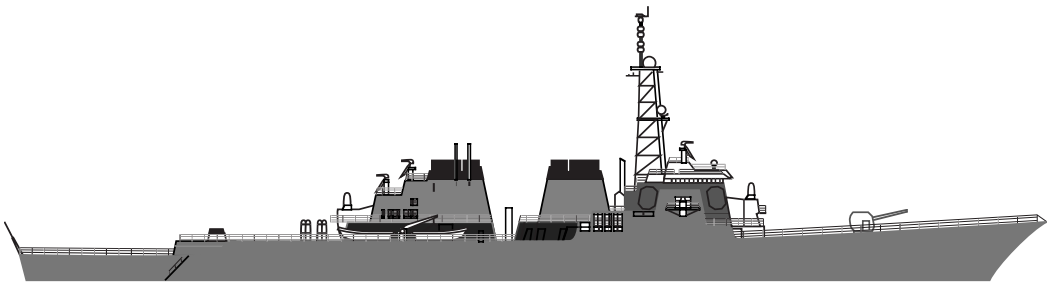
Surface Warfare
Program Manager's Guide



Human Systems Integration
(HSI)

Volume 1
Overview

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VISION

Human systems integration (HSI) is the systems engineering discipline dedicated to ensuring that Navy systems are designed, produced, supported, fielded, and modernized based on a complete and careful integration of requirements for the human into the system, specifically requirements for human performance, human availability, human utilization, health and safety, and human accommodation.

The Navy Need

A major driver of weapon systems currently being acquired in the DoD is to reduce the total ownership costs (TOC) of these systems. The largest single TOC component is the cost associated with selecting, training and supporting system personnel. The need to significantly reduce the TOC of warfare systems results in the need to reduce costs associated with manpower, personnel and training for new systems as compared with predecessor systems.

The Navy surface ship constitutes one of the most complex weapon systems in the US defense arsenal. It is a multi-personnel system conducting multiple operations in multi-warfare environments, most often in harm's way. It can operate as an independent combatant, member of a squadron, or as an element of a battle force. The demands that the ship and ship systems place on the sailor are unique in the breadth of their scope and the depth of their complexity.

Surface ship systems employed in the fleet today, and those being designed for the fleet tomorrow, make severe demands on the readiness, performance effectiveness and mental and physical capabilities of personnel who must man them. These systems are complex and extremely demanding on the sensory, motor and cognitive skills and decision-making capabilities of these personnel. Add the highly varied capability of the threat, the need to conduct multi-warfare scenarios, and the need to integrate, coordinate and interpret information from multiple sources and it becomes evident that we are rapidly approaching the limits of human capacity and capability.

As ship systems are becoming more sophisticated and complex, the capability of ship personnel has been degraded. The International Maritime Organization and the U.S. Coast Guard in addition to the Navy have estimated that human error is the root cause of 80% of ship accidents.

The need is for an approach that will result in reducing the costs associated with manpower, personnel and training, will reduce the potential for human error and resultant accidents, and will improve the performance capability of sailors in ships and advanced technology systems of the future. This approach is human systems integration.

Human Systems Integration

Human systems integration (HSI) resulted from the perceived need to consolidate the various disciplines of system acquisition that addressed the roles, requirements, provisions and accommodations for humans in complex systems. The aspects of a system acquisition which are concerned with humans include manpower, personnel, and training, (MPT), human factors engineering, habitability and quality of life, personnel survivability, and safety and health. These aspects of human involvement are the domains of HSI.

Human Systems Integration						
Manpower	**Personnel**	**Training**	**Human Factors Enginerng**	**Habitab**	**Personnel Surviv**	**Safety and Health**
Rate/Rating Officer & Enlisted Workload	Career progression Personnel classif Selection Recruiting Retention Skill Mix Special Skills Occupational Standards	KSAs Skill Acquisition Individual & Team Delivery Systems Organic Embedded Distance Learning	Human Perform Human Interfaces Human error avoidance Top down analysis Design for Usability Design for Maintainab	Quality of Life Quality of Work Environmnt limits and controls Personnel Services	Anti-Fratricide Personnel Protection Perform effects of Ensembles Damage Control	Accident Avoidance Safety hazard avoidance Health hazard avoidance Risk mitigation Medical Systems

Directives Mandating HSI

DoD 5000.2R section C2.8.5 (System Support) requires that the PM shall pursue HSI initiatives to optimize total system performance and minimize TOC. The PM shall integrate manpower, personnel, training, safety and occupational health, habitability, human factors, and personnel survivability considerations into the acquisition process. The support strategy shall identify responsibilities, describe the technical and management approach for meeting HSI requirements, and summarize major elements of the associated training system.

DoD 5000.2R section C5.2.3.5.9 (System Engineering) requires the PM to initiate a comprehensive strategy for HSI early in the acquisition process to minimize ownership costs and ensure that the system is built to accommodate the human performance characteristics of the user population that will operate, maintain, and support the system. The PM shall work with the manpower, personnel, training, safety and occupational health, habitability, survivability, and human factors engineering (HFE) communities to translate the HSI thresholds and objectives in the ORD into quantifiable and measurable system requirements. The PM shall include these requirements in specifications, the Test and Evaluation Master Plan (TEMP), and other program documentation, as appropriate, and use them to address HSI in the statement of work and contract. The PM shall identify any HSI-related schedule or cost issues that could adversely impact program execution.

SECNAVINST 5000.2C section 5.2.3.5.9 Human Systems Integration Total life cycle cost, including logistics support and human systems integration (HSI), must be demonstrated as representing the lowest cost of ownership to the DON. Therefore, the PM shall ensure that HSI costs (e.g., manpower, personnel, training (MPT), human factors engineering, safety, occupational health and habitability) and impacts are adequately considered, weighted, and integrated with other engineering and logistics elements beginning at program initiation. See paragraphs 5.2.3.5.9 and 5.2.3.5.10, for further implementation requirements for all DON programs.

HSI Objectives in Surface Warfare System Acquisition

The primary objective of HSI is to influence design with human requirements. The way in which this is accomplished is through several initiatives:

- addressing HSI issues and concerns early in system acquisition;
- defining the roles of humans in system operations and maintenance early in system development;
- identifying deficiencies and lessons learned in baseline comparison systems;
- applying simulation and prototyping early in system development;
- applying human-centered design throughout the development;
- applying human-centered test and evaluation.

Additional objectives of HSI are to:

- achieve optimal manning, defined as the minimum number of personnel consistent with human performance, workload, and safety requirements, and affordability, risk, and reliability constraints.;
- reduce the incidence and impact of human errors (the direct cause of 80% of ship accidents);
- enhance human performance, specifically situational awareness and decision making;
- enhance ship space habitability and quality of life at sea;
- enhance the maintainability of shipboard equipment and maintainer performance capability;
- improve training and personnel management;

HSI in the Acquisition of New Systems

The acquisition of new systems from an HSI perspective requires the clean sheet of paper approach to system manning and human-machine interface design. This approach begins with an assumption of zero manning, and implements an HSI process which features top down requirements analysis and human-centered design to identify relevant functions for selected missions, allocate the performance of these functions to humans or automation, define the roles and requirements of humans in the conduct of tasks derived from functions, develop and verify concepts for designing human-machine interfaces through modeling and simulation, develop techniques for human-automation interaction, specify human performance competencies and needed training methods, and assess human performance, workload and safety through HSI test and evaluation.

In the application of HSI to the acquisition of new systems, HSI requirements and activities must be identified for each acquisition phase, including: the Technology Opportunities and User Needs Phase; the Concept and Technology Development Phase; the System Development and Demonstration Phase; and the Production and Deployment Phase. HSI applications for each of these phases are described in the following subsections.

The products of HSI application include:

- The HSI Plan (HSIP)
- the Navy Training System Plan
- the Ship Manning Document
- the Manpower Estimate

- design concepts and criteria for human-machine interfaces
- design concepts and criteria for ensuring Quality of Service
- design concepts and criteria for habitability and personnel survivability
- design concepts and criteria for safety and health
- HSI inputs to acquisition documentation, including MNS, ORD, CRD, TEMP, M&S Plan, Risk Reduction Plan, ILSP, and procurement documents.

Modernization and System Upgrade

This acquisition strategy is concerned with improvement of systems already fielded and in the fleet. According to DoD 5000.2R,the DoD shall structure the Performance-Based Business Environment to use performance requirements during re-procurement of systems, subsystems, components, spares, and services beyond the initial production, and during post-production support to facilitate technology insertion and modernization of operational weapons systems.

Prototype to Production Acquisition

The approach of acquiring a system by progressing directly from prototype to production relies on a top down requirements analysis (TDRA) , uses the technique of simulation-based design, and is based on a performance specification that includes HSI considerations. Prototype to production is an attempt to reduce cycle time to produce a system.

In the application of simulation-based design, the HSI M&S approaches of major relevance to this acquisition strategy are two: (a) task network simulation to determine the effectiveness of task sequence performance with time constraints; and (b) human-in-the-loop simulation to assess human performance with alternate levels of automation control and support.

In the development of HSI Inputs to the Prototype Performance Specification, the thrust is to determine the roles and requirements of humans in impacting what the system will be capable of doing (through the TDRA), and specifying the performance tolerances required for successful performance and risk reduction. In the system performance specification, determination of human performance requirements shall address requirements for: (a) the capability for sustained performance; (b) prevention of human error; (c) information management approaches which will reduce cognitive workload while enhancing human decision making and warfighting capabilities; (d) provision of information products and effective integration of information so as to minimize the probability of human error; and (e) design concepts for human-machine interfaces and shipboard communications systems that address human capabilities and requirements.

HSI in COTS NDI Acquisition

DoD 5000.2R directs that, when acquiring COTS software products or other commercial items, the PM shall implement a spiral development process. In this context, integration may encompass the amalgamation of multiple COTS components into one deployable system (or block of a system) or the assimilation of a single COTS product. In either case, the PM shall ensure that the system co-evolves with essential changes to doctrine or reengineered business processes (for combat support and IT systems). The PM shall apply commercial item best practices.

No matter how much of a system is provided by commercial items, the PM shall engineer, develop, integrate, test, evaluate, deliver, sustain, and manage the overall system. The determination of HSI requirements for NDI begins with an identification of HSI Inputs to NDI Concepts and Issues. This entails a determination of the extent to which the NDI must meet users' needs in the users' environment. HSI issues in NDI operational requirements are then identified which include: (a) human performance issues; (b) human safety and health issues; (c) human quality of life – habitability issues; (d) personnel management issues; (e) workload and manning issues; and (f) training issues. The HSI effort will provide inputs to ensure that the developer is responsive to legitimate needs but is also conscious of technical risks and affordability constraints. The HSI

effort will also provide inputs to the determination of Life Cycle Cost, including the determination of how to identify which NDI approach has the: (a) lowest projected life-cycle cost, within acceptable risks, and meets essential requirements, including human performance and safety requirements; (b) lowest human workload and manning requirements for operations and maintenance; (c) most effective training program; (d) least safety and health hazards; (e) best mean time to repair; (f) best overall availability; and (g) best overall supportability.

Benefits

The payoffs expected from the application of HSI to surface warfare system design and development are as follows:

- Workloads that are acceptable;
- Manning that is optimal;
- Personnel utilization that is efficient;
- Error and accident rates that are minimal;
- Human performance that is effective;
- Teams that are capable;
- Crew members that are productive;
- Environments that are safe;
- Facilities that are habitable;
- Information and knowledge that is readily understood;
- Communications that are meaningful;
- Human computer interfaces that are usable;
- Displays that are readable;
- Workstations that are integrated;
- Components to be maintained that are accessible;
- Training that is responsive to requirements and effective;
- Procedures that are consistent;
- Jobs that are enriching;
- Duty cycles that are satisfying;
- Systems that are affordable.