disease in otherwise healthy humans.
3. Chemical Substances – The hazards from excessive airborne concentrations of toxic materials contracted through inhalation, ingestion, and skin or eye contact.
4. Oxygen Deficiency – The displacement of atmospheric oxygen from enclosed spaces or at high altitudes.
5. Radiation Energy – Ionizing: The radiation causing ionization when interfacing with living or inanimate matter. Non-ionizing: The emissions from the electromagnetic spectrum with insufficient energy to produce ionizing of molecules.
6. Shock – The mechanical impulse or impact on an individual from the acceleration or deceleration of a medium.
7. Temperature Extremes and Humidity – The human health effects associated with high or low temperatures, sometimes exacerbated by the use of a materiel system.
8. Trauma – Physical: The impact to the eyes or body surface by a sharp or blunt object. Musculoskeletal: The effects to the system while lifting heavy objects.
9. Vibration – The contact of a mechanically oscillating surface with the human body.

4.6.2.5 Programmatic Environmental, Safety and Occupational Health Evaluation

The PESHE is the repository for program office ESOH data. The PESHE supplements the Systems Engineering Plan (SEP) and Life Cycle Management Plan (LCMP) by detailing the PM's ESOH risk management approach and identified hazard and compliance risks. As the program evolves, the primary objective is for the PESHE to document the ESOH hazards and risks associated with the system. The HSI Plan should reference the PESHE and define how the program intends to ensure the effective and efficient flow of information to and from the ESOH domain SMEs to work the integration of SOH considerations into the systems engineering process and all its required products.

The PESHE is intended to assist PMs and their staff to comply with the requirements of DoDI 5000.02, DoDI 5000.88, DoDI 5000.85, and MIL-STD 882E in identifying and tracking ESOH-related risks. HSI practitioners should support SOH-domain SMEs in tracking the SOH-related issues and risks associated with the system.

4.7 Force Protection and Survivability Domain

Force Protection and Survivability (FP&S) factors consist of those system design features that reduce the risk of fratricide, detection, and the probability of being attacked and that enable the crew to withstand natural and manmade hostile environments without aborting the mission or suffering acute chronic illness, disability or death. Force Protection and Survivability requirements and attributes, as described in the CJCSI 3170.01 "Joint Capabilities Integration and Development System" and JCIDS Manual (2021), are those that contribute to the survivability of manned systems. The HSI construct considers the human to be integral to the system, and personnel survivability should be considered in the encompassing "system" context.

FP&S domain is the capability of an individual, crew, unit, or other force structure to avoid or withstand man-made hostile environments and situations without suffering an abortive impairment of its ability to accomplish the mission. The FP&S domain characteristics contribute to system design that can effectively meet warfighter needs in protection, defense, and egress. FP&S addresses issues involving enemy and friendly combat weapons-induced injuries and platform damage, as well as the inherent hazards to humans under threat or combat conditions.

During the early stages of the acquisition process, sufficient information may not always be available to develop a complete list of survivability issues. An initial report is prepared; listing those identified issues and any findings and conclusions. Classified data and findings are to be appropriately handled according to each DoD Component's guidelines. The FP&S practitioner addresses survivability issues, typically are divided into the following components:

- Reduce Fratricide – Fratricide is the accidental, unintentional killing of one's own forces in war; the death or injury of friendly users resulting from friendly forces' employment of weapons and munitions. To avoid these types of issues, systems should include anti-fratricide systems, such as Identification of Friend or Foe and Situation Awareness systems.

- Reduce Detectability – Reduce detectability considers a number of issues to minimize signatures and reduce the ranges of detection of friendly personnel and equipment by confounding visual, acoustic, electromagnetic, infrared/thermal and radar signatures and methods that may be utilized by enemy equipment and personnel. Methods of reducing detectability could include camouflage, low-observable technology, smoke, countermeasures, signature distortion, training, or doctrine.
- Reduce Probability of Attack – Reduce the probability of attack by avoiding the appearance as a high-value target and by actively preventing or deterring attack by using warning sensors and active countermeasures.
- Minimize Damage if Attacked – Minimize damage, if attacked, by:
  - Designing the system to protect the users and crew members from enemy attacks.
  - Improving tactics in the field so survivability is increased.
  - Designing the system to protect the crew from on-board hazards in the event of an attack (e.g., fuel, munitions, etc.).
  - Designing the system to minimize the risk to users if the system is attacked. SMEs in areas such as nuclear, biological, and chemical warfare, ballistics, electronic warfare, directed energy, laser hardening, medical treatment, physiology, human factors, and information operations can add issues.
- Minimize Injury – Minimize:
  - Combat, enemy weapon-caused injuries.
  - The combat-damaged system's potential sources and types of injury to both its crew and supported troops as it is used and maintained in the field.
  - The system's ability to prevent further injury to the warfighter after being attacked.
  - The system's ability to support treatment and evacuation of injured users. This portion of user survivability addresses combat-caused injuries or other possible injuries, along with the different perspectives on potential mechanisms for reducing damage. Evacuation capability and personal equipment needs (e.g., uniform straps to pull a crew member through a small evacuation port) are addressed here.
- Minimize Physical and Mental Fatigue – Minimize injuries that are directly traceable to physical or mental fatigue. These types of injuries are traceable to complex or repetitive tasks, physically taxing operations, sleep deprivation, or high-stress environments.
- Survive Extreme Environments – This component addresses issues that may arise once the user evacuates or is forced from a combat-affected system such as an aircraft or watercraft and should immediately survive extreme conditions encountered in the sea or air until rescued or an improved situation on land is reached. Dependent upon requirements, this may also include some extreme environmental conditions found on

land, but generally, this component is for sea and air, where the need is immediate for special consideration to maintain an individual's life.

Per DoDI 5000.88 and DoDI 5000.95, the PM will assess risks to users and address, in terms of system design, protection from direct threat events and accidents (such as chemical, biological, radiological, and nuclear (CBRN) threats). Design consideration will include primary and secondary effects from these events and consider any special equipment necessary for egress, survivability, and mission sustainability.

4.7.1 Definition

FP&S domain is the characteristics of a system than can: reduce fratricide, detectability, and probability of being attacked; and minimize system damage, and user injury.

4.7.2 Best Practices

The PM should apply FP&S principles, guidelines, and criteria during development and acquisition of manned systems to effectively enhance personnel and system survivability. Crew systems engineering or HFE should develop or improve the protections, defense, and egress of the system. The FP&S effort should be well integrated with other HSI domain participation and supported by HSI practitioners, user community, and other functionals when necessary.

4.7.2.1 Force Protection and Survivability Domain Parameters and Requirements

According to the JCIDS Manual (2021):

- "The Force Protection (FP) KPP (one of the four mandatory KPPs) is intended to ensure protection of occupants, users, or other personnel who may be adversely affected by the system or threats to the system. Although the FP KPP may include many of the same attributes as those that contribute to SS, the intent of the FP KPP is to address protection of the system operator or other personnel against kinetic and non-kinetic fires, CBRN, and environmental effects, rather than protection of the system itself and its capabilities."
- "System Survivability (SS) KPP (mandatory KPP). The SS KPP is intended to promote the development of critical warfighter capabilities that can survive kinetic (i.e., traditional, non-traditional, and CBRN (including EMP)) and non-kinetic (cyber and EMS)) threats across domains and applicable environments including space." [EMP = electromagnetic pulse]
- "Human Systems Integration (HSI) considerations that have a major impact on system effectiveness, suitability, and survivability. The HSI Force Protection and Survivability domain contributes to the Force Protection KPP by defining requirements for personnel force protection and personnel survivability."

The FP&S requirement should be included for any manned system or system designed to enhance personnel survivability when potentially employing the system in an asymmetric threat environment. The capability documents should include applicable FP&S parameters to meet warfighter needs in protection, defense, and egress, which may include requirements to eliminate significant risks of fratricide or detectability or to be survivable in adverse weather conditions and the CBRN battlefield. CBRN survivability, by definition, encompasses the instantaneous, cumulative, and residual effects of CBRN weapons upon the system, including its users. It may be appropriate to require that the system permit performance of mission-essential operations, communications, maintenance, resupply, and decontamination tasks by suitably clothed, trained, and acclimatized personnel for the survival periods and CBRN environments required by the system.

The consideration of FP&S should also include system requirements to ensure the integrity of the crew compartment and rapid egress in cases where the system or platform is damaged or destroyed. It may be appropriate to require that the system provide for adequate emergency systems for contingency management, escape, survival, and rescue. FP&S requirements would be included under the System Survivability KPP.

4.7.2.2 Force Protection and Survivability Domain Program

The JCIDS capability documents define the program's combat performance and survivability needs. Consistent with those needs, the PM should establish a FP&S program. This program, overseen by the PM, should seek to minimize: the probability of encountering combat threats; the severity of potential wounds and injury incurred by users operating or maintaining the system; and the risk of potential fratricidal incidents. To maximize effectiveness, the PM should assess FP&S in close coordination with systems engineering and T&E activities.

FP&S assessments assume the user is integral to the system during combat. Damage to the equipment by enemy action, fratricide, or an improperly functioning component of the system can endanger the user. The FP&S program should assess these events and their consequences. After making these initial determinations, the FP&S program should evaluate the design of the equipment to determine if there are potential secondary effects on the personnel. The appropriate management level should formally document each management decision to accept a potential risk as defined in DoDI 5000.02.

The PM should summarize plans for FP&S in the Life Cycle Sustainment Plan Section 3.1.5 under Other Sustainment Considerations. If the Director, Operational Test & Evaluation for live-fire test and evaluation (LFT&E) oversight has designated the system or program, the PM should integrate T&E to address crew survivability issues into the LFT&E program to support congressional requirements. The PM should address the special equipment or gear needed to sustain crew operations in an operational environment.

5 HSI TOOLS AND METHODS

5.1 Introduction

While completing HSI analyses, practitioners use a variety of resources to ensure consideration of all relevant factors, to develop quantitative guidance to inform decisions, and to perform trade-offs among competing factors. While seasoned practitioners likely employ a preferred subset of HSI tools, a consideration of characteristics and categories of available tools, how to select the best tools for a given purpose, and where to find lists of the many available tools will likely benefit all practitioners of all competency.

It is first helpful to consider the definition of “HSI tool.” Many tools fit the typical definition, including various simulation tools (e.g., for task network modeling or digital human modeling). However, in this context, tools also include guidelines and standards, checklists, subjective assessment tools, and other miscellaneous resources (Lockett and Powers). Any HSI tool should aid in the application of methods that ensure systems consider human limitations and capabilities across the spectrum of HSI domains; however, HSI tools do not supplant the knowledge, training, and experience of a qualified HSI practitioner.

5.2 Taxonomy of HSI tools and Methods

One may broadly categorize HSI tools by the types of analyses that they support or by HSI domain. Practitioners have developed various taxonomies and have integrated these into a single classification. Table 2 presents a single generic taxonomy of HSI tools, which provides a definition of each class along with a few typical examples.

This taxonomy is intended to represent tools applicable across various domains and services. Domain- or Service-specific classes of tools are not included here but should be considered as appropriate (e.g., environmental analysis). An overview of the classes of tools appears in the following subsections (some tool classes have been combined into larger groupings for the discussion).

5.3 Characteristics of HSI Tools and Methods

Practitioners have created certain types of HSI tools to address certain classes of problems. When applying a given tool, programs should consider whether there are any restrictions on its use or applicability, the degree to which the tool was verified and validated, the accuracy or precision expected of the tool, and so on. It is helpful to have a set of criteria by which to judge an HSI tool for its appropriateness for an analysis need. A tool may not satisfy all these criteria perfectly. The practitioner should prioritize required and desired characteristics from these lists, as well as any other relevant considerations (such as level of technical support available or restricted use).

Table 2. Classifications of HSI Tools

Class of Tool	Definition	Example(s)
Guidelines, standards, and handbooks	Guidelines are documents that describe recommended practice, standards provide mandates for compliance of a system, and handbooks provide supplemental information for execution of guidelines and standards. Documents in these categories may originate from both government and industry.	Standards: MIL-STD-46855, MIL-STD-1472, MIL-STD-1474 Guidelines: MIL-HDBK-759
Checklists	Lists of issues or design parameters to be evaluated based on prior experience.	Human Factors Evaluation Checklist for Tanks
Subjective assessment tools and questionnaires	Dependent measures used during the conduct of a study; includes open-ended surveys as well as standard validated tools (e.g., NASA TLX).	NASA Task Load Index (TLX), Situation Awareness Global Assessment Technique (SAGAT)
Modeling	Software tools that create virtual elements of a future situation before they are readily available.	IMPRINT (task network modeling), ACT-R (cognitive process modeling), Jack (digital human modeling), MADYMO (biomechanical modeling)
Simulation – Human-In-the-Loop	Hardware and software that are configured to reproduce a set of circumstances or an environment under which a task or activity is performed.	Mockups, desktop simulators, full simulators
Cost and risk assessment	Tools that provide estimates of the resources required or costs incurred by specific system design decisions that affect the user.	Army Medical Cost Avoidance Model
Miscellaneous	Tools that address a specific method or technique or provide information on other tools.	HSI Tools Catalog

6 HSI Workforce Advancement

6.1 General

Implementing HSI within the acquisition process can be successful only if some members of the workforce are trained and educated in the tools, techniques, approaches, and methods of HSI and have a command of HSI KSAs and other attributes. This crucial education and training is not limited to those designated as HSI leads or HSI domain practitioners. PMs, Systems Engineers, Product Support Managers/logisticians, T&E practitioners, and other acquisition professionals need knowledge of HSI at varying levels of competency. While not all workforce members need a deep understanding of HSI, it is incumbent that some groups do. Having a passing knowledge of HSI is sufficient for those removed from the immediate practice of HSI, while those directly engaged in applying HSI need a thorough knowledge.

6.2 HSI Education and Training Resources

The Joint HSI Working Group published a DoD HSI Course catalog in 2019. The Joint HSI community is conducting analysis and will be updating this catalog for currency as DoD and DAU workforce development initiatives evolve in order to provide DoD-centric options for HSI training and competency development for HSI practitioners and stakeholders (HSI CoP).

6.2.1 DAU Courses with HSI Content

At present, DAU offers knowledge of HSI, serving awareness and basic competency needs. ENG 062, "Introduction to Human Systems Integration," takes just 2 hours to complete, is not required by any acquisition career field, and awards only two continuous learning points. Several other DAU courses offer exposure to HSI in the form of a few slides.

As the DAU training environment evolves, the Joint HSI community is working to publish a tool for providing the latest HSI content offered by DAU, organized by course, acquisition functional area, phase, and learning objectives. At this time, HSI leads, HSI domain practitioners, and others who require HSI knowledge beyond awareness or basic levels of competency will need to look beyond DAU for their education and training needs. See options offered in the next section.

6.2.2 HSI Programs and Courses External to DAU

At present, the DAU HSI CoP Education and Training website and the 2019 DoD HSI Course catalog offer the most current course offerings external to DAU for consideration in HSI application within DoD contexts. While other academic programs exist for systems engineering, human engineering, HFE, human systems engineering, and others, these programs are under review but are not recommended or validated for DoD HSI competency practice. The Joint HSI Working Group continues to research these additional academic resources for consideration.

7 HSI COMMUNITIES OF PRACTICE

Multiple communities serving the DoD and other Federal agencies and industry and academic partners exist and continue to evolve to connect HSI stakeholders. For a list of relevant communities, refer to the OUSD(R&E) HSI website (ENG HSI).

7.1 Joint HSI Steering Committee

Established in October 2015, the JHSISC facilitates execution of the National Defense Strategy priorities by collaborating within the DoD, across government, and with industry, academia, and U.S. allies to strengthen partnerships, highlight critical needs for improving lethality, adapt and deliver technology for improved human performance in DoD missions, and solve problems of urgent operational significance through improved business reform and to meet the modernization priorities. Toward this end, the JHSISC supports the overarching goal of accelerating the delivery of human-systems capabilities, scaling the Department-wide impact of HSI, and synchronizing DoD HSI activities to expand Joint Force advantages.

The JHSISC provides for information exchange and collaboration among Services to ensure efficient use of resources, eliminate redundancy, and facilitate maximum effectiveness in the application of HSI to DoD research and throughout the acquisition programs of the DoD. The JHSISC serves as a leadership forum to improve the effectiveness and efficiency of the HSI discipline. In July 2018, the JHSISC endorsed the five gaps of the HSI CBA conducted by the JHSIWG. The JHSISC Charter was renewed in April 2020.

7.2 Joint HSI Working Group

The JHSIWG facilitates communication between operators and system designers to ensure operator-informed decision-making during the system design process. The JHSIWG provides recommendations to the JHSISC to set program management standards for HSI processes, data, and products consistent with Service and DoD policies, regulations, and guidelines, to operationalize, integrate, and continuously assess user needs as a means of optimizing TSP. Upon request from the JHSISC, the JHSIWG may review Joint Staff and Component analyses and interpretations of mishap and combat data to recommend ways to mitigate significant hazards using HSI, as applicable.

The JHSIWG mission is to develop recommendations to DoD planning, policy, guidance, and standards for effective and proactive HSI program management in the acquisition life cycle; provide an avenue for inter-Service collaboration; and support the DoD's research, development, test, and evaluation (RDT&E) of user capabilities. The JHSIWG continues to work closure strategies for the identified CBA gaps and workstreams (i.e., lines of effort). The JHSIWG Charter was renewed in October 2020.

7.3 Defense Acquisition University HSI Community of Practice

The DAU HSI Community of Practice (CoP) serves as a hub for information and inspiration for human systems practitioners and stakeholders across government, industry, and academia. It offers a platform to connect and share knowledge across disciplines and organizations for the purpose of advancing user-centered design. The target audience for this site includes both human systems practitioners and stakeholders from all technical areas concerned with integrating humans and technology effectively. The HSI community's objective is to help practitioners and stakeholders find resources, locate references, discover best practices, identify education opportunities, engage in community events and discussions, and connect with organizations across the community to advance the HSI discipline and practice.

The website is maintained and moderated by volunteers from a variety of DoD, government, industry, and academic organizations. Membership is open to all persons eligible for a DAU account.

The DAU HSI CoP was deployed in July 2021 (HSI CoP).

GLOSSARY

Acceptable Risk: A level of risk associated with a hazard that DoD Components determine is allowable, and can remain from the standpoint of balancing benefit to the mission against the potential for accidental losses or harm to personnel, equipment, and mission.

Affordance: Psychologist James Gibson coined the word “affordance” in 1977, referring to all action possibilities with an object based on users' physical capabilities. Affordances in technology allow the user to execute specific actions, unlike constraints that restrict user actions.

Concept of Operations (CONOPS): A verbal or graphic statement, in broad outline, of a commander's assumptions or intent in regard to mission(s) and each phase of a mission(s), inclusive of multiple views: human view, Operational view, System view, technical views. Included are details of the tasks, events, durations, frequency, operating conditions and environment in which the recommended materiel solution is expected to perform.

Critical Task: A task requiring human performance which, if not accomplished in accordance with system requirements, will most likely have adverse effects on cost, system reliability, efficiency, effectiveness, or safety.

Force Protection and Survivability (FP&S) domain: The characteristics of a system than can reduce fratricide, detectability, and probability of being attacked, and can minimize system damage and Soldier injury.

Habitability domain: The consideration of the characteristics of systems focused on satisfying personnel needs that are dependent upon physical environment, such as berthing and hygiene.

Hazard: A real or potential condition that could lead to an unplanned event or series of events (i.e. mishap) resulting in death, injury, occupational illness, damage to or loss of equipment or property, or damage to the environment.

Human Factors Engineering (HFE): The application of knowledge about human capabilities and limitations to system or equipment design and development to achieve efficient, effective, and safe system performance at minimum cost and manpower, skill, and training demands.

Human Performance: A measure of human functions and actions in a specified environment, under the operational and tactical conditions, reflecting the ability of actual users and maintainers to meet the system’s performance standards with or without system facilitation, in order to support mission accomplishment.

Human Reliability Analysis (HRA): A process to determine the likelihood of human error for a given task when a user is operating, maintaining, and supporting a given system. The analysis describes and quantifies both the human behavior and system design contribution to deficiencies, leading to improved mitigation strategies.

Human Systems Integration (HSI): The systems engineering process and program management effort that provides integrated and comprehensive analysis, design, and assessment of requirements, concepts, and resources for human factors engineering (HFE), manpower, personnel, training, safety and occupational health (SOH), force protection and survivability (FP&S), and habitability. These domains are intimately and intricately interrelated and interdependent and must be among the primary drivers of effective, efficient, affordable, and safe system designs. HSI integrates and facilitates trade-offs among these domains, but does not replace individual domain activities, responsibilities, or reporting channels.

HSI lead: An HSI practitioner appointed by the PM or Lead Systems Engineer to plan, coordinate and execute the Government HSI program.

HSI practitioner: Personnel trained or experienced in HSI or the HSI domains who participate in the execution of the HSI program. May also be called HSI subject matter experts (SME), HSI domain-level representative, or HSI representative.

Human-Centered Design (HCD): An approach to design products focused on the human limitations and capabilities of those who will operate, maintain, and support the system, including the services and processes associated with the system and across domains that align with human performance needs.

Human-Machine Interface (HMI): The actions, reactions, and interactions between humans and other system components. This also applies to a multi-station, multi-person configuration or system. Term also defines the properties of the hardware, software or equipment which constitute conditions for interactions. SYN: Human-Computer Interaction (HCI), Human-Machine Interaction, and Man-Machine Interface (MMI).

Interface: The functional and physical characteristics required to exist at a common boundary or connection between persons, between systems, or between persons and systems.

Knowledge, Skills, Abilities (KSA) and Other Attributes. A set of taxonomy bounded by cognitive, psychomotor, and affective conditions defined and required for an individual to perform the mission or job to a standard. This taxonomy of learning is separated into four learning types, which can also be interdependent: (1) knowledge, (2) skills, and (3) abilities; (4) other attributes. These attributes are generally demonstrated through qualifying service (e.g., experience), education, and training.

1. Knowledge – A body of information (factual or procedural knowledge) required for performance of a function achieved through knowledge (via formal cognitive processes) and intelligence growth (via informal cognitive processes).
2. Skill – Proficiency (direct application of knowledge) to perform a particular task or a learned psychomotor act achieved through formal psychomotor processes.

3. Ability – Enduring capability to perform an observable behavior or competent performance that results in an observable product to include abilities (via informal psychomotor processes)

4. Other Attributes – Attributes not captured as KSAs that describe the learning characteristics and requirements an individual must meet based on an individual's perceptions of reality and behavioral affect. Includes characteristics such as attitudes (via formal affective processes) and motivation (via informal affective processes).

Manpower domain: Total number of personnel or positions required to perform specific tasks. Indexed by requirements including jobs lists, slots, or billets characterized by descriptions of the people required to fill them and the number of people required to operate, maintain, train, and support a system.

Mission: The objective or task, together with the purpose, that clearly indicates the action to be taken, and the reason therefore.

Mission Analysis: A process of reviewing mission requirements, developing collective task statements, and arranging the collective tasks in a hierarchical relationship. Mission analysis generally precedes task analysis, combining to become a Mission Task Analysis (MTA). MTA has a number of common components which make it extremely useful as the basis for further analysis methods used in human factors engineering, manpower, training, personnel, and safety domains. The job analysis, manning and manpower analysis, workload analysis, and human performance reliability/error analysis all rely heavily on common components of the MTA (e.g., mission context, function list, function allocation, task list, task performance parameters, information requirements, and characteristic errors).

Mission Profile: An artifact containing a time-phased, detailed description of the operational events (equipment usage) and environments (natural and man-made) that a formation or system experiences from the beginning to the end of a specific mission.

Occupation: The specialty skill or job series that represents the minimum qualification requirement of a billet or position. If required by the billet, additional skill requirement information shall be included as part of the occupation. (DoDI 7730.64)

Occupational Groups: One or more functionally related occupations, specialties, families, or classes of positions that share distinct, common technical qualifications, competency requirements, career paths, and progression patterns. (DoDI 1400.25)

Occupational Series: Classes of positions that share distinct, common technical qualifications, competency requirements, career paths, and progression patterns. (DoDI 1400.25) This includes civilian and military career fields.

Operational Effectiveness: Measure of the overall ability of a system to accomplish a mission when used by representative personnel in the environment planned or expected for operational employment of the system considering organization, doctrine, tactics, supportability, survivability, vulnerability, and threat

Operational Environment: A set of operational conditions defined and constrained by the physical and tactical surroundings that are representative of the desired spectrum of operational employments for the human and system to perform in, outlined by the Concept of Operations (CONOPS).

Operational Suitability: The degree to which a system can be satisfactorily placed in field use with consideration to reliability, availability, compatibility, transportability, interoperability, wartime usage rates, maintainability, safety, human factors, habitability, manpower supportability, product supportability, usability, training requirements, withstanding operational environmental effects and documentation. A test event, such as an operational assessment or STP, supports the evaluation of operational suitability.

Personnel domain: The human aptitudes (i.e., cognitive, physical, and sensory capabilities); knowledge, skills, abilities; and experience levels needed to properly perform job tasks and required to train, operate, maintain, and sustain materiel and information systems.

Safety and Occupational Health (SOH) domain: The characteristics of a system that can minimize the risks of acute or chronic illness, disability, or death or injury to operators and maintainers; damage or loss of equipment or property, and enhance human job performance and productivity of the personnel who operate, maintain, or support the system safely in the intended operational environment(s).

Safety Risk: A combination of the severity of the mishap and the probability that the mishap will occur.

Subject Matter Expert (SME): The Subject Matter Expert is the individual(s) who exhibits the highest level of expertise required in performing a specialized job, task, or skill within the organization for an HSI effort.

System Safety: The application of engineering and management principles, criteria, and techniques to achieve acceptable risk within the constraints of operational effectiveness and suitability, time, and cost throughout all phases of the system life cycle.

System Safety Engineering: An engineering discipline that employs specialized knowledge and skills in applying scientific and engineering principles, criteria, and techniques to identify hazards and then to eliminate the hazards or reduce the associated risks when the hazards cannot be eliminated.

Target Audience Description (TAD): The target audience description defines the range of individual qualifications and all relevant physical, mental, physiological, biographical, and motivational dimensions of the intended human to be included to operate, maintain, and support the system, which can include the target user population.

Task Analysis: A systematic method used to develop a time-oriented description of personnel-equipment/software interactions brought about by an operator, controller or maintainer in accomplishing a unit of work with a system or item of equipment.

Task Reallocation: Redistribution of actions or activities across available resources to optimize workload for meeting competing or emerging requirements

Top Down Requirements Analysis (TDRA): The process by which human performance requirements are identified, categorized, and analyzed throughout the program acquisition life cycle.

Total Force: All Active and Reserve military, civilians, and contractors of the DoD (DoDI 5160.70). The organizations, units, and individuals that comprise DoD resources for implementing the National Security Strategy. It includes DoD Active and Reserve Component military personnel, DoD civilian personnel (including foreign national direct- and indirect-hires, as well as non-appropriated fund employees), DoD retirees, contracted support, host nation support personnel, and volunteers (DoDI 5124.10).

Total System Performance: The end state functionality achieved by a system when including the human with hardware and software components under its intended operational condition(s) to achieve required operational, effectiveness, and suitability, survivability, safety, and affordability.

Training domain: The policy, processes and techniques, training aids, devices, simulators and simulations, planning, and provisioning for the training, to include equipment used to train personnel to operate, maintain, and support a system.

Usability: A quality attribute that assesses how easy user interfaces are to use. The word "usability" also refers to methods for improving ease-of-use during the (user, human, soldier-centered) design process. The accuracy, completeness, efficiency, and satisfaction with which specified users achieve specified goals in particular environments. Usability is defined by 5 quality components: (1) Learnability: How easy is it for users to accomplish basic tasks the first time they encounter the design? (2) Efficiency: Once users have learned the design, how quickly can they perform tasks? (3) Memorability: When users return to the design after a period of not using it, how easily can they reestablish proficiency? (4) Errors: How many errors do users make, how severe are these errors, and how easily can they recover from the errors? (5) Satisfaction: How pleasant is it to use the design? Denotes the level of user friendliness achieved. Usability is a metric to inform User acceptance or qualify the User experience.

User: Personnel who will operate, maintain, train, and support the equipment, system, or facility.

User Acceptance: (1) The measurable contribution of system design through HCI or HMI for achieving a defined, expected user experience with the context of system's performance; (2) verification by operational users that software is capable of satisfying their stated needs in an operationally representative environment. (DoDI 5000.87)

User Accommodation: Optimizing complex systems so as to not exceed the physical and cognitive capabilities of the target users within other systems-of-systems or Family of systems, especially with regard to ensuring the user's safety, performance, health, and morale.

User Experience: Criteria that encompasses all aspects of the end-user's interaction with a system's software or human interaction design that contributes to usability.

Workload: A quantitative expression of human tasks, usually identified as standard hours of work or a corresponding number of units.

Workload Analysis: Examine the ability of humans to reliably perform assigned tasks to the level of performance required within visual, physical, cognitive, and physiological workload limits. This should include the assessment of both short-duration acute workload and longer duration sustained workload. Workload analysis also validates the allocation of function between users and the system.

ACRONYMS

AAF	Adaptive Acquisition Framework
ADDIE	Analysis, Design, Development, Implement and Evaluation
AoA	Analysis of Alternatives
APA	Additional Performance Attribute
APB	Acquisition Program Baseline
ASVAB	Armed Services Vocational Aptitude Battery
AWF	Acquisition Working Group
CAPE	Cost Assessment and Program Evaluation
CARD	Cost Analysis Requirements Description
CBA	Capabilities-Based Assessment
CDD	Capability Development Document
CoP	Community of Practice
DAG	Defense Acquisition Guidebook
DAS	Defense Acquisition System
DAU	Defense Acquisition University
DID	Data Item Description
DoD	Department of Defense
DoDD	Department of Defense Directive
DoDI	Department of Defense Instruction
DOTmLPF-P	Doctrine, Organization, Training, materiel, Leadership, Personnel, Facilities, and Policy
ESOH	Environment, Safety, and Occupational Health
FP&S	Force Protection and Survivability

HEP	Human Error Probability
HFACS	Human Factors Analysis and Classification System
HFE	Human Factors Engineering
HMI	Human-Machine Interface
HRA	Human Reliability Analysis
HSI	Human Systems Integration
HTS	Hazard Tracking System
ICD	Initial Capabilities Document
ICE	Independent Cost Estimate
IOC	Initial Operational Capability
IPPD	Integrated Product and Process Development
IPT	Integrated Product Team
ISD	Instructional System Design
IT	Information Technology
JCIDS	Joint Capabilities Integration and Development System
JHSIWG	Joint HSI Working Group
KPP	Key Performance Parameter
KSA	Knowledge, Skill, and Ability
KSAO	Knowledge, Skills, Abilities, and Other Attributes
LCSP	Life Cycle Sustainment Plan
MOS	Military Occupational Specialty
MPT	Manpower, Personnel, and Training
OEM	Original Equipment Manufacturer

OPM	Office of Personnel Management
OSA	Other System Attribute
OSD	Office of the Secretary of Defense
PESHE	Programmatic Environment, Safety, and Occupational Health Evaluation
PM	Program Manager
PMO	Program Management Office
PPBE	Planning, Programming, Budgeting, and Execution
PS	Product Supportability
PULHES	Military Physical Profile Serial System (Physical capacity/stamina, Upper extremities, Lower extremities, Hearing and ears, Eyes, Psychiatric)
RAM	Reliability, Availability, and Maintainability
SCORM	Shareable Content Object Reference Model
SE	Systems Engineering
SME	Subject Matter Expert
SOH	Safety and Occupational Health
T&E	Test and Evaluation
TAD	Target Audience Description
TOC	Total Ownership Cost
TSP	Total System Performance
TTAMs	Tools, Techniques, Approaches, and Methods
WIPT	Working Integrated Product Team

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HSI and HSI Domain-Related Data Item Descriptions

General HSI DIDs

DI-HFAC-81743 Human Systems Integration Program Plan (HSIPP)

DI-HFAC-81883 Human Systems Integration Report (HSIR)

DI SESS-81785 HSI in Systems Engineering System Engineering Management Plan (SEMP)

Human Factors Engineering-Associated DIDs

DI-HFAC-80742 Human Engineering Simulation Concept

DI-HFAC-80743 Human Engineering Test Plan

DI-HFAC-80744 Human Engineering Test Report

DI-HFAC-80745 Human Engineering System Analysis Report

DI-HFAC-80746 Human Engineering Design Approach Document – Operator

DI-HFAC-80747 Human Engineering Design Approach Document – Maintainer

DI-HFAC-81399 Critical Task Analysis Report

DI-HFAC-81742 Human Engineering Program Plan

Manpower and Personnel-Associated DIDs

DI-SESS-81759 Logistics Product Data Summaries

Training-Associated DIDs

DI-SESS-81517 Training Situation Document

DI-SESS-81518 Instructional Performance Requirements Document

DI-SESS-81519 Instructional Media Requirements Document

DI-SESS-81520 Instructional Media Design Packages

DI-SESS-81521 Training Program Structured Document

DI-SESS-81522 Course Conduct Information Package

DI-SESS-81523 Training Conduct Support Document

DI-SESS-81524 Training Evaluation Document

DI-SESS-81525 Test Package

DI-SESS-81526 Instructional Media Package

DI-SESS-81527 Training System Support Document

DI-SESS-81637 Training Planning Process Methodology (TRPPM) Report

DI-SESS-81638 Equipment Facility Requirements (EFR) Plan

Safety and Occupational Health–Associated DIDs

DI-MISC-80043 Ammunition Data Card

DI-SAFT-80101 System Safety Hazard Analysis Report

DI-SAFT-80102 Safety Assessment Report

DI-SAFT-80103 Engineering Change Proposal System Safety Report

DI-SAFT-80104 Waiver or Deviation System Safety Report

DI-SAFT-80105 System Safety Program Progress Report

DI-SAFT-80106 Health Hazard Assessment Report (HHAR)

DI-SAFT-80184 Radiation Hazard Control Procedures

DI-MISC-80370 Safety Engineering Analysis Report

DI-SAFT-81066 Safety Studies Plan

DI-SAFT-81124 Threat Hazard Assessment

DI-SAFT-81125 Hazard Assessment Test Report

DI-SAFT-81128 Vibration Test Data

DI-SAFT-81299 Explosive Hazard Classification Data

DI-SAFT-81300 Mishap Risk Assessment Report

DI-MISC-81397 Hazardous Material Management Program (HMMP) Report

DI-MGMT-81398 Hazardous Materials Management Program (HMMP) Plan

DI-MISC-81479 Ozone Depleting Substance (ODS) Plan

DI-SESS-81495 Failure Mode, Effects, Criticality Analysis Report

DI-SAFT-81626 System Safety Program Plan (SSPP)

DI-SAFT-80931 Explosive Ordinance Disposal Data

DI-SAFT-81065 Safety Studies Report

DI-ENVR-81840 Programmatic Environmental Safety and Health Evaluation (PESHE) Plan

Habitability-Associated DIDs

DI-MISC-81123 Color Coordination Manual(s) for Habitability Spaces

early. often.
for the warfighter.

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https://ac.cto.mil/hsi/