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An American National Standard

Standard Practice for Human ~~Engineering~~Systems Integration Program Requirements for Ships and Marine Systems, Equipment, and Facilities[1]

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1. Scope

~~1.1This practice establishes and defines the requirements for applying human engineering to the development and acquisition of ships and marine systems, equipment, and facilities. These requirements are applicable to all phases of development, acquisition, and testing and shall be integrated with the total system engineering and development, and test effort. It is not expected nor intended that all of the human engineering activities should be applied to every marine program or program phase. Therefore, these activities shall be tailored to meet the specific needs of each program and the milestone phase of the program within the overall life cycle. This tailoring shall be performed by the procuring activity or by the contractor or subcontractor with the assistance and approval of the procuring activity in order to impose only the essential human engineering requirements on each program. Guidance for selection of only the essential requirements is contained in Appendix X1~~

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.

[1] This practice is under the jurisdiction of ASTM Committee F25 on Ships and Marine Technology and is the direct responsibility of Subcommittee F25.07 on General Requirements.

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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, and other humans.

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

2.1.6 *Personal 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.Referenced Documents~~

~~2.1*ASTM Standards:*~~

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 and 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

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, and/or system.
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 and/or marine system 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, and/or marine systems.
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.

systems engineering and design processes. In the government environment, other HSI domains provide insights, data, 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, and bulletin boards.

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

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 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

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 and/or training burden, enhanced safety, or increased human and total system performance requirements.

2.3.1.3 The potential to significantly 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.

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 not 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?

2.3.4 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.

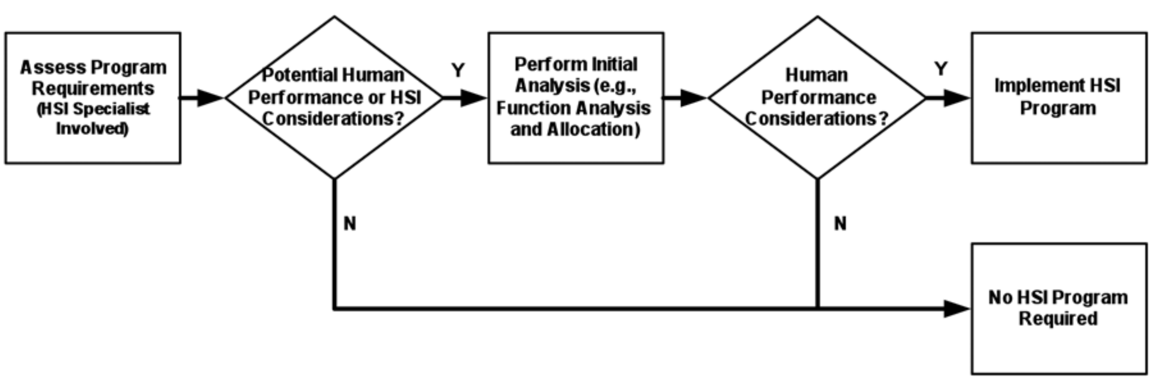

FIG. 1 Process for Determining the Need for an HSI Program

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:*

F1166 Practice for Human Engineering Design for Marine Systems, Equipment, and Facilities

2.2 *Other Standard:*

SNAMESample Model Specification for Human Engineering Purposes—Technical and Research Bulletin 4–22

3.Terminology

3.1*Definitions of Terms Specific to This Standard:*

3.1.1*arrangement drawings*—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 work stations, and (*2*) within the work station, such as in a modular rack or on a fiddleboard.

3.1.2

3.3 *Commercial Standards and Documents:*

ABS Guidance Notes on the Application of Ergonomics to Marine Systems, 2003
ABS Guidance Notes on the Ergonomic Design of Navigation Bridges, 2003
ABS Guide for Crew Habitability on Offshore Installations, 2002
ABS Guide for Crew Habitability on Ships, 2001
Woodson, W., Tillman, B. and Tillman, P., Human Factors Design Handbook, 1992
ANSI/ITAA GEIA-STD-0010 Standard Best Practices for System Safety Program Development and Execution, 1 October 2008

3.4 *Government Standards and Documents:*

Beaton, R., Bost, R., and Malone, T., NAVSEA Human Systems Engineering Best Practices Guide, 2008
CNO P-751-1-9-97 Navy Training Requirements Documentation Manual, 21 July 1998
CNO P-751-2-97 Training Planning Process Methodology Guide, 21 July 1998
CNO P-751-3-9-97 Training Planning Process Methodology Manual, 21 July 1998
DOD Directive 1100.4 Guidance for Manpower Programs, 12 February 2005
MIL-HDBK-46855A Human Engineering Process and Procedures, 17 May 1999
MIL-STD 882D DOD Standard Practice for System Safety, 10 February 2000
ABS Guide for Building and Classing Naval Vessels 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, January 2009
NAVSEA Standard 03-01 Common Presentation Layer Guide, September 2006
NAVSEAINST 5100.12A Requirements for Naval Sea Systems Command System Safety Program for Ships, Shipborne Systems and Equipment, 20 January 2005
OPNAVINST 1000.16 Manual of Navy Total Force Manpower Policies and Procedures, 17 June 2002
OPNAVINST 1000.16K Navy Total Force Manpower Policies and Procedures, 22 August 2007
OPNAVINST 5100.23G Navy Safety and Occupational Health Program Manual, 30 December 2005
OPNAVINST 5100.24B Navy System Safety Program, 6 February 2007
OPNAVINST 9640.1A Shipboard Habitability Program, 3 September 1996
SECNAVINST 5100.10H Navy Policy for Safety, Mishap Prevention, Occupational Health and Fire Protection Program, 15 June 1999

4. Terminology

4.1 *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.

4.2 *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.

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

3.1.34.4 *cultural expectation*—the cause and effect relationships (for example, red means stop or danger) that humans learn from their culture.

3.1.4*duty*—a set of operationally related tasks within a given job (for example, communicating, operator maintenance).

3.1.5—*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.*

4.5 *function*—an activity performed by a system (for example, provide electric power) to meet mission objectives.

3.1.6*human engineering*—a specialized engineering discipline within the area of human factors that applies scientific knowledge of human physiological and psychological capabilities and limitations to the design of hardware to achieve effective man-machine integration.

3.1.7*human factors*—the application of scientific knowledge about human characteristics, covering both biomedical and psychosocial considerations, to complete systems, individual equipments, software, and facilities. This application is through such specialized fields as human engineering, manning, personnel selection, training, training devices and simulation, life support, safety, job performance aids, and human performance testing and evaluation.

3.1.8*human interface*—any direct contact (that is, physical, visual, or auditory) with a piece of hardware or software by a human operator or maintainer.

3.1.9*job*—the combination of all human performance required for operation and maintenance of one personnel position in a system.

3.1.10*life support*—that area of human factors that applies scientific knowledge regarding the effects of environmental factors on human behavior and performance to items that require special attention or provisions for health promotion, biomedical aspects of safety, protection, sustenance, escape, survival, and recovery of personnel.

3.1.11*—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.*

4.6 *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.

4.7 *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.

4.8 *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.

4.9 *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.

4.10 *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.

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

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

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

4.13 *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.

4.14 *operational requirements*—requirements under which the platform, system, equipment, or software will be 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.

3.1.134.15 *panel layout drawings*—detailed drawings that include such features as: a scale layout of the controls and displays on each panel or an item of equipment such as a shipboard command console; a description of all symbols used; identification of the color coding used for displays and controls; the labeling used on each control or display; and the identification of control type (for example, alternate action or momentary), also screen layouts for software generated displays.

3.1.14*platform*—the major hardware (for example, ship, off-shore rig, barge, submarine) on, or in which, the individual equipment, system, or software will be installed or added.

3.1.15*spatial relationships*—placement of multiple but separate components of a system together, so it is visually obvious that the components are related and used together, or placement of identical components used on multiple systems to provide the user with a spatial clue as to where the components are located.

3.1.16*subtask*—activities (perceptions, decisions, and responses) that fulfill a portion of the immediate purpose within a task (for example, remove washers and nuts on the water pump).

3.1.17*—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.*

4.16 *procuring organization*—the organization that purchases a ship, offshore structure, marine equipment, or marine system. For commercial shipping and offshore structures, this is a ship or offshore structure owner.

4.17 *system*—a composite of subsystems, including equipment, communications, software, and personnel that either independently, or in conjunction with other systems, performs functions.

3.1.18*system analysis*—a basic tool for systematically defining the roles of and interactions between the equipment, personnel, communications, and software of one or more systems. It is an iterative process, requiring updating. Used in the early phases of design, it can be useful in allocating assignment of tasks to personnel, equipment, software, or some combination thereof. Done in later design stages, it can serve as the basis for the arrangement of equipment and work stations.

3.1.19—*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.

4.18 *task*—a composite of related activities (perceptions, decisions, and responses) performed for an immediate purpose, written in operator/maintainer language (for example, change a water pump).

3.1.20*task analysis*—a method used to develop a time-oriented description of the interactions between the human operator/maintainer and the equipment or software in accomplishing a unit of work with a system or individual piece of equipment. It shows the sequential and simultaneous manual and intellectual activities of personnel operating, maintaining, or controlling equipment, in addition to sequential operation of the equipment.

3.1.21*task element*—the smallest logically and reasonably definable unit of behavior required in completing a task or subtask (for example, apply counterclockwise torque to the nuts, on the water pump, with a wrench).

3.1.22*vendor drawings*—design drawings prepared by the manufacturer of an individual piece of equipment which is purchased for installation aboard a ship or other marine platform.

4.Summary of Practice

4.1*Human Engineering Program Plan*—The human engineering program plan, in accordance with the requirements of this practice and the equipment or ship specification, shall include the tasks to be performed, human engineering milestones, level of effort, methods to be used, design concepts to be used, and the test and evaluation program, in terms of an integrated effort within the total project.

4.2—*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.*

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

4.20 *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 and/or reduce the overall training burden, 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 and/or operation 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 and/or the contractor and vendor, 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 includes all specifications provided to vendors and contractors, as well as involvement in source selection.

5.3 *HSI 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.

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.

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 organization 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 ~~human engineering~~ HSI

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