



# Standard Practice for Human Systems Integration Program Requirements for Ships and Marine Systems, Equipment, and Facilities<sup>1</sup>

This standard is issued under the fixed designation F1337; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 *Objectives*—This practice establishes and defines the processes and associated requirements for incorporating Human Systems Integration (HSI) into all phases of government and commercial ship, offshore structure, and marine system and equipment (hereafter referred to as marine system) acquisition life cycle. HSI must be integrated fully with the engineering processes applied to the design, acquisition, and operations of marine systems. This application includes the following:

1.1.1 Ships and offshore structures.

1.1.2 Marine systems, machinery, and equipment developed to be deployed on a ship or offshore structure where their design, once integrated into the ship or offshore structure, will potentially impact human performance, safety and health hazards, survivability, morale, quality of life, and fitness for duty.

1.1.3 Integration of marine systems and equipment into ships and offshore structures including arrangements, facility layout, installations, communications, and data links.

1.1.4 Modernization and retrofitting ships and offshore structures.

1.2 *Target Audience*—The intended audience for this document consists of individuals with HSI training and experience representing the procuring activity, contractor or vendor personnel with HSI experience, and engineers and management personnel familiar with HSI methods, processes, and objectives. See 5.2.3 for guidance on qualifications of HSI specialists.

1.3 *Contents*—This document is divided into the following sections and subsections.

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1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

## 2. Human Systems Integration

2.1 *Definition of Human Systems Integration*—HSI is a systematic life-cycle engineering process that identifies and integrates human considerations into the design, acquisition, and support of marine systems through the application of knowledge of human behavior, capabilities, and limitations. The goal is to optimize human performance, including human capability, proficiency, availability, utilization, accommodation, survivability, health and safety by influencing

design, construction, and operations through the integration of requirements that rely on the expertise found in the following HSI domains:

2.1.1 *Manpower*—Establishing the number and type of personnel needed to operate and maintain the marine system.

2.1.2 *Personnel*—Determining where the people with the required knowledge, skill, and abilities (KSAs) required to fill marine system billets will be drawn.

2.1.3 *Training*—Establishing and providing the training requirements for the personnel selected.

2.1.4 *Human Factors Engineering*—Designing and assessing user interfaces between humans and hardware, software, firmware, webware, courseware, information, procedures, policy and doctrine, documentation, design features, technology, environments, organizations, other humans, and (co) robots.

2.1.5 *Safety and Occupational Health*—Providing a safe and healthy working environment.

2.1.6 *Personnel Survivability*—Providing a platform that maximizes crew survivability.

2.1.7 *Habitability*—Providing the characteristics of systems, facilities, personal services, and living and working conditions that result in high levels of crew morale, quality of life, safety, health, and comfort.

2.1.8 Government-oriented definitions of the HSI domains are provided in **Table 1**.

2.1.9 It is understood that not all HSI domains will be involved in every marine system design project. For example, in the commercial maritime setting, design requirements affecting several HSI domains (for example, manpower, personnel selection, and training requirements) are set by entities other than the procuring organization. This does not diminish the fact that inattention to these HSI domains can lead to the increased likelihood of human error, accidents, and incidents. Therefore, the procuring organization must exert maximum effort to ensure that all HSI domains are considered in the design, construction, and operation of any maritime system.

2.1.10 HSI fundamentally involves engineering processes and program management efforts that provide integrated and comprehensive analyses, design and assessment of requirements, operational and maintenance concepts, and resources for system manpower, personnel, training, human factors engineering (HFE), safety and occupational health (SOH), personnel survivability, and habitability. These seven HSI domains are interrelated and interdependent, and they are primary drivers of effective, affordable, and safe design concepts and deployed systems. HSI relies on a concurrent engineering process to perform co-operative trade-offs among the seven HSI domains to achieve effective system performance levels and affordable life-cycle costs, but does not replace individual domain activities, responsibilities, or reporting channels.

2.1.11 The HSI framework for organizing and integrating of human considerations into marine system design represents a system-level engineering approach. HSI uses the results of its technical domain analyses and tradeoffs to integrate them into the systems engineering and design processes. In the government environment, other HSI domains provide insights, data,

**TABLE 1 Description of Government-Oriented HSI Domains**

Domain	Description
Manpower	Manpower is the number of personnel (military, civilian, and contractor) required, authorized, and potentially available to operate, maintain, train, administer, and support each ship, offshore structure, system, or combination thereof.
Personnel	Personnel is the source, in terms of people, for the human knowledge, skills, abilities, aptitudes, competencies, characteristics, and capabilities required to operate, maintain, train, and support each ship, offshore structure, marine system, or combination thereof, in peacetime and war.
Training	Training is the instruction, education, assessment, resources required to provide ship and marine facility personnel with requisite knowledge, skills, and abilities to operate, maintain, and support ship, offshore structure, marine systems, or combination thereof.
Human Factors Engineering	Human factors engineering is the comprehensive integration of human characteristics and capabilities and limitations into system definition, design, development, and evaluation to promote effective human-machine integration for optimal total system performance.
Safety and Occupational Health	Safety is the process for hazard identification, risk evaluation, design analysis, hazard mitigation, control, and management. The process manages the design and operational characteristics of a system to eliminate or minimize the possibilities for accidents or mishaps caused by human error. Occupational health is the systematic application of biomedical knowledge, early in the acquisition process, to identify, assess, and minimize health hazards associated with the system's operation, maintenance, repair, storage, or support.
Personnel Survivability	Personnel Survivability is the how the system design minimizes medical implications when humans are injured, provides escape and evacuation routes for crew, and minimizes human mental and physical fatigue.
Habitability	Habitability is the ship, offshore structure, and system characteristics that provide for environment control of living and working conditions (temperature, noise, vibration, and space attributes); and provides accommodations and support facilities (berthing, sanitary, food service, exercise, training, laundry, medical, dental, administrative, ship stores, and community or lounge facilities). Habitability is concerned with the level of comfort and quality of life that is conducive to maintaining optimum crew performance, readiness, and morale.

**TABLE 2 Key Interactions Among HSI Domains**

Domain	Interactions
Manpower	Personnel – Qualities and quantities of personnel required versus availability in inventory and pipeline Training – Qualities and quantities required versus ability to train to meet requirements HFE – Qualities and quantities of personnel required versus ability of system design or redesign to support manpower, task complexity, and workload SOH – Qualities and quantities of personnel required versus ability to safely perform tasks, particularly in a reduced manpower environment Personnel Survivability – Quantities versus availability of personnel protection equipment (PPE) and designs that support survivability Habitability – Quantities of personnel and workload required to perform tasks versus habitability support requirements such as berthing, food service, laundry, administrative, postal, ship stores, and other habitability support spaces
Personnel	Training – Availability in the inventory or in the pipeline of quantities of personnel required versus ability to train required knowledge, skills and abilities (KSAs) HFE – Availability of quantities and qualities of personnel required versus complexity of task and system design
Training	HFE – Complexity and duration of training and training system design versus task/design complexity and the ability to train KSAs versus complexity of tasks and design Personnel Survivability – Transfer of information on training requirements for PPE and other emergencies
HFE	SOH – How does design avoid or mitigate risks to safety and occupational health; Risks versus ability of design to mitigate risks Personnel Survivability – Emergency egress and personal protection versus design's ability to support Habitability – How do habitability facilities support the ability of users to safely and effectively inhabit space and perform tasks
SOH	Habitability – Reduction of safety and health risks through the design of environmental control (temperature, noise, and vibration levels) and habitability facilities and working spaces not under habitability purview (work shops, machinery spaces, etc.)
Personnel Survivability	Habitability – Ensure that requirements for PPE and survivability are integrated with the overall design of habitability facilities and working spaces
Habitability	All HSI Domains – Ensure domain concerns are addressed in habitability facilities, e.g., address the manpower or training implications of a food service facility

and design considerations that HFE translates into hardware, software, workspace, and task design. This is a more formal government process. In the commercial environment, HSI relies heavily on HFE, assigning it responsibility of being

aware of considerations associated with manpower, personnel, training, safety, and habitability and representing those as part of a human-centric design process.

## 2.2 HSI Integration Process:

2.2.1 A key HSI focus is *integration*. HSI takes a total system level view of design, acquisition, and operations. This system level view starts with the performance requirements of the total system that are translated into requirements for total system performance and total cost of ownership. The system performance and cost requirements then are integrated into the design by the application of HSI methods and standards to the design of the marine system. HSI continues as an integrated element of the operations and support activity as a mechanism to support training, maintenance, and identify system improvement opportunities.

2.2.2 HSI relies on the individual technical HSI domains, but also the integration of these domains among themselves and with the other systems engineering and logistics requirements and processes. The domains of HSI must work in concert among themselves and with other systems engineering processes to address human design issues and trade-offs that optimize overall system performance and reduce life cycle costs. **Table 2** provides a high-level view of some of the types of interactions and tradeoffs that occur among HSI domains.

2.2.3 Integration between HSI domains occurs through the following activities:

2.2.3.1 Developing and maintaining a Human Systems Integration Plan (HSIP) that includes all HSI domains and discusses interactions required among these domains. The key here is to maintain the HSIP over the marine system life cycle through updates as design issues and considerations change. See **5.3** for more information on the HSIP. The HSIP should be integrated with the Systems Engineering Plan (SEP) and other engineering plans.

2.2.3.2 Close coordination and communication among HSI domains. This occurs through informal and formal meetings, design reviews, and other communications such as email, telephone conversations, list serves, bulletin boards, and video conferences.

2.2.3.3 Use of an HSI Integrated Product Team. See **5.4** for more information.

2.2.3.4 Performing a unified front-end analysis that addresses requirements and concepts for each domain, the interactions among HSI domains, and the integration with systems engineering. A unified front-end analysis represents one analysis that accepts input and provides output to all the HSI domains and other engineering areas.

2.2.3.5 Maintaining a consolidated database of HSI issues and design decisions. This database should include all HSI issues identified during the design effort, suggested HSI inputs from all the HSI domains, a description as to whether or not each HSI recommendation was incorporated in the marine system design; and if not accepted, provide the reason for rejection along with the risk assessment. The database is created and maintained by the HSI specialists from the procuring organization. This database should be maintained through the marine system life cycle to support the documentation of HSI issues that arise during training, operation, and maintenance. The consolidated database of HSI issues should include lessons learned from the design process, feedback from

in-service ships and offshore structures on marine systems, machinery, and equipment.

2.2.3.6 Defining and empowering an integrator role that has responsibility for facilitating and managing the information flow among HSI domains and with systems engineering. This individual must be someone with an understanding of HSI, preferably possess an engineering background, and be a senior member of the organization. The HSI integrator should not be responsible for performing the HSI activities, rather should focus on ensuring communication between the various HSI domains and with the engineering program.

2.2.3.7 Collecting and tracking information on operator or maintainer feedback and lessons-learned from legacy or similar operational systems concerning human performance, workload, health and safety, and accommodation. This provides information on how well a design approach has worked in meeting objectives, and what problems or issues have been identified regarding human performance, behavior, availability, productivity, competence, health and safety, and accommodation.

2.2.3.8 Conducting user-centered design of user interfaces that emphasizes requirements for human performance, including human capability, behavior, availability, productivity, competence, health and safety, and accommodation.

2.2.3.9 Conducting Test and Evaluation (T&E) activities that assess all HSI domains and the efficacy of any tradeoffs that have occurred. The T&E activities should focus on the human performance aspects of total system performance, behavior, availability, productivity, competence, health and safety, and accommodation.

2.3 *HSI Program Requirements*—HSI is required for government system acquisition programs. For the commercial marine industry, there is no policy requirement for HSI, but this document serves as a best practice that can be required through contract language by the procuring organization.

2.3.1 The decision as to whether to invoke this practice as a mandatory provision for design, development, and operational programs for government or commercial industry marine systems is dependent on three key factors:

2.3.1.1 The potential influence of human performance on mission and task success.

2.3.1.2 The existence of any overarching HSI drivers for the acquisition, such as reduced manpower or training burden, or both, enhanced safety, or increased human and total system performance requirements.

2.3.1.3 The potential to reduce total ownership costs for systems by reducing costs associated with manpower, training, human errors and accidents.

2.3.2 **Fig. 1** provides a high-level decision process for determining the requirement for an HSI Program. This process is performed as a precursor to any front-end analysis to make judgments about human involvement with the marine system. These judgments will be detailed, refined, and validated in the early phases of the marine system design and acquisition process. The size and significance of any required HSI program will depend on a number of factors, including those associated with the answers to the questions in **2.3.3**.

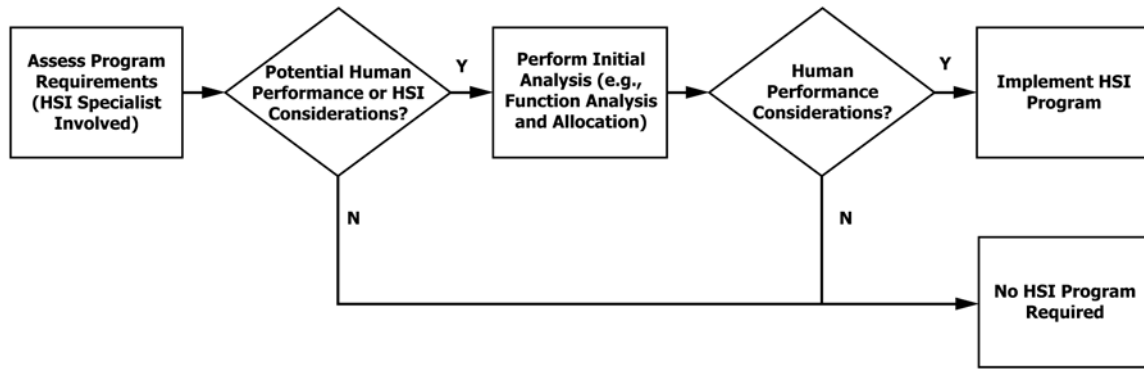


FIG. 1 Process for Determining the Need for an HSI Program

2.3.3 Once the HSI program decision has been made, key considerations that should be looked at to scope the level of the HSI program effort include the following:

2.3.3.1 Will the type of personnel involvement or the approaches related to operation or maintenance of the marine system differ substantially from what is the current practice of the organization?

2.3.3.2 Will the marine system introduce new technologies or impose new tasks and skill requirements on the operators/maintainers not previously supported to acceptable levels?

2.3.3.3 Are there opportunities to increase operator/maintainer levels of efficiency through improved design?

2.3.3.4 Will the marine system be operated and maintained by individuals not normally assigned to work on the facility?

2.3.3.5 Is one objective of the marine system to reduce manpower?

2.3.3.6 Will the marine system be used by personnel from a culture or geographic part of the world different from the individuals doing the design and construction? If so, what HSI requirements need to be modified to meet the target user population?

2.3.3.7 Will the marine system be operated or maintained by both males and females?

2.3.3.8 Will the marine system provide equipment with which the personnel have had little or no previous experience?

2.3.3.9 Is one goal of the marine system to reduce accidents or incidents that have occurred on other marine systems?

2.3.3.10 Will the new marine system be more complex than, or different from, any previous system?

2.3.3.11 Does the procuring organization lack any previous HSI experience on previous design projects that could be transferable to the new marine system?

2.3.3.12 Is one goal of the new project to reduce operating and maintenance costs?

2.3.3.13 Does the procuring organization have a specific mission to enhance safety and quality of the work environment for its employees?

2.3.3.14 Has the procuring organization had previous unfavorable rulings from regulatory agencies on issues of safety, pollution control, or system design based on HSI issues?

2.3.3.15 Does the marine system add or reduce logistics issues?

2.3.3.16 Does the marine system reduce or add to the damage control response?

2.3.4 Where a HSI program is required, decisions to implement or comply with this practice by tailoring the HSI activities to be performed should be made by HSI specialists and include detailed justification for the decision. The procuring organization has final approval of any tailoring.

### 3. Referenced Documents

3.1 *Introduction*—The following documents, where appropriate, should be used in conjunction with this practice in implementing a HSI program. These documents should be considered for use by both the government and the commercial industry.

3.2 *ASTM Standards*:<sup>2</sup>

[F1166 Practice for Human Engineering Design for Marine Systems, Equipment, and Facilities](#)

3.3 *Commercial Standards and Documents*:<sup>3</sup>

[ABS Guidance Notes for the Application of Ergonomics to Marine Systems, August 2013 \(Updated August 2018\)](#)

[ABS Guidance Notes on the Ergonomic Design of Navigation Bridges, October 2003 \(Updated August 2018\)](#)

[ABS Guide for Crew Habitability on Offshore Installations, February 2016](#)

[ABS Guide for Crew Habitability on Ships, February 2016](#)

[ABS Guide for Building and Classing Naval Vessels \(limited distribution\) Part 0 General Provisions, Chapter 7 “Human Systems Integration,” Chapter 8 “System Safety,” Chapter 9 “General Arrangements,” and Chapter 10 “Margins;” Part 4 Control, Automation, and Navigation Systems; Part 6 Habitability and Outfit](#)

[Human Factors Design Handbook Woodson, W., Tillman, B. and Tillman, P., 1992](#)

[ANSI/HFES 100 Human Factors Engineering of Computer Workstations](#)

[ANSI/HFES 200 Human Factors Engineering of Software User Interfaces](#)

[ANSI/ITAA GEIA-STD-0010 Standard Best Practices for System Safety Program Development and Execution, 18 October 2018](#)

<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard’s Document Summary page on the ASTM website.

<sup>3</sup> Referenced ABS guides are available at the ABS website, [www.eagle.org](http://www.eagle.org).

### 3.4 *Government Standards and Documents:*<sup>4</sup>

- NAVSEA Human Systems Engineering Best Practices Guide Beaton, R., Bost, R., and Malone, T., 2008
- OPNAVINST 1500.76D Naval Training Systems Requirements, Acquisition, and Management, 29 July 2021
- DOD Directive 1100.4 Guidance for Manpower Programs, 12 February 2005
- MIL-STD-46855 Rev A Requirements for Military Systems, Equipment and Facilities, 21 December 2020
- MIL-STD 882E DOD Standard Practice for System Safety, 11 May 2012
- NAVSEA Standard 03-01 Common Presentation Layer Guide, September 2006
- NAVSEAINST 5100.12B System Safety Engineering Policy, 3 August 2011
- OPNAVINST 1000.16L Navy Total Force Manpower Policies and Procedures, 2 July 2021
- OPNAVINST 5100.23H Navy Safety and Occupational Health Program, 5 June 2020
- OPNAV M-5100.23 Navy Safety and Occupational Health Manual
- OPNAVINST 9640.1C Shipboard Habitability Program, 17 June 2019
- SECNAVINST 5100.10L Department of the Navy Safety Program, 9 April 2021

## 4. Terminology

### 4.1 *Definitions:*

4.1.1 *arrangement drawing*—engineering design drawings that provide plan, sectional, and elevation views of (1) the configuration and arrangement of major items of equipment for manned compartments, spaces, or individual workstations, and (2) within the workstation, such as in a modular rack.

4.1.2 *contractor*—the organization or company with the contractual responsibility for designing the ship, offshore structure, or marine system. For ships or offshore structures, this is typically a shipyard.

4.1.3 *critical activity*—any human activity that, if not accomplished in accordance with system requirements (for example, time limits, specific sequence, necessary accuracy), would have adverse effects on system or equipment cost, reliability, efficiency, effectiveness, or safety.

4.1.4 *cultural expectation*—the cause and effect relationships and use conditions (for example, red means stop or danger, moving a toggle switch up to activate) that humans learn from their culture and form the bases for design conventions. Also referred to as population stereotype.

4.1.5 *damage control*—the emergency control of a situation that may cause the loss of a vessel.

4.1.6 *function*—a higher-level activity performed by a system or human (for example, provide electric power) to meet mission objectives usually decomposed into sub functions and tasks.

4.1.7 *human systems integration*—modern systems engineering that addresses optimization of manpower, personnel and training, and enhancement of human performance affecting total system performance and life cycle costs, including human capability, availability, safety, survivability and fitness for duty.

4.1.8 *high drivers*—high drivers for HSI include functions that impose high demands on manpower, are labor intensive, are expected to impose high risks, workloads, and performance complexities, are error prone, require excessive training, or are unsafe.

4.1.9 *human error*—inappropriate or undesirable human decision or behavior. Human errors can be categorized into errors of omission where the human forgets or does not perform a task or step and commission where the human unintentionally performs a task or step incorrectly. In addition, there are intentional errors where the human consciously and purposefully omits or performs a task incorrectly. Another way to classify human error is by slips, where errors are due to incorrect automated/unconscious behavior, and mistakes, where errors are due to incorrect conscious decision making.

4.1.10 *manning*—represents the personnel assigned to, or required for, a marine system in terms of whether people are currently in the personnel inventory, are in the recruitment pipeline, or need to be recruited. Manning also deals with how the personnel need to be trained to meet KSA requirements.

4.1.11 *manpower*—the requirements for the number and types of people needed to perform the required workload associated with the tasks defined for a marine system as expressed in the number and characterization of the billets approved for a marine system crew.

4.1.12 *marine system*—ships, offshore facilities, equipment, and software used in a marine environment.

4.1.13 *mission*—a specific performance requirement imposed on one or more systems (for example, unload cargo) within the operational requirements.

4.1.14 *offshore structure or facility*—fixed and floating installations, offshore supply vessels (OSVs), offshore terminals, or any other offshore facility created for exploration, production, distribution, and/or transportation of natural gas and oil.

4.1.15 *operational requirements*—requirements under which the platform, system, equipment, or software are expected to operate and be maintained (for example, day/night, all weather operation, sea state, speed, endurance) while completing a specific mission or missions.

4.1.16 *panel layout drawings*—detailed drawings include scale layouts (for example, controls and displays on each panel), items of equipment (for example, shipboard command console), descriptions of all symbols used, identification of the color coding used for displays and controls, the labeling used on each control or display, identification of control type (for example, rotary or pushbutton), and screen layouts for software generated displays.

4.1.17 *procuring organization*—the organization that purchases a ship, offshore structure, marine equipment, or marine

<sup>4</sup>SECNAV and OPNAV instructions are available at <https://www.secnav.navy.mil/doni/Directives/>.

system. For commercial shipping and offshore structures, this is a ship or offshore structure owner.

4.1.18 *system*—a combination of components that interact together to achieve a common goal. Systems can be machine-to-machine, human-to-machine, and human-to-human. The term *system* can be used for individual components that are integrated into a ship or offshore structure, as well as the complete ship or offshore structure.

4.1.19 *task*—a lower level activity, compared to a function, which is the unit of human performance. A task represents a composite of related activities (for example, perceptions, decisions, and responses) performed by a human for an immediate purpose under specified conditions (for example, environmental, operational and/or tactical) with a definite beginning and end.

4.1.20 *user interface*—all interfaces between the human and the system, including hardware, software, and workspace.

4.1.21 *vendor*—a supplier of marine systems, equipment, or machinery to the contractor.

## 5. Summary of Practice

5.1 *HSI Design Objectives*—Key objectives for HSI in marine system design are the following:

5.1.1 *Enhancement of Human Performance*—A critical factor underlying mission success is human performance; that is, the demonstrated capability of the intended user to operate, maintain, support, manage, and use the systems and equipment under all expected environmental and operational conditions.

5.1.2 *Manpower Optimization*—Manpower optimization is defined as determining the number of personnel and skillsets required to perform the required missions, functions, or tasks successfully given the anticipated human performance, workload, and safety requirements, as well as affordability, risk, and reliability constraints. This supports cost-effective operation of ships, offshore structures, and marine equipment.

5.1.3 *Training Requirement Reduction*—Reduction of difficult to train skills through design, which can reduce personnel requirements or reduce the overall training burden, or both, support the objectives of optimizing manpower, and enhancing human performance, as well as reducing life cycle costs associated with training.

5.1.4 *Enhancement of Safety and Survivability*—Safety consists of those system design characteristics that serve to minimize the potential for mishaps causing death or injury to operators and maintainers or threaten the survival or operation, or both, of the system.

5.1.5 *Improvement in Quality of Life*—Quality of life factors are those living and working conditions, that is, effective design of space, equipment, and environmental control in habitability facilities and work spaces, which result in levels of personnel morale, safety, health and comfort, and fitness for duty adequate to sustain maximum personnel effectiveness to support mission performance and avoid personnel retention problems. This includes avoidance of exposure to risks of adverse health and occupational health effects.

5.1.6 These key objectives are met through the application and integration of HSI within the systems engineering process

throughout the life cycle of the marine system. This includes incorporating the feedback gained from lessons learned during design, development, build, and system operation (for example, operator and maintainer feedback) into updates to HSI processes and requirements. The execution of only one or more of these key objectives without requisite system integration efforts does not constitute HSI.

5.2 *Key Success Factors*—The following success factors should be part of any HSI program:

5.2.1 *Management Commitment*—Management within the procuring organization, as well as contractor and vendor organizations must be committed to the procuring organization's HSI program by emphasizing planning, providing funding, and making available appropriate resources. This commitment should be demonstrated by the following:

5.2.1.1 Identification of an HSI champion within the procuring organization or the vendor organization who has responsibility for implementation of HSI within the program, as well as the required authority to be successful.

5.2.1.2 Location of the HSI activity within the engineering organization.

5.2.1.3 Providing appropriate resources, including adequate funding and qualified personnel, to the HSI activity to ensure success.

5.2.1.4 During design and development phases, provide adequate margin for design and service life growth.

5.2.1.5 Providing HSI awareness training to other parts of the organization.

5.2.1.6 Incorporation of HSI into the systems engineering process through integration with the systems engineering plan or other master planning document.

5.2.2 *Early and Consistent Involvement of HSI*—HSI must be integrated with the engineering effort throughout the life cycle of the marine system. This integration is facilitated by HSI specialists from the procuring organization or the contractor and vendor, or both, depending on the phase of the acquisition life cycle.

5.2.3 *Involvement of Qualified HSI Personnel*—Qualified HSI specialists should be used to provide the required HSI support to the program. HSI specialists should bring to the program a broad, systems engineering orientation with a behavioral science and ergonomics background. Knowledge of the systems being designed and their operational environments also is important and can be fine tuned early in the program. HSI domain experts should provide technical supporting capabilities. Recommended minimum qualifications for HSI specialists are provided in [Table 3](#). The HSI specialist should meet the qualifications listed for a Practitioner or Lead/Senior level HSI professional to lead HSI programs. Individuals with qualifications listed for the Junior or Entry levels should work on a project under technical supervision of senior HSI personnel.

5.2.4 *Incorporation of HSI into Program Documentation*—HSI requirements and standards must be incorporated into all program requirements documents, specifications, statements of work, requests for proposals or quotes, test and evaluation plans, and other contract documentation, where relevant. This

**TABLE 3 Minimum Qualifications for HSI Specialists**

Role	Minimum Education	Minimum Years Experience
Lead/Senior	Ph.D. or Master's degree in relevant field such as human factors engineering, behavioral science, industrial engineering, and systems engineering.	15 years experience applying their HSI specialty in a system design environment. Preferably, some of that experience is with marine systems. Years of applied experience may offset the educational requirements.
Practitioner	Master's or Bachelor's degree in relevant field such as human factors engineering, behavioral science, industrial engineering, and systems engineering.	8 years experience applying their HSI specialty in a system design environment. Preferably, some of that experience is with marine systems. Years of applied experience may offset the educational requirements.
Junior Level	Bachelor's degree in relevant field such as human factors engineering, behavior science, industrial engineering, and systems engineering.	4 years experience applying their HSI specialty in a system design environment. Advanced degrees may offset years of experience.
Entry Level	Bachelor's degree in relevant field such as human factors engineering, behavioral science, industrial engineering, and systems engineering.	1 year or less experience applying their HSI specialty in a system design environment.

includes all specifications provided to vendors and contractors, as well as involvement in source selection.

**5.3 Human Systems Integration Plan**—The HSIP is the technical strategy and programmatic management plan to ensure that HSI is implemented as early as possible and throughout the system life cycle to affect the design, affordability, and supportability of the system. The HSIP must be integrated with the systems engineering plan or with other relevant engineering plans when a systems engineering plan is not part of the program. For government acquisitions, HSI planning may be incorporated into the systems engineering plan where possible rather than having a stand-alone HSIP.

5.3.1 The HSIP is an essential element of the HSI effort and possesses the following characteristics:

5.3.1.1 It is a dynamic document updated as the acquisition process progresses and as new information is available.

5.3.1.2 It is a planning and management guide, which ensures that HSI issues are addressed at the required time throughout the life cycle of the system. It provides a system management approach for identifying and addressing HSI issues and concerns, as well as tools and analyses that potentially provide answers for these HSI issues.

5.3.1.3 It identifies information sources, documents the results of analyses and trade-offs conducted, provides an audit trail for decisions made in each acquisition phase, and identifies when products and events were completed.

5.3.1.4 It can be a stand alone document that serves as the single source of what information is required, when the information is required, who is responsible for the information, what is the strategy for collecting the information, and what are the required resources in terms of personnel, facilities, and funding.

5.3.1.5 It integrates requirements from all the HSI domains and addresses overarching HSI considerations.

5.3.1.6 It integrates HSI requirements into the systems engineering plan.

5.3.2 The HSIP should be prepared early in the marine system acquisition process and maintained throughout.

5.3.3 Preparation of the HSIP is the responsibility of the procuring organization, whether that is the government or a commercial activity. However, the procuring organization may delegate responsibility for the HSIP to the contractor or require that the contractor also prepare a coordinated HSIP that describes the contractor and vendor HSI requirements, activities, deliverables, and schedule. The procuring organiza-

tion has approving authority over the HSIP. An example outline of a typical HSIP is provided in [Fig. 2](#).

5.3.4 For the government, the HSIP integrates information sources (see [Table 2](#)), as well as information from other HSI documents such as the HSI risk management plan and HSI T&E plans.

5.3.5 For the commercial industry, the HSIP can be synonymous with the Human Engineering Program Plan (HEPP) provided that the HEPP adopts a systems perspective. The HEPP should emphasize how HFE will integrate manpower, personnel, safety, and other domain considerations into the design and acquisition of the marine system.

**5.4 HSI Integrated Product Team**—Successful integration of HSI requires a team approach where HSI specialists work closely with other personnel from engineering, SOH, program management, logistics, and stakeholders to ensure that the HSI goals and objectives of the program are met. The formation of an Integrated Product Team (IPT) facilitates this team approach. The IPT should include representatives of the procuring organization and the contractor(s). An HSI specialist should be the chair of the IPT and coordinate all meetings and agendas. Other members should provide input in their respective areas of expertise. The IPT should address the following, at a minimum:

5.4.1 Measuring progress in meeting stated HSI goals.

5.4.2 How to deal with new HSI concerns or issues that arise during the acquisition process.

5.4.3 Coordination and communication between the acquisition and design team with respect to HSI issues, scheduling, and resources.

5.4.4 Integrating HSI into engineering.

5.5 The HSI IPT should have membership with other IPTs to ensure coordination of HSI issues and requirements with the overall engineering process.

**5.6 Quality Assurance**—Verification of compliance with the requirements of this practice and other HSI requirements specified by the contract is the responsibility of the procuring organization. HSI performed during the design and construction program by a contractor or vendor must be demonstrated to the satisfaction of the procuring organization at the scheduled design and configuration reviews and inspections throughout the design and construction period, as well as during test and evaluation inspections, demonstrations, and tests.



System Name	
Human Systems Integration Plan	
1. Background	
a. System/Program Description	Describes the ship, offshore installation, or marine system in terms of technology, components, mission/purpose, expected operational environment, and performance goals.
b. Scope	Summarizes the objectives of the HSI program.
2. Target Audience/Users	Describes the expected operator, maintainer and other users. This description includes, but may not be limited to, their knowledge, skills, and aptitudes (KSAs), training, demographics, physical attributes, and nationalities.
3. Acquisition Strategy	Describes the acquisition approach and process for developing the system such as standard design process versus evolutionary acquisition or other approach. Describes how HSI fits into the chosen approach.
4. Organization, Responsibilities, and Coordination	Describes the HSI organization, where it fits into the overall procuring activity or contractor organization, responsibilities of each HSI participant, and how coordination among HSI participants and between HSI and engineering will occur.
5. HSI Master Schedule	Describes the master schedule for HSI activities and events, overlaid on the system engineering schedule.
6. HSI Goals and Constraints	
a. Goals by Domain	Describes the performance requirements, objectives, and success criteria for each HSI domain.
b. Constraints by Domain	Describes any constraints on the HSI goals such as specific limitations to the types of personnel available to operate the system.
7. HSI Activities	Describes the planned HSI tasks and activities that will be performed by the government as well as the contractor.
Annex A – HSI Issues	Provides a “living” list of issues and their resolution
Annex B – References	Provides relevant references for the HSI program

FIG. 2 Sample Outline of a Typical HSIP

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<https://standards.iteh.ai/catalog/standards/sist/a0eea035-bbe4-4ad6-a9d5-2f8550c5de4/astm-f1337-22>

5.7 *Nonduplication*—The efforts performed to fulfill the HSI requirements specified herein should be coordinated with, but not duplicated by, efforts performed in accordance with other requirements. An extension of the results of other efforts for use in the HSI program is not considered duplication. Instances of duplication or conflict should be brought to the attention of the procuring activity.

5.8 *Cognizance and Coordination*—Where appropriate, the HSI program should be coordinated with maintainability, reliability, and integrated logistic support. Results of HSI analyses or lessons learned information are provided to the logistics support community. The HSI portion of any analysis, design, and development, or test and evaluation program is conducted by, or under the direct cognizance of the Lead/Senior or Practitioner HSI specialist.

## 6. Significance and Use

6.1 *Intended Use*—Compliance with this practice provides the procuring organization with assurance that human users will be efficient, effective, and safe in the operation and maintenance of marine systems, equipment, and facilities. Specifically, it is intended to ensure the following:

6.1.1 System performance requirements are achieved reliably by appropriate use and accommodation of the human component of the system.

6.1.2 Usable design of equipment, software, and environment permits the human-equipment/software combination to meet system performance goals.

6.1.3 System features, processes, and procedures do not constitute hazards to humans.

6.1.4 Trade-offs between automated and manual operations results in effective human performance and appropriate cost control.

6.1.5 Manpower, personnel, and training requirements are met.

6.1.6 Selected HSI design standards are applied that are adequate and appropriate technically.

6.1.7 Systems and equipments are designed to facilitate required maintenance.

6.1.8 Procedures for operating and maintaining equipment are efficient, reliable, approved for maritime use, and safe.

6.1.9 Potential error-inducing equipment design features are eliminated, or at least, minimized, and systems are designed to be error-tolerant.

6.1.10 Layouts and arrangements of equipment afford efficient traffic patterns, communications, and use.

6.1.11 Habitability facilities and working spaces meet environmental control and physical environment requirements to provide the level of comfort and quality of life for the crew that is conducive to maintaining optimum personnel performance and endurance.

6.1.12 Hazards to human health are minimized.

6.1.13 Personnel survivability is maximized.

6.2 *Scope and Nature of Work*—HSI includes, but is not limited to, active participation throughout all phases in the life cycle of a marine system, including requirements definition, design, development, production, operations and decommissioning. HSI, as a systems engineering process, should be integrated fully into the larger engineering process. For the government, the HSI systems engineering process is manifested in both a more formalized, full scale system acquisition, as well as a non-developmental item acquisition. For the commercial industry, the system acquisition process is less formal and more streamlined. Each process is described below.

6.3 *Government Formalized, Full Scale Acquisition*—The U.S. Government’s acquisition process is composed of six steps, as illustrated in Fig. 3. Each phase is briefly summarized below.

6.3.1 *Capabilities Requirements*—The Capabilities Requirements phase precedes the other acquisition phases and it is performed by the procuring organization. It focuses on defining operational goals and desired capabilities that will be used to guide marine system development; clarifying requirements; developing initial design concepts and alternatives; and assessing the feasibility and costs of development.

6.3.1.1 These are developed through the Analysis of Alternatives (AoA) process, as defined in the Joint Capabilities Integration Development System (JCIDS), and captured in the Initial Capabilities Document (ICD). These are based on analyses of multiple concepts that consider affordability, technology maturity, and responsiveness.

6.3.1.2 Typical HSI inputs during this phase include defining human performance, habitability, and safety issues; identifying high level HSI requirements; identifying HSI risks, functions, and tasks from legacy or predecessor systems that will challenge human performance; identifying HSI lessons learned from legacy or predecessor systems, or both; and identifying opportunities for workload reduction, manpower optimization, and enhancement of human performance, safety, and survivability.

6.3.2 *Materials Solution Analysis*—The objective of the Materials Solution Analysis phase is to refine the concept(s) for marine system design developed during the previous phase and

to evaluate the technical soundness of the selected concept(s), as well as to determine if the concept(s) meet requirements.

6.3.2.1 This phase is entered once the ICD has been approved, and includes the conduct of an AoA by the Government. This includes developing and evaluating initial design concepts in response to the ICD.

6.3.2.2 Typical HSI inputs in this phase include task and requirement analyses; manpower, personnel, and training analyses; trade-off studies for alternatives; iterative assessments of user interface (UI) design concepts; input to design decisions and products; identification of human performance and safety requirements; development of the HSIP; initial development of habitability and quality of life requirements; and input into test and evaluation strategies.

6.3.3 *Technology Development*—The technology development phase focuses on detailing the design to the level required for the shipbuilder or system developer to be able to have a clear understanding of required features and develop an accurate estimate for the costs to construct. Outputs should include detailed drawings, design specifications, and design standards.

6.3.3.1 This phase, which is entered after Milestone A approval, focuses on reducing risk, selection of a final concept, if not already determined, and determining the technologies to be integrated into the full system design. During technology development, the government prepares the Capability Development Document (CDD) to support program initiation. The CDD builds on the ICD and provides the detailed operational performance parameters necessary to design the proposed system. During this phase of the design process, the safe disposal of the marine system should be estimated and planned, including documenting the use of hazardous materials contained in the system.

6.3.3.2 HSI activities during this phase include top down requirements analysis, human performance evaluations of technology alternatives, UI specification development, inputs to the CDD, personnel, habitability, and training requirements analysis, and developing crewing concepts. After CCD is completed, HSI activities in this phase include HSI input into the development of the preliminary design, detail or performance specification, and contract design including detailed requirements for habitability.

6.3.4 *Engineering and Manufacturing Development*—The focus of the engineering and manufacturing development phase is on performing the design and development activities required to achieve an initial operational capability, as well as demonstrating that the marine system will achieve operational requirements. In terms of ships, this might include development of the lead ship of its class.

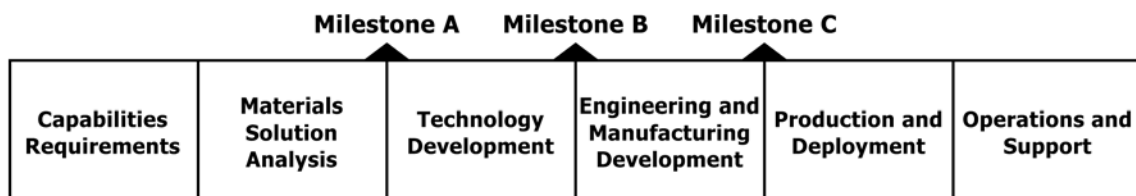


FIG. 3 Government HSI Systems Engineering Process and the System Acquisition Life Cycle

6.3.4.1 This phase is entered after Milestone B. During this phase, the Capability Production Document (CPD) is prepared to update and extend the CDD.

6.3.5 HSI activities during this phase include development and prototyping of design concepts for UI, equipment access, maintainability, space layout, and machinery layouts; performing human performance studies and evaluations of prototypes and concepts; refining manpower estimates; developing training concepts; providing inputs to the CPD; and conducting safety and health risk assessments. Detail design is developed for compartment layout, equipment access, machinery layout, habitability facilities, and personnel access routes, etc. Human performance analysis is performed, manpower estimates are refined, and training concepts are developed.

6.3.6 *Production and Deployment*—The goal of the production and deployment phase is to achieve an operational capability that meets mission needs.

6.3.6.1 This phase is entered after Milestone C. The marine system is evaluated through Operational Test and Evaluation (OT&E) for effectiveness and suitability, and the system may go into limited production before full production is approved.

6.3.6.2 HSI activities during this phase for government development include support to OT&E, capturing lessons learned for future builds and development cycles, and implementation of training and personnel plans.

6.3.7 *Operations and Support*—The objective of the Operations and Support phase is the execution of a support program that meets operational performance requirements; sustains the system in the most cost-effective manner over its total life cycle; provides for improvements, upgrades, and modernization; allows for safe disposal at the end of the system’s useful life; and provides for the elicitation of structured user feedback. Operations and Support has two major efforts: Sustainment and Disposal.

6.3.7.1 Sustainment strategies evolve and are refined throughout the life cycle, particularly during development of subsequent increments of an evolutionary strategy, modifications, upgrades, and re-procurement.

6.3.7.2 Disposal strategies at the end of the useful life of a system should focus on decommissioning in accordance with all legal and regulatory requirements and policy relating to safety (including explosives safety), security, and the environment.

6.3.7.3 HSI continues to be integrated into these stages of the life cycle through participation in all upgrades, retrofits, and modernization efforts. Emphasis is placed on understanding the potential impacts on manpower, personnel, training, human performance, habitability, quality of life, safety and occupational health, as well as on capturing lessons-learned for influencing future designs, training systems, and support of new technologies.

6.4 *Commercial Acquisition Process*—As indicated earlier, the commercial marine system acquisition process is more streamlined and less formal than the government process, but it follows a logical systems engineering like process. This process is illustrated in Fig. 4.

6.4.1 *Identify Components*—During the identify components phase, which is analogous to the capabilities requirements phase in the government process, basic requirements for the acquisition are defined. This includes, but is not necessarily limited to, operating specifications, applicable laws, human and marine system performance expectations, and estimated crew size. These requirements are used to determine the types of ships/offshore facility equipment, systems, structures, and other components that will be needed.

6.4.1.1 HSI activities during this phase include identification of the HSI team, identification of appropriate HSI specifications, analysis of human performance requirements, development of HSI lessons learned, HSI risk analysis, and development of any planned HSI training for engineers and others on the acquisition team.

6.4.2 *Assess*—During the assess phase, trade-offs between design alternatives are performed. This is analogous to the materials solutions analysis phase in the government acquisition process. The trade-off process focuses on comparing various alternatives for the equipment and other components identified during the previous phase, as well as exploring alternatives for the design for considerations such as space arrangements.

6.4.2.1 HSI activities during this phase include preparing the procuring organization’s HSIP, participation in trade-off studies including performing human performance studies and evaluations, and preparation of HSI input to specifications and statements of work.

6.4.3 *Select*—During the select phase, which is analogous to the government technology development and engineering and manufacturing development phases, the results of the Assess phase are used to “select” the design, in essence to develop the detailed design of the marine system. The design is developed with computer-aided design (CAD) drawings and specifications. Trade-offs continue to be made as the design is detailed out. A final design solution is defined in the design specification or specifications.

6.4.3.1 HSI activities during this phase include the development of HSI input to design specifications; performance of any front-end analyses that support the evolution of the design such as task analysis, link analysis, critical valve analysis, and Hazardous Operations (HAZOPS); design reviews using CAD tools; and assessment of vendor HSIPs. Any planned training of engineers and other members of the acquisition team should occur during this phase as well. During this phase, the HSI specialist should consider how the design impacts planned

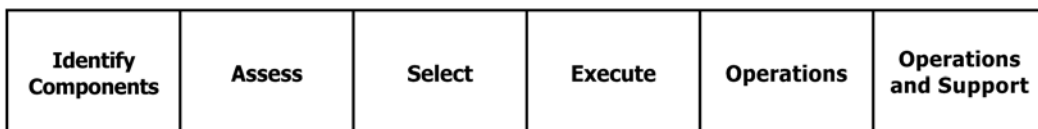


FIG. 4 Phases of the Commercial Ship Acquisition Process