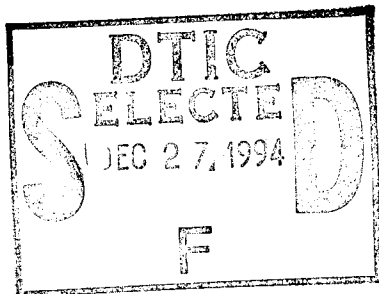


Report No. CG-D-25-94

**U.S. COAST GUARD HUMAN SYSTEMS INTEGRATION (HSI)
PROGRAM REQUIREMENTS DOCUMENT**



Wayne Wright
and
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OGDEN/ERC Government Systems
Fairfax, Virginia



FINAL REPORT
APRIL 1994

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Technical Report Documentation Page

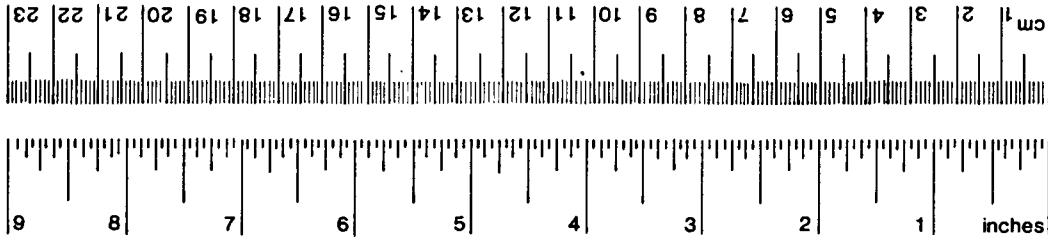
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15. Supplementary Notes A process model for implementing Human Systems Integration into the Coast Guard acquisition process was completed in phase two of this effort, "U.S. Coast Guard Human Systems Integration (HSI) Process Model," report number R&DC 11/94. The Coast Guard Technical contact and COTR is Dr. Antonio B. Carvalhais, (203) 441-2846.					
16. Abstract <p>The Coast Guard has identified a need to improve Human System Integration (HSI) in the planning, design, and development of new system acquisitions. There is a long-term need to integrate the various elements of HSI (i.e., Manpower, Personnel, Training, Human Factors Engineering, and Safety/Health Hazards) into all new Coast Guard hardware acquisitions, including ships, aircraft, and all equipment/systems/subsystems fielded through the acquisition program. In response to this need, a multi-phase effort was undertaken to develop and implement a HSI program into the Coast Guard acquisition process. This report documents phase one of the effort: a review of the Coast Guard acquisition process, including interfaces with major program areas, to assess how the process currently operates, organizational relationships, and the advantages/disadvantages of implementing HSI into the acquisition process. The report identifies the extent to which HSI principles are currently being used in the Coast Guard acquisition process and specifies additional requirements for HSI which are not currently part of the acquisition process. In addition, unique requirements or circumstances that may promote or adversely impact the ability of the Coast Guard to implement a HSI program are identified. The review revealed inconsistent use of HSI principles throughout the acquisition process. A review of previous acquisitions identified numerous human factors deficiencies which could have been eliminated or minimized if HSI principles had been used during new system acquisitions. A Coast Guard HSI program is proposed.</p>					
17. Key Words Human System Integration (HSI), manpower, personnel, training, human factors engineering, safety and health, acquisition system, life-cycle costs, integrated logistical support, baseline comparison			18. Distribution Statement Document is available to the U.S. public through the National Technical Information Service, Springfield, Virginia 22161		
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METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

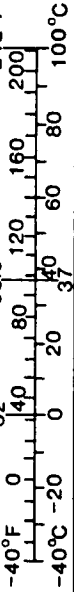
Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
in	inches	* 2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
AREA				
in ²	square inches	6.5	square centimeters	cm ²
ft ²	square feet	0.09	square meters	m ²
yd ²	square yards	0.8	square meters	m ²
mi ²	square miles	2.6	square kilometers	km ²
	acres	0.4	hectares	ha
MASS (WEIGHT)				
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
VOLUME				
tsp	teaspoons	5	milliliters	ml
tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft ³	cubic feet	0.03	cubic meters	m ³
yd ³	cubic yards	0.76	cubic meters	m ³
TEMPERATURE (EXACT)				
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

* 1 in = 2.54 (exactly).



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
AREA				
cm ²	square centimeters	0.16	square inches	in ²
m ²	square meters	1.2	square yards	yd ²
km ²	square kilometers	0.4	square miles	mi ²
ha	hectares(10,000 m ²)	2.5	acres	
MASS (WEIGHT)				
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
VOLUME				
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	0.125	cups	c
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m ³	cubic meters	35	cubic feet	ft ³
m ³	cubic meters	1.3	cubic yards	yd ³
TEMPERATURE (EXACT)				
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



U.S. COAST GUARD HUMAN SYSTEMS INTEGRATION PROGRAM REQUIREMENTS DOCUMENT

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DHC 378	<input type="checkbox"/>
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**SECTION A
INTRODUCTION**

Final Revision: 1/20/93

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1. WHAT IS HUMAN SYSTEMS INTEGRATION (HSI)?

The study and application of HSI methodology in system design and acquisition can be traced to F.W. Taylor's efforts in 1898 to design effective shovels for men working in steel plants and later with F.B. Gilbreth's attempt in 1916 to design a work chair and a work space that would minimize strain and fatigue while increasing worker efficiency. The field was further advanced in 1926 by the Great Britain Industrial Fatigue Research Board, which introduced the idea that "the worker and machine form a single system," and which recommended the redesign of machines in such fields as laundering, leather working, and textiles in order to enhance efficiency. During World War II, systems such as aircraft, missiles, and radars increased in complexity to the point where human capacities became severely taxed. This resultant complexity subsequently led to the development and refinement of human oriented design principles which have been increasingly applied throughout industry and the Military Services.

More recently, the Department of Defense (DoD) and Military Services began to see the efficacy of institutionalizing HSI practices within their materiel acquisition systems. Accordingly, an HSI program was developed and adopted by DoD to integrate human considerations into the design and acquisition of materiel systems.

Based on analyses of human participation in the operation, maintenance, and support of new materiel systems, HSI provides system design support to maximize the combined man-machine performance. In the design process, HSI focuses on human capabilities and limitations with the objective of optimizing human performance in meeting mission requirements of the system. HSI impacts the design, development, and deployment of new systems from five distinct perspectives or domains.

The five domains are introduced in the subsections below.

1.1 HUMAN FACTORS ENGINEERING (HFE). This is the technical effort to integrate design, development, test and evaluation criteria, psychological principles, and human capabilities as they relate to complex systems. The primary goal of HFE is to maximize the ability of the human in the system to perform at required levels by eliminating design-induced error. HSI develops equipment that permits effective man-machine interaction within established, allowable limits of training time, aptitudes, skills, physical endurance, physiological tolerance limits, and physical standards. HFE provides coordination between the five HSI domains and system engineering in the design of new systems, subsystems, equipment, and their interfaces.

1.2 SYSTEM SAFETY/HEALTH HAZARDS. System Safety involves the application of both engineering and management principles, criteria, and techniques to optimize safety within the constraints of operational effectiveness, time, and cost throughout all phases of the new system's life-cycle. System Safety deals with both the safety of the materiel system and the safety of the operators, maintainers, and support personnel. The goal of System Safety is

to improve the ability of humans to perform to specified standards without unnecessary risk of injury, death, or equipment damage. System Safety relates to:

- a. Safety design, test, and demonstration requirements for systems, equipment, and personnel interfaces
- b. System Safety procedures
- c. Environmental safety
- d. Safety equipment
- e. System Safety engineering program requirements and plans
- f. Personnel safety procedures
- g. Explosive and fuse safety requirements
- h. Occupational safety procedures

Health Hazards includes the application of biomedical and psychological knowledge and principles to identify, evaluate, and eliminate or control risks to the health and effectiveness of personnel who manufacture, test, operate, maintain, and support new materiel systems. Closely aligned with System Safety, Health Hazards seeks to improve total system performance while protecting humans from the unnecessary risk of illness, injury, or death from the short- or long-term exposure to the equipment, its component material (such as nuclear, biological, or chemical agents), or its operation.

1.3 MANPOWER. This domain addresses the affordability of fielding a new materiel system in terms of military and civilian resources. Manpower includes the number and quality (i.e., experience, specific capabilities, and other human characteristics) of military billets/civilian positions/contractor man-hours and the organizational structure needed to operate, maintain, and support a new materiel system.

1.4 PERSONNEL. This domain refers to the quantity and quality (i.e., experience, specific capabilities, and other human characteristics) of military/civilian/contractor personnel required to operate, maintain, and support a new materiel system. The Personnel Domain involves consideration of whether the management/assignment system will have the right number of qualified personnel at the right time and place to support the new system within established constraints and priorities. New systems should be designed to accommodate the capabilities of personnel projected to be available when the new system is fielded (i.e., designed to the target audience expected when the system becomes operational).

1.5 TRAINING. This domain considers the time and cost required to provide the necessary skills and knowledge to qualify personnel to operate, maintain, and support a new materiel

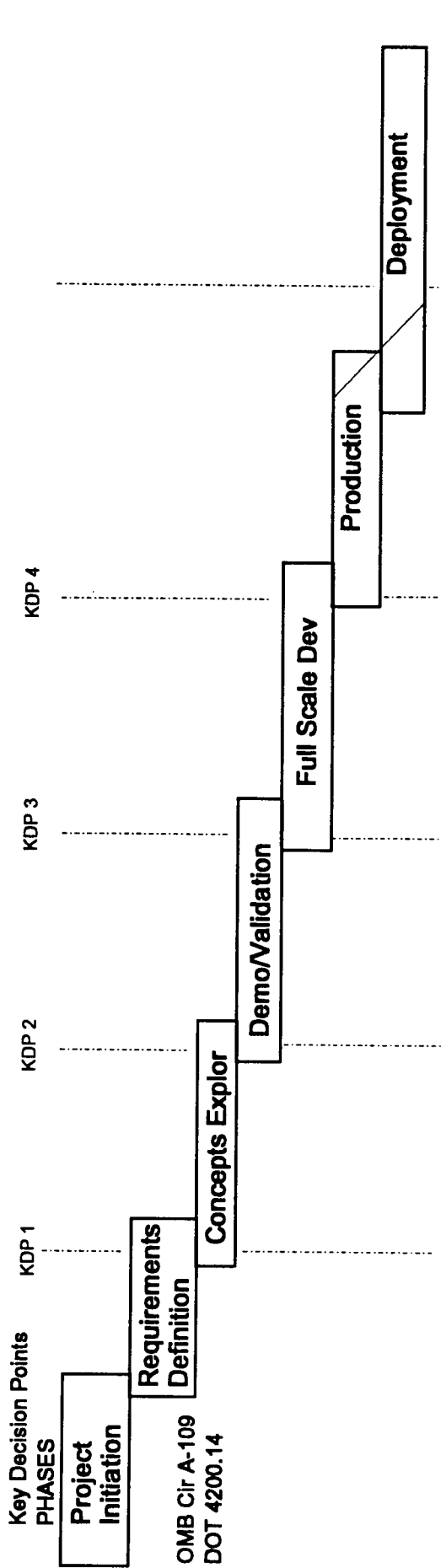
system. This includes the ability of the training base to support both the entry-level training requirements of the new system and the requirements of sustainment training in the field. The training domain includes the formulation and selection of engineering design alternatives that are supportable from a training perspective, the development and documentation of training strategies, as well as the timely determination of training facilities that require long lead times and other training support required to field the new system.

Human Factors Engineering and System Safety/Health Hazards considerations are built into the materiel system through the design process. Manpower, Personnel, and Training (MPT) are HSI Program elements that are integral to the design process, but which also transcend the system design effort and become a major part of the system life-cycle support. MPT costs account for the majority of ownership costs once the system is fielded. When the system design is completed, Human Factors Engineering becomes less of a factor in the deployed system unless the system is expanded or redesigned for other reasons. System Safety/Health Hazards continue to be a consideration throughout the system life-cycle, but the major focus is on designing a safe and hazard-free system on the front end of the system life-cycle.

The Coast Guard has indicated a desire to take full advantage of previous work in HSI to avoid unnecessary duplication of past mistakes and to expedite implementation of HSI methodology into the acquisition process. Accordingly, Exhibit A-1 is provided to show a comparison of the Coast Guard and DoD acquisition systems. This comparison is particularly relevant given the similarities in structure and documentation of the two acquisition systems. Differences in the two systems are largely driven by the relative size and complexity of the acquisitions. This accounts for differences such as the Coast Guard's practice of normally selecting one system design concept at Key Decision Point 2 (KDP-2) to carry forward into the remaining acquisition phases. In contrast, DoD typically approves more than one design concept at Milestone I for evaluation in the Demonstration and Validation Phase; parallel efforts by more than one contractor result in approval of one design concept at Milestone II; one or two prime contractors complete the Engineering and Manufacturing Development Phase; and one prime contractor then builds the system in the Production and Deployment Phase.

Despite these differences, the two systems are comparable in basic functions and strive to achieve the same end results. This comparability suggests that successful programs, like HSI, in the DoD acquisition system are excellent candidates for adoption in the Coast Guard acquisition process.

COAST GUARD ACQUISITION SYSTEM



DoD ACQUISITION SYSTEM

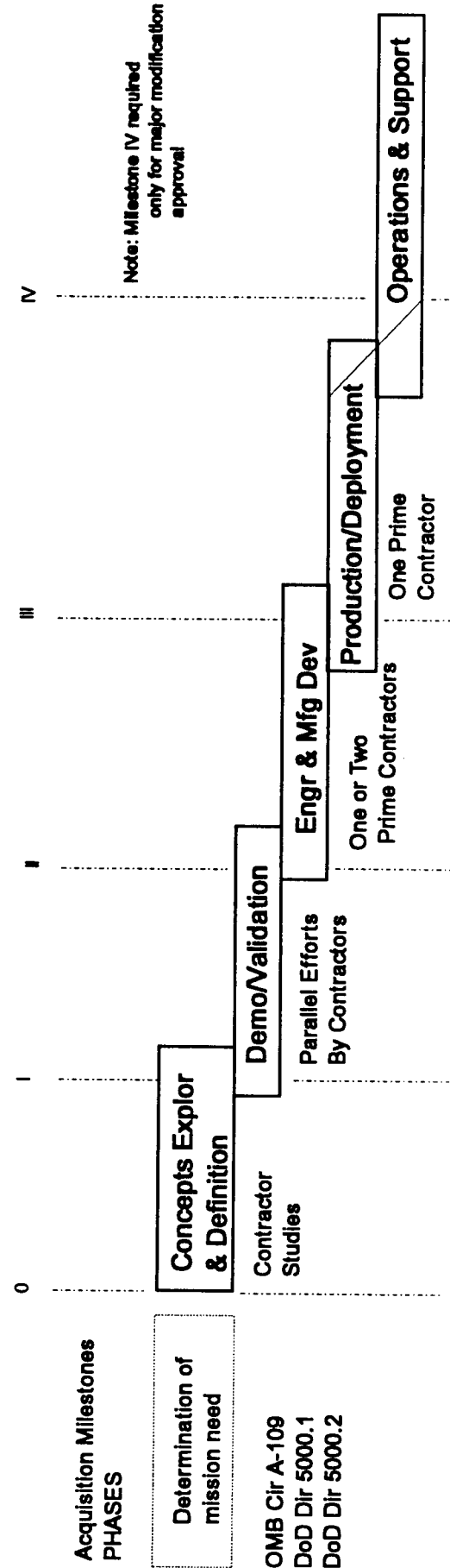


Exhibit A-1. COMPARISON - COAST GUARD/DoD ACQUISITION SYSTEMS

2. IS THERE A NEED FOR HSI IN THE COAST GUARD ACQUISITION SYSTEM?

The principal design objective of new materiel systems is to ensure sufficient system performance to meet essential Sponsor Requirements. Total system performance is a function of equipment performance and human performance in a specific environment. If either the equipment or the human is deficient in carrying out their assigned functions, the system will not achieve optimum performance. In the last few decades, man has gained the technical knowledge to build machines that are limited by human performance. Accordingly, if the Coast Guard is to design and build high-tech equipment to support modern day Coast Guard missions in the 1990s and beyond, optimizing human performance in the design and development of such equipment is critical to achieving acceptable total system performance. It is important to note that human performance is a function of system workload, and workload is a function of human-related elements, such as manning levels, personnel qualifications, and training levels, as well as equipment dysfunction caused by poor design; therefore, human performance and system performance are closely intertwined. The implication is that if human considerations are not adequately accounted for in system design, workload will be adversely impacted and total system performance will be degraded; perhaps below acceptable system performance levels, which will require expensive and time-consuming alterations or redesign of the equipment. Employing HSI principles throughout the design and development of materiel acquisitions produces user-friendly equipment, optimizes human performance, maximizes total system performance, and eliminates or greatly reduces the need for alterations and redesigns due to dysfunction of the equipment.

The DoD HSI requirements described in this document have been specifically tailored to meet Coast Guard needs based on the goals, policies, organization, and execution of the Coast Guard acquisition process.

The following discussions concerning HSI applications within the Coast Guard's acquisition process are based upon our review of the DoD's, the Military Services', and the Coast Guard's acquisition documentation. This documentation review was supplemented by in-depth interviews of 14 managers, analysts, and procurement specialists within the Coast Guard's materiel acquisition system.

We have concluded from our analysis that human considerations should be integrated into the design effort of Coast Guard materiel systems to improve total system performance and reduce costs by focusing attention on the capabilities and limitations of Coast Guard operators, maintainers, and support personnel.

2.1 WHAT ELEMENTS OF HSI ARE CURRENTLY INCLUDED IN THE COAST GUARD ACQUISITION PROCESS? While the term "Human Systems Integration" is new to the Coast Guard, none of the five domains of HSI are new. In reviewing previous Coast Guard acquisitions, there have been instances where extraordinary emphasis has been placed on individual domains with excellent results. There are also indications that this emphasis may have resulted more from individual contractor work practices than from deliberate Coast Guard requirements.

Unfortunately, the Coast Guard has not maintained lessons learned records that would have allowed these successes to be repeated in subsequent acquisitions. The HSI Program requires the review of lessons learned in each domain as an integral part of the process. HSI also requires development of lessons learned and the maintenance of specific records for each acquisition.

Coast Guard system acquisition documentation refers to the following HSI elements in describing procedures to be used in materiel acquisitions:

- a. Human Factors
- b. Safety
- c. Manpower
- d. Personnel
- e. Training

After reviewing this documentation and conducting interviews of 14 Coast Guard managers, analysts, and procurement specialists in the acquisition system, we conclude that while there is some mention in the documentation, the Coast Guard does not have a Human Factors Engineering or System Safety/Health Hazards program in the acquisition process. By contrast, estimates of Manpower, Personnel, and Training (MPT) needs are determined in each acquisition, and MPT inputs are included in most of the major program documentation. The System Acquisition Manual, Commandant Instruction M4150.2B, lists the following HSI requirements:

- a. The Project Manager (PM) will ensure that system logistics support resources, including MPT, are in place prior to hand-off of the first unit.
- b. The PM will ensure that Human Factors are a design consideration for the system. Human Factors include ease of operation, ease of maintenance, ergonomics, physical characteristics, access for maintenance, etc. Computer models, simulations, models, and mockups may be used to evaluate equipment arrangement for safe operation and maintenance.

In our interviews we determined that the extent to which Human Factors considerations are included in system design is primarily left to the contractor's discretion.

- c. The PM will ensure that Safety Factors are a design consideration for the system. Safety Factors include Hazards of Electromagnetic Radiation to Ordnance (HERO), Radiation Hazards to Personnel (RADHAZ), ambient noise, structure-borne noise, vibration, air quality, ammunition handling and storage, equipment removal, emergency egress, fire fighting, etc.

Like Human Factors, we found that System Safety is primarily left to the contractor's discretion.

- d. **MPT and training support are included in the logistics support elements for Integrated Logistics Support (ILS) required by each acquisition. Safety is listed as a "related element."**
- e. **Under "Logistics Responsibilities," the PM is to address MPT requirements throughout the acquisition process. The PM is assisted in this effort by the ILS manager.**
- f. **ILS requirements by phase:**
 - (1) **Concepts Exploration.**
 - (a) **Include basic concepts for staffing and training in the Preliminary Sponsor Requirements Document (PSRD). These elements are subject to trade-off analysis as alternative designs are evaluated.**
 - (b) **Develop Integrated Logistics Support Plan (ILSP) near the end of this phase, including MPT considerations.**
 - (2) **Demonstration/Validation. Conduct comparative analysis of all support requirements associated with alternative design concepts, including MPT.**
 - (3) **Full-Scale Development. Conduct detailed MPT support task analysis and early field analysis.**
 - (a) **Conduct MPT support tests during development testing.**
 - (b) **Conduct MPT suitability tests during operational testing.**
 - (c) **Conduct full MPT support effectiveness assessment after the system achieves operational status.**
 - (4) **Production Phase. Develop Operational Logistics Support Plan (OLSP), including MPT.**
- g. **Minimum staffing policy must be followed as a system design criterion.**
- h. **Staffing and facilities projections will be validated during development operational testing.**
- i. **It is essential to do a cost-benefit analysis of training options early in the acquisition process.**

- j. As much as five years lead time may be required for funding, developing of the Master Training List, and establishing new Coast Guard or Navy courses and quotas.
- k. The PM must ensure acquisition documents consider MPT requirements starting in the initial phase.
- l. For each design alternative, the PM will ensure personnel and training requirements are integrated with design criteria to develop system MPT resource requirements.
- m. The following items shall be addressed for each system design alternative:
 - (1) Operator requirements
 - (2) Preventive and corrective maintenance workload
 - (3) Training requirements, including personnel training time, instructor requirements, and training facility requirements. Included will be consideration of trade-offs conducted among job aids, formal training, on-the-job training, unit training, and training simulators.
 - (4) Cross-utilization of personnel for various conditions of readiness
 - (5) Administrative and support workload
 - (6) Facilities maintenance workload
 - (7) Physical habitability requirements for personnel
 - (8) Personnel safety
 - (9) Other unique personnel requirements
- n. Capability studies of various design alternatives shall be conducted to develop the best mix of personnel, technology, and equipment to meet sponsor requirements.
- o. The degree of MPT analysis is dependent upon the level of staffing provided to the PM, and the development of analytic techniques to perform the MPT analysis. The PM is responsible to use the available staffing and techniques to develop MPT estimates.

Other Coast Guard instructions, such as Commandant Instruction 4105.3 titled Acquisition and Management of Integrated Logistics Support (ILS) for Coast Guard Systems and

Equipments, further define MPT requirements in the acquisition process. This instruction references MIL-STD 1388-1A and 2A for task-based detail and further direction in specific ILS areas.

It is obvious from these various references that the Coast Guard meant for MPT to be a prominent part of each acquisition. Two major interrelated shortcomings, however, are evident in the way MPT is currently integrated into the acquisition process:

- a. While there is ample reference in the documentation considering MPT issues early in the process, in practice this is not done. To be effective, MPT requirements development must start in the Project Initiation Phase.
- b. The documentation stops at the program level, i.e., there are no analyst guides or how-to documents to detail the specific techniques needed to permit MPT issues to be analyzed so data can be made readily available to decision makers in a timely fashion. This additional level of how-to-detail is especially important in the very early phases of the acquisition when the least is known about the new system.

The following subparagraphs describe how Human Factors Engineering, Safety, Manpower, Personnel, and Training have been used in the Coast Guard acquisition process.

2.1.1 Human Factors Engineering (HFE). The success of some previous Coast Guard acquisitions has been partly attributed to the use of HFE. A case study¹ of the 41-foot Utility Boat (UTB), with initial requirements identified in 1966 and the first unit delivered in 1973, concluded that success of this procurement was based on the following:

- a. A clear focus on the user during design and development
- b. Good Human Factors Engineering
- c. Stable requirements based on sound prototype tests and evaluations conducted by users

While the Sponsor's Requirements Document could not be located for the UTB, there is very little evidence of the Coast Guard requiring specific Human Factors Engineering considerations in system design during this timeframe or since. Therefore, it is more likely that the use of Human Factors Engineering in this case was the result of this particular contractor including these considerations as a customary way of doing business, rather than the contractor complying with specific Coast Guard requirements. Nonetheless, the UTB is a

¹ Advanced Technology, Inc., U.S. Coast Guard Manpower, Personnel, Training, and Safety (MPTS) Concept Document, undated (circa 1990), p. C-1

concrete example of the benefits to be derived from using Human Factors Engineering considerations in Coast Guard acquisitions.

There is also ample evidence, documented in previous Coast Guard acquisitions, of the problems created by not using adequate Human Factors Engineering. For example, during prototype testing of the 47-foot Motor Life Boat (MLB) replacement, the Coast Guard had to issue an Engineering Change Proposal (ECP)² to redesign the following features of the open/closed bridge:

- a. Replaced two crew chairs
- b. Changed location of an overhead console
- c. Relocated a communications speaker
- d. Relocated an auxiliary machinery device
- e. Relocated a HVAC unit and duct
- f. Installed remote communications speakers
- g. Relocated lighting panels
- h. Installed new hand holds
- i. Provided outdoor microphone covers
- j. Relocated magnetic compass
- k. Installed a new helm on the bridge wings

This ECP cost the Coast Guard \$62,697. There have been 48 ECPs issued on this MLB to date. HSI would be expected to eliminate or greatly reduce the requirement for this kind of redesign.

Failure to design in human considerations into new equipment and procedures can have disastrous results. Researcher's have conducted analyses of catastrophic human error incidents and investigated how Human Factors Engineering considerations in design may have been a factor in the resulting disaster. Using the critical incident approach to

²Textron Marine Systems, New Orleans, LA, Awarded ECP-026 to redesign open/closed bridge for Coast Guard Motor Life Boat replacement

understanding human error, researchers³ have focused on the human errors that led to the Three Mile Island, Chernobyl, Bhopal, KAL-007, and Vincennes incidents. Examination of these critical incidents of human error have led to identification of several error situation elements as follows:

- a. Error situations usually include multiple errors or error-equipment failure relationships;
- b. There is usually an erroneous expectancy on the part of the personnel as to what is happening in the system;
- c. Personnel are usually under some form of stress;
- d. There usually exists some degree of complacency on the part of the individuals involved with technology; and
- e. Most error situations are the result, at least in part, of man-machine interface design problems and/or training problems.

After analyzing the five critical incidents, the conclusions were that all five incidents were caused, to some extent, by:

- a. Human complacency with technology;
- b. Erroneous expectancies concerning what was going on; and
- c. Deficiencies in the design of equipment and the training of personnel.

The major lesson learned from these critical incidents is that complex systems must be designed in terms of capabilities, limitations, and requirements of the personnel who operate, manage, maintain, or otherwise use them. System personnel must be considered an important component of the acquisition, to be designed into the system rather than added on after the design is complete. HSI is the program that can give the Coast Guard this capability in system acquisitions.

2.1.2 System Safety/Health Hazards (SS/HH). This is another HSI domain that is not new to the Coast Guard, but gets very little emphasis in specifying requirements or in the follow-up procedures of the current acquisition process. This domain is important in system acquisition because health and safety risks left uncorrected degrade total system performance by degrading human performance. Health and safety considerations in general receive a higher level of attention than Human Factors Engineering in the design and development of Coast Guard acquisitions primarily because System Safety programs are relatively mature,

³Thomas B. Malone, Ph.D., Human Factors and Human Error, June 8, 1989

and contractors are accustomed to clients with high expectations in these areas. As a result, contractors are more likely to include safety and health considerations in their designs as a normal way of doing business.

There have been numerous instances in past Coast Guard acquisitions when a stronger System Safety/Health Hazards program in system design would have prevented costly and time-consuming redesigns and replacement of equipment to eliminate personnel hazards that were inadvertently designed into the system. For example, a number of safety deficiencies were revealed by a Human Factors Engineering Assessment⁴ of the prototype Coast Guard 47-foot MLB. This after-design assessment evaluated the following areas:

- a. Steps
- b. Platforms and railings (including ladders)
- c. Doors, hatches, and passageways
- d. Controls
- e. Instruments and displays
- f. Work space
- g. Habitability considerations (including chairs)

Approaches to problem resolutions included redesign, reconfiguration, relocation, or replacement of equipment. The following are examples of safety problems discovered after the initial design that required some form of correction.

- a. The ladders leading to and from the open bridge, enclosed bridge, and survivors compartment required design changes because:
 - (1) Tread depth, riser height, and stringer angle were not standardized throughout the boat.
 - (2) The surface of the tread was not appropriate, especially when the ladder was wet.
 - (3) The hand rails in the enclosed bridge were "squared off" at the ends, making them slippery when wet, thus compromising crew safety.

⁴Naval Biodynamics Laboratory and U.S. Coast Guard Research and Development Center, Human Factors Assessment of USCG 47-ft MLB: Preliminary Evaluation of Ergonomic and Safety Deficiencies, December 14, 1990

- b. The three steps leading from the survivors compartment to the aft deck posed a potential hazard to the crew because of the possible inadvertent activation of a fuel shut-off switch that during wet conditions.
- c. Grab bars were needed on the radar platform for crew members to brace and balance themselves during rough sea conditions.
- d. The watertight hatch providing access to the open bridge from the enclosed bridge needed to be designed with a self-locking mechanism to secure the hatch in the open position. The prototype configuration posed a hazard in rough seas due to lack of positive control by crew members transiting the hatch. Protruding bolts also presented a hazard to crew members passing through the door and needed to be recessed, capped, or threads removed to eliminate the workspace hazard.
- e. The watertight door between the survivors compartment and the aft deck was not wide enough to accommodate a Stokes litter with flotation devices without dangerously tilting the litter to pass through the door.
- f. Operation of the 11 windows surrounding the enclosed bridge needed redesign because crew members were required to reach over electrical panels and the frame flange, creating a potential safety hazard. In addition, the window release mechanism had to be pushed forcefully (i.e., hit) to effectively open each window. This configuration was not only judged hazardous for potential injury, but may encourage crew members to take chances that could lead to more serious injury, especially in rough seas.

The HSI Program focuses specifically on human needs and human limitations in the system design. As a result, these types of hazards are identified and corrected in the initial design process, thus eliminating or significantly reducing the need for subsequent redesigns.

2.1.3 Manpower, Personnel, and Training (MPT). MPT requirements transcend the procurement process and become life-cycle support elements representing well over 60 percent of the life-cycle cost of a materiel system. MPT support requirements have traditionally been Integrated Logistics Support (ILS) elements in the Coast Guard acquisition process, except that manpower requirements have been determined (usually by contract) in some cases by the sponsor, and by the Project Manager in other cases.

Estimates of required MPT are included in each Coast Guard acquisition, and some form of MPT inputs are included in most of the major program documentation. However, MPT has yet to integrate systematic, consistent, well-established procedures into the earliest phases of the acquisition process. Adoption of the HSI Program will provide such procedures and will

effectively integrate MPT into the process at appropriate times, as well as provide applicable input to program documentation in a timely manner.

HSI also highlights and emphasizes the importance of the trade-off decision between acquisition costs and life-cycle costs in source selection evaluations for choosing competing contractor design concepts. In past procurements, the Coast Guard has not always demonstrated sensitivity to this issue. For example, the Coast Guard completed requirements for the HH-65 helicopter in 1973⁵, with delivery of the first aircraft in 1984. The winning vendor had an initial investment cost (i.e., acquisition cost) that was \$1.3 million less than the next lowest bidder; but, the winning contractor also had an ownership cost of \$10 million more every 5 years than the next lowest bidder. The winning vendor was apparently selected in this case because the Source Selection Board had no confidence in the Government costing scenario that the contractors were to use. HSI would help prevent this kind of costly error by generating detailed MPT data well in advance of source selection and emphasizing the importance of life-cycle ownership cost in choosing design concepts.

2.1.4 Conclusions. In our review of Coast Guard acquisition documentation and in interviewing Coast Guard managers, analysts, and procurement specialists involved in the acquisition system, we concluded that while there is mention of Human Factors Engineering and Safety in the documentation, in practice the Coast Guard does not have a Human Factors Engineering or System Safety/Health Hazards program in the acquisition process. We determined that the only way HFE and SS/HH considerations are included in acquisitions is by reference to applicable standards in some acquisition Requests for Proposals (RFPs). These domains are primarily left to the contractor to include as part of the contractor's "good working practices." There is typically little or no reference to these domain requirements in major program documentation. Few, if any, HFE or SS/HH plans are required, and little or no follow-up is done to determine the extent to which the contractor has considered these domains. Implementation of the HSI Program will correct these shortcomings and provide a systematic approach for considering both domains in each acquisition.

In the past, management of MPT was not as efficient as it could have been. Late starts resulted in major acquisition decisions made with little or no MPT input, minimal or no inputs to major program documentation, inconsistency between requirements and results from one acquisition to the next, and little or no follow-up to ensure that all relevant issues were considered.

In the current system, MPT planning and development of requirements and constraints begins in the Concepts Development Phase and may not be completed until the Production Phase. Starting that late precludes meaningful input to major program documentation, such as the Mission Need Statement (MNS) and the acquisition objectives that drive the Acquisition Plan

⁵Advanced Technology, Inc., U.S. Coast Guard Manpower, Personnel, Training, and Safety (MPTS) Concept Document, undated (circa 1990), p. C-1

(AP). Decision makers have already made such decisions as prioritizing potential design concepts and initial estimates of total life-cycle cost of the system with only minimal MPT inputs. These major documents and early decisions guide and bound the design, development, and production of the new system in the remaining phases, and need inputs from all HSI domains.

Another major shortcoming of the current system is that the documentation stops at the program level. There are no analyst guides or how-to documents to detail the specific techniques needed to permit MPT issues to be consistently analyzed so data can be made readily available to decision makers in a timely fashion. Analysts must "reinvent the wheel" before each analysis. HSI program documentation will cover the entire breadth of detail from the program level through the supervisory level, and also includes the analyst level. Each action required for each domain in each acquisition phase will be described in sufficient detail to permit in-house analysts to perform that action the same way each time, or to have the action contracted with consistency from one acquisition to the next.

2.2 HOW WILL AN HSI PROGRAM IMPROVE THE COAST GUARD ACQUISITION PROCESS? HSI will correct shortcomings in the current system by providing:

- a. An enhanced management structure to manage HSI in each acquisition -- a structure to focus existing Coast Guard expertise on satisfying specific HSI requirements in each new acquisition.
- b. Systematic, consistent technical and management approaches to achieve system-wide objectives in each HSI domain.
- c. Standards applicable to each domain that specify detailed requirements of that domain -- this includes contract requirements for contracting HSI work (e.g., sample Statements of Work; Contract Data Requirements Lists; Section L -- Instructions, Conditions, and Notices to Offerors).
- d. Analyst-level procedural guides that describe specific techniques to be used for each evolution required in each phase for each HSI domain -- these guides can be used by in-house analysts to accomplish the work or the guides may be used as standards for contractor support.
- e. Early application of HSI principles starting in the Project Initiation Phase -- including appropriate inputs to all applicable program documentation starting with the Major System Acquisition Project Nomination Memorandum, Mission Needs Statement, and Acquisition Plan.
- f. Subject matter experts and engineering expertise to focus specifically on human considerations in system design and life-cycle support -- the Human Factors Engineer on the HSI staff coordinates and resolves design problems from all domains with system design engineers -- reduces acquisition and life-

cycle ownership costs by reducing or eliminating alterations, redesigns, and dysfunction.

- g. **Human Engineering in system design and procedural development to improve human functions in the system and ensure human tasks are efficient, safe, and reliable -- this also ensures these results are reflected in operational, training, and technical publications and improves total system performance by optimizing the man-machine interface.**
- h. **Synergism created by the reinforcing effect between domains when applied simultaneously to the same acquisition.**
- i. **Lessons-learned records in each domain as an integral part of the process -- and provisions to maintain specific records for each acquisition to use in future procurements.**

3. IMPLEMENTING HSI IN COAST GUARD ACQUISITION.

The office executing the HSI Program would establish objectives for the human element of the system in the Project Initiation and Requirements Definition Phases prior to the first KDP. Human objectives should be traceable to readiness, force structure, affordability, and both peacetime and mobilization objectives. Human element objectives should be subsequently refined and updated at each successive Key Decision Point.

3.1 HSI PROGRAM OBJECTIVES. The following HSI Program objectives have been defined as critical to the success of an HSI Program:

- a. **Implement HSI principles early and throughout the Coast Guard acquisition process to improve total system performance, enhance the man-machine interface, and produce safe, reliable, hazard-free, and supportable materiel systems.**
- b. **Conducting adequate, early front-end analysis (FEA) is the most critical element to success of the HSI Program. FEA includes the efforts required in the very earliest stages of an acquisition to develop HSI criteria for inclusion into the program documentation that drives the system design, such as MNS, PSRD, and acquisition strategy objectives. FEA includes the following analysis and data gathering activities:**
 - (1) **Analyze Baseline Comparison System(s) - to determine manpower and training estimates**
 - (2) **Review lessons learned - for all five domains**
 - (3) **Develop a Target Audience Description - for life cycle cost estimate**

- (4) Review new technology considerations
- (5) Develop HSI criteria for inclusion in major program documents
- c. Focus system design on the capabilities, limitations, and interface needs of Coast Guard personnel required to operate, maintain, and support the new system to reduce acquisition and life-cycle ownership costs by eliminating or significantly reducing alterations, redesigns, and dysfunction in the system.
- d. Establish objectives for the human element of each system as soon as a manned materiel solution to the mission need is established in the Project Initiation and Requirements Definition Phases. Human element objectives should reflect HSI goals and constraints in all applicable acquisition documentation, and the office executing the HSI Program would make HSI data available for use in the decision making process.
- e. Apply all five HSI domains to the acquisition of each materiel system simultaneously to take advantage of the synergism created by the reenforcing effect between the domains.
- f. Implement the five HSI domains into system acquisitions to improve the management and technical aspects of system design and to create a systematic approach for determining and documenting manpower, personnel, and training life-cycle support requirements of the system.
- g. Incorporate Human Engineering into system design and procedural development to improve human functions and ensure human tasks are efficient, safe, and reliable.

3.1.1 HSI Relationship to Integrated Logistics Support. Determining and documenting manpower, personnel, and training (especially maintenance) associated with system acquisition has traditionally been the responsibility of ILS managers. The HSI Program combines MPT with System Safety/Health Hazards and Human Factors Engineering to improve overall management of HSI and to take advantage of the synergism resulting from implementation of all five domains simultaneously. HSI also introduces engineering expertise to resolve and coordinate HSI domain issues with design engineers.

Rather than replace ILS managers, the HSI Program is envisioned as an opportunity to improve the acquisition process through a joint effort. One of the primary tenets of HSI is that human considerations are included up-front in the process, starting with project initiation. ILS managers can be a part of this early effort by providing MPT analysts or other forms of input to assist the office executing the HSI Program. Similarly, as ILS managers become involved in trade-off analyses and logistics documentation in later phases, the HSI Program can provide analyst and data support. The HSI Program should reduce

some of the workload on ILS managers, while jointly improving MPT data inputs to the system design and program documentation.

3.1.2 Advantages of the HSI Program. HSI is structured to produce the following benefits to the Coast Guard.

- a. Improves total system performance by optimizing the man-machine interface.
- b. Reduces development, procurement, and life-cycle ownership costs by reducing or eliminating alterations, redesigns, and dysfunction. Evaluation of human domains early in the acquisition process also makes critical HSI data available for consideration in selecting the most cost effective design alternative and other decision making processes.
- c. Provides a systematic approach to determine and document manpower, personnel, and training life-cycle support requirements of the system.
- d. Offers organizational streamlining by focusing minimum resources to properly manage the five HSI domains, which represent well over 60 percent of the life-cycle cost of materiel systems.
- e. Offers a thorough, effective technical and management approach to achieve system-wide objectives in each domain. Brings together subject matter experts and engineering expertise to focus specifically on human considerations in system design and life-cycle support.
- f. Produces safe, efficient materiel systems, operating in a hazard-free, healthy environment.
- g. Incorporates Human Factors Engineering into equipment design and procedural development to assure that human functions and tasks are organized and sequenced for efficiency, safety, reliability, and to ensure that the results of this effort are reflected in development of operational, training, and technical publications.

3.2 DOMAIN INTERDEPENDENCY. HSI domains are interdependent. Decisions made in one domain will have a ripple effect in one or more additional domains. For example, a decision to man a function with five people will be based on a specific set of skills, experience, mental group, and training levels. The manpower decision will become the starting point and, therefore, directly impact decisions made in the Personnel and Training Domains. However, if the decision is to man the same function with three people, a different combination of skills, experience, mental group, and training levels would be required. The Human Factors Engineering design would be different to optimize the human interfaces in the two cases (e.g., more automation may be required with three people versus five). Safety would also become an issue if manning the function with three people resulted

in increased levels of stress or fatigue. The interdependency of domains is one of the primary advantages realized by managing the HSI Program as a single entity under one organization.

Changes or constraints in one domain will have the same ripple effect in other domains. For example, if the Coast Guard personnel system cannot provide the skills or mental group required by the manpower decision, or if the design is too training-intensive, then accommodations will be required in other domains to account for these constraints. In addition, the long term goal should be that all system design teams use a common data source to preclude disconnects caused by discrepancies in data maintained by difference sources.

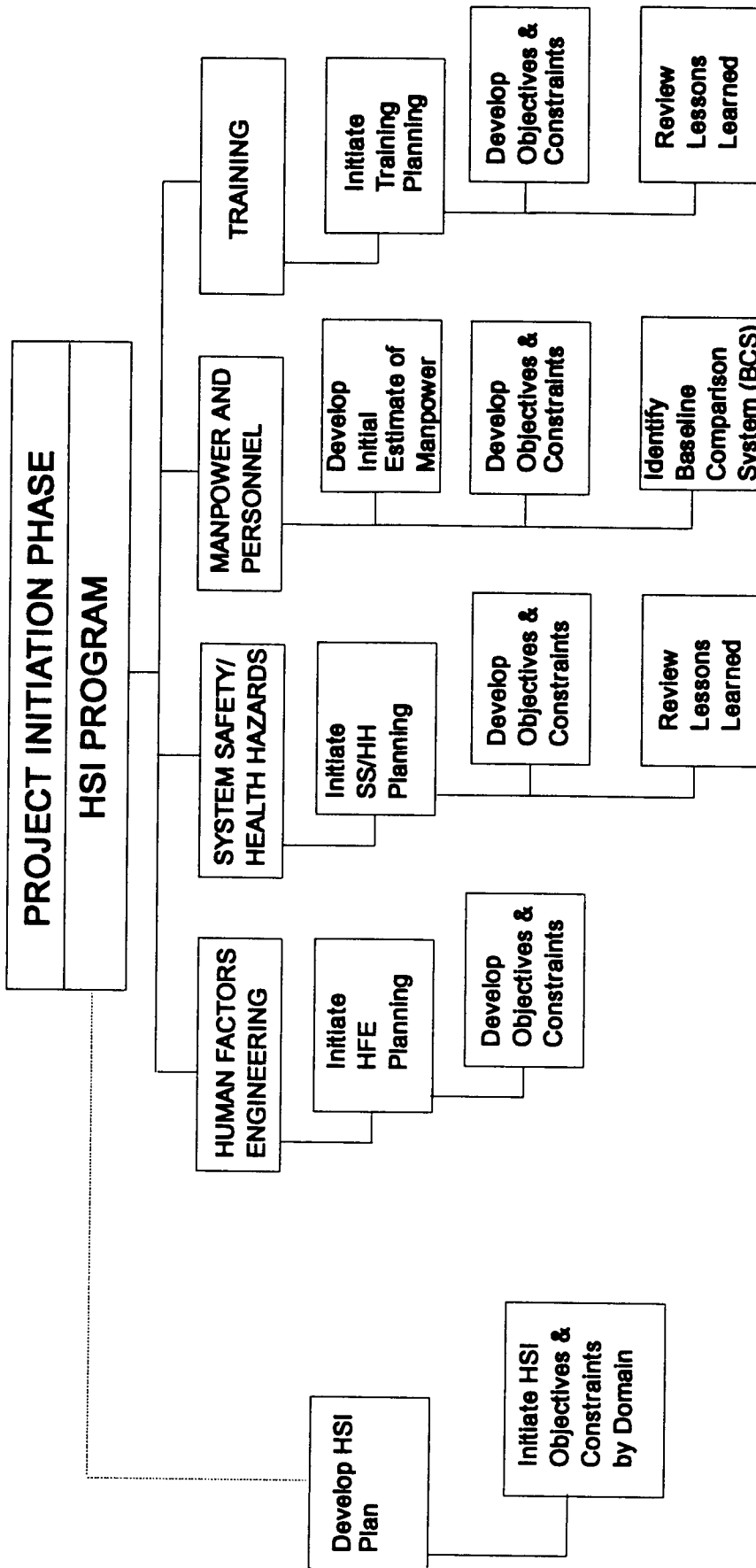
These examples also highlight the critical importance of determining accurate manpower requirements at the earliest possible point in each acquisition. Ideally, the Coast Guard will have studied existing systems enough to know where potential manpower savings can be achieved when replacing the old system. This permits the sponsor to specify the manpower requirement as a design criteria in the Mission Need Statement.

3.2.1 Integration of Domains. Integrating HSI domains entails evaluating potential tradeoffs between the five domains. For example, system performance is impacted by the number of personnel assigned to the system, the quality of those personnel (i.e., occupational specialty, experience level, mental group, etc), and the amount of training provided. Integration within the context of this example means optimizing the tradeoff between the number of people, their quality, and their training. Lowering the quality can be compensated for by an increase in training, but only up to a point. Conversely, the number of people involved may be reduced provided the personnel quality and training are increased. The relevant questions include how much change is possible and what is the cost. Most HSI design issues require tradeoffs between two or more of the five domains.

3.3 HSI ACTIVITIES AND DOCUMENTATION BY PHASE. In order to integrate the HSI Program into the current acquisition process, Exhibits A-2 through A-8 show the HSI activities and HSI documentation developed in each acquisition phase to support the process. Also shown are the primary HSI objectives in each phase. It should be noted that some overlap occurs between phases. Plans and activities started in one phase (such as developing HSI objectives and constraints in the Project Initiation Phase) may extend into the next phase before completion. In addition, planning and other initial actions for some activities may commence in the previous phase.

Exhibit A-9 displays a summary of HSI activities and documentation by acquisition phase, as well as existing Coast Guard acquisition program objectives, program activities, and program documentation.

3.3.1 HSI Program Documentation Inputs By Phase. HSI is not intended as a stand-alone program. As plans are completed in each domain, HSI will provide the Project Manager (PM) with a consistent, systematic, and standardized methodology to develop and produce

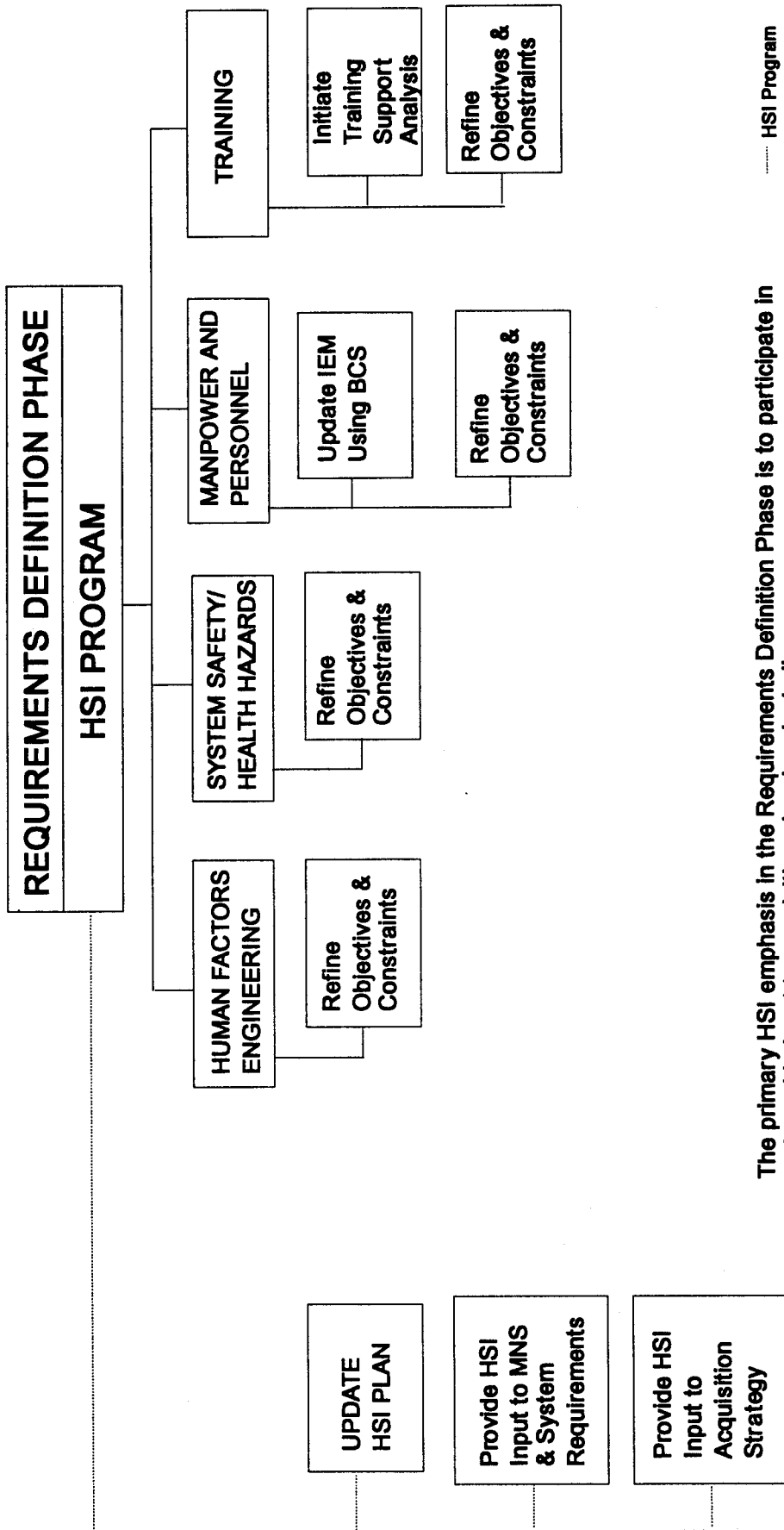


..... HSI Program actions not related to a single domain

The major objectives of the HSI Program Office in the Project Initiation Phase are:

1. Ensure HSI objective/constraints are included in the early stages of mission analysis and requirements definition.
2. Make HSI data available to decision making process.

Exhibit A-2. HSI Activities During Project Initiation Phase

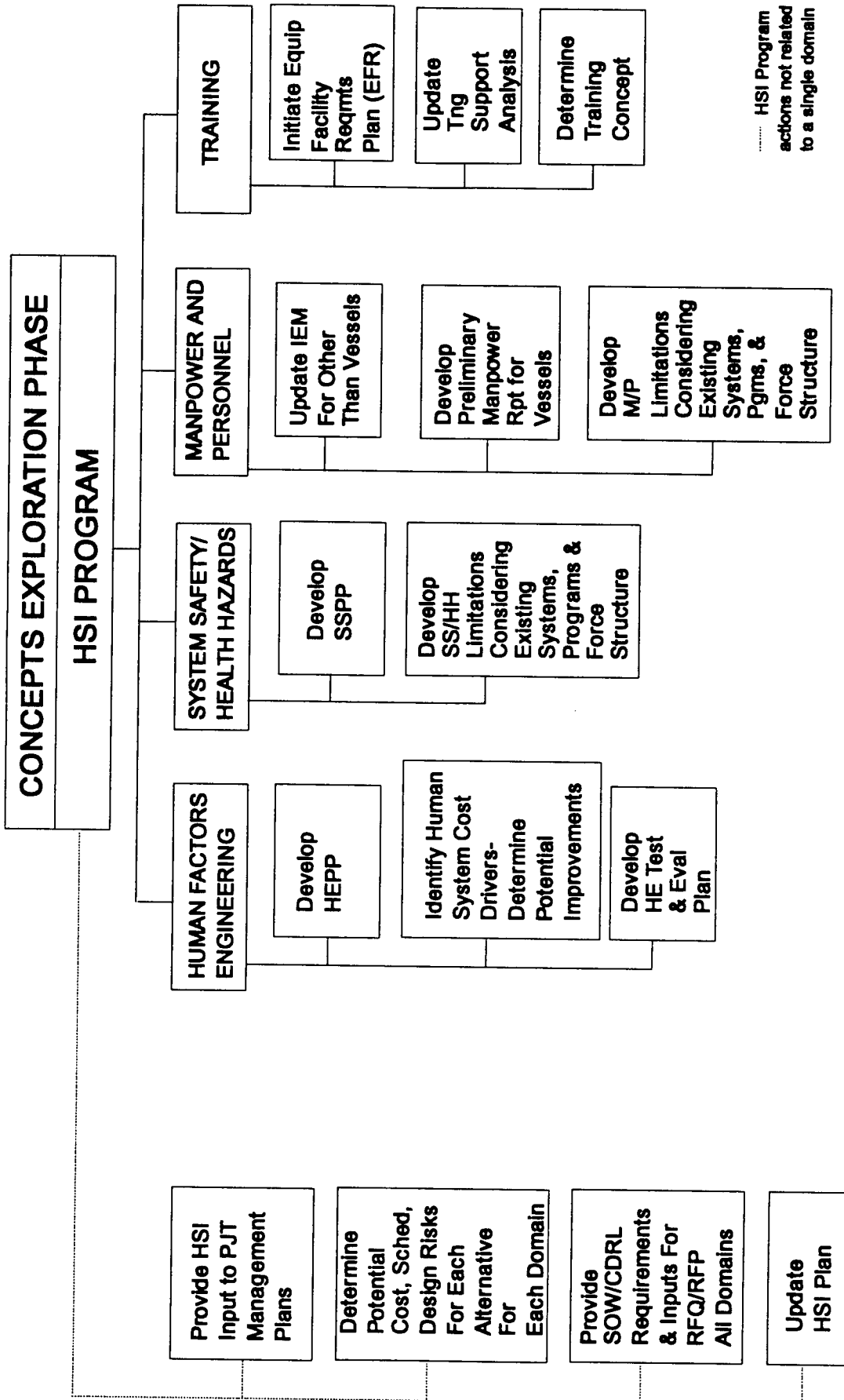


The primary HSI emphasis in the Requirements Definition Phase is to participate in and provide input to acquisition planning, including:

1. Mission cost/effectiveness analysis
2. Defining acquisition strategy objectives
3. Defining system requirements
4. Meeting requirements of KDP 1, including input to MNS

..... HSI Program actions not related to a single domain

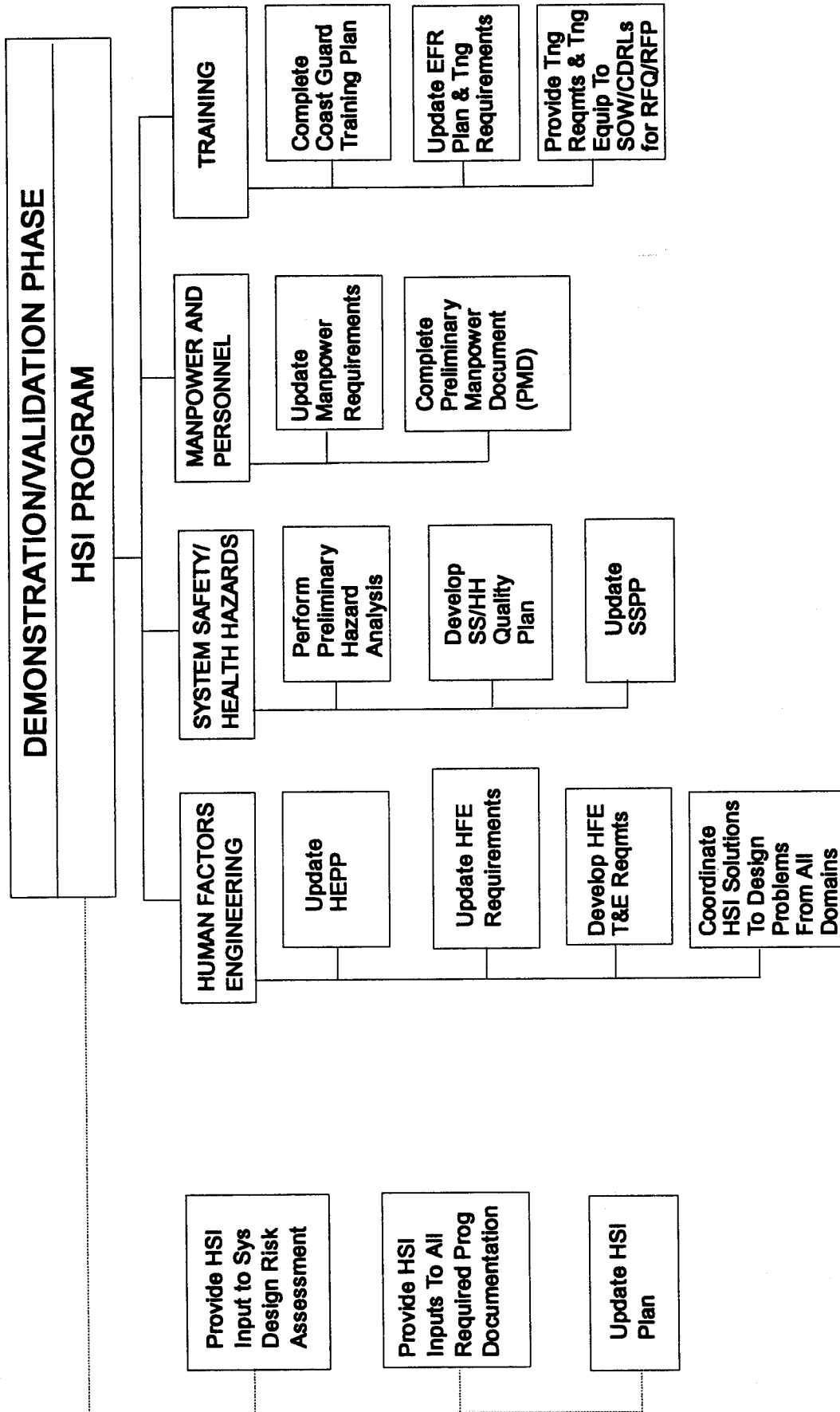
Exhibit A-3. HSI Activities During Requirements Definition Phase



The major HSI contributions during the Concepts Exploration Phase are:

1. Provide inputs to primary program documentation development
2. Evaluate each design concept from HSI perspective
3. Assist in defining program capability requirements and critical Test & Evaluation issues
4. Update HSI studies, requirements, and trade-off analyses
5. Meeting requirements of KDP 2

Exhibit A-4. HSI Activities During Concepts Exploration Phase

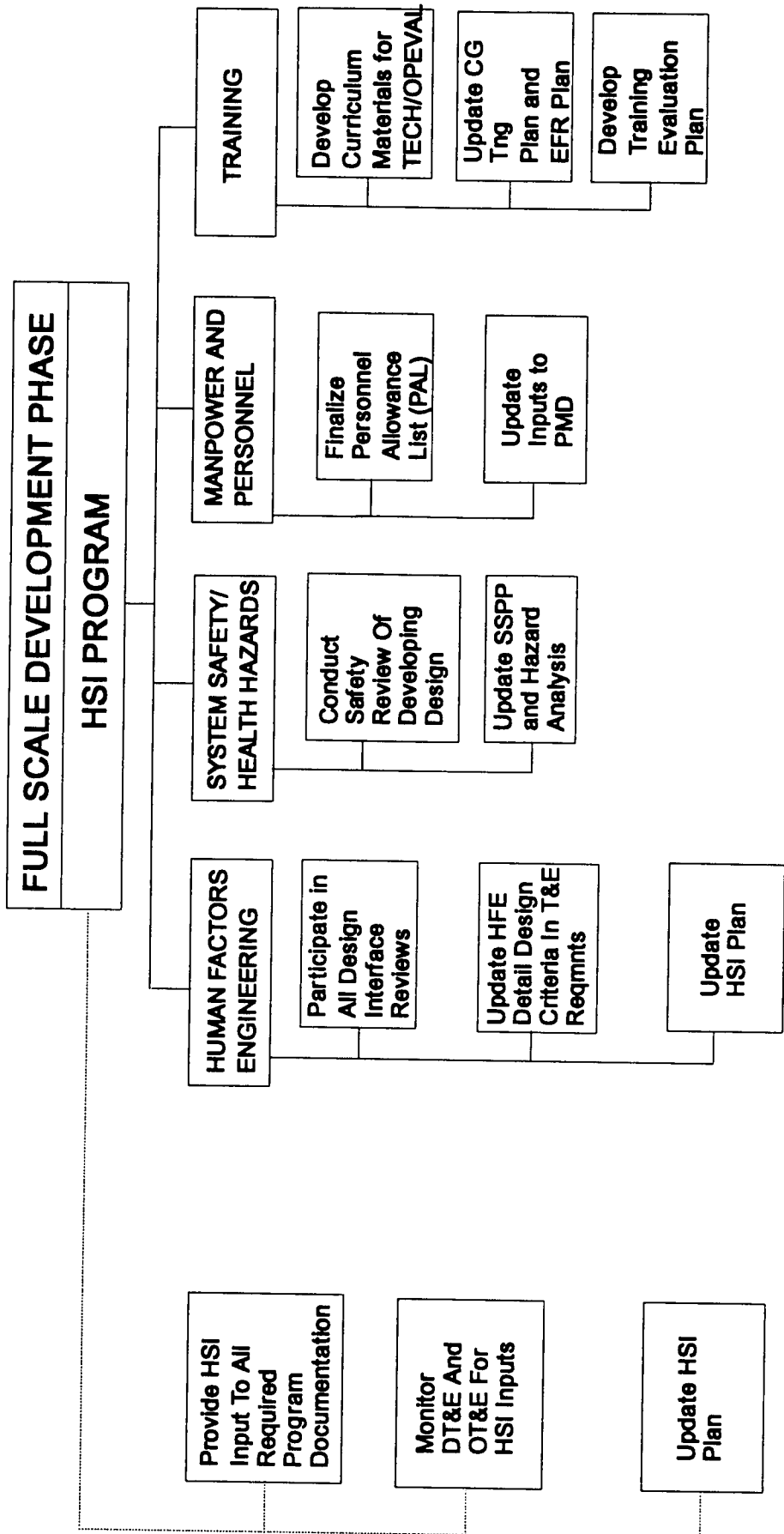


The major HSI contributions during the Demonstration/Validation T&E Phase are:

1. System design, subsystem compatibility/trade-off analysis
2. Advanced development model demonstration/validation T&E
3. Define technical requirements
4. Meet requirements of KDP 3

..... HSI Program actions not related to a single domain

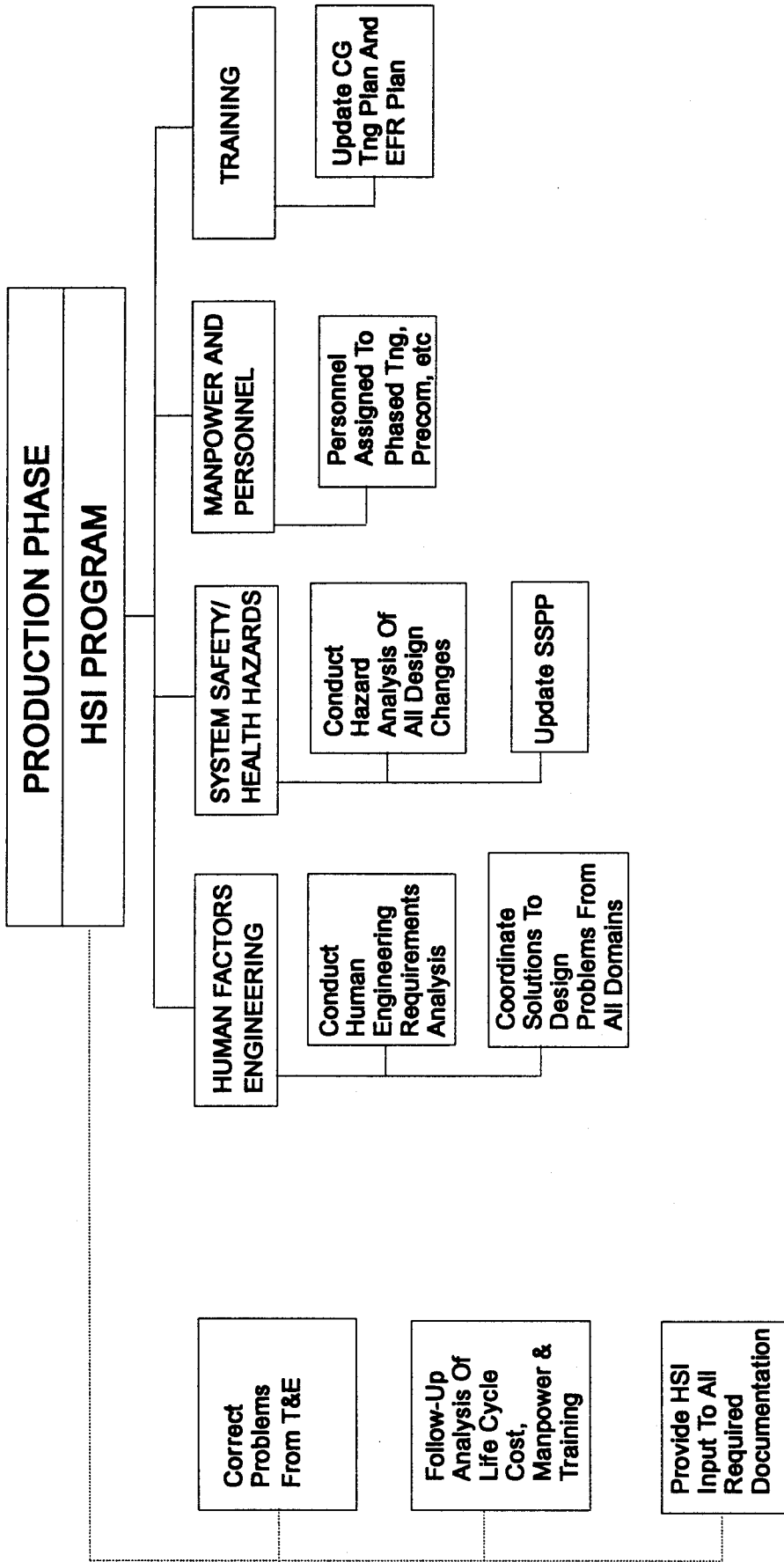
Exhibit A-5. HSI Activities During Demonstration/Validation Phase



The major HSI contributions during the Full Scale Development Phase are:

1. Provide inputs to primary program documentation development
2. Assist in defining program capability requirements and critical Test & Evaluation issues
3. Update HSI studies, requirements, and trade-off analyses
4. Meeting requirements of KDP 4

Exhibit A-6. HSI Activities During Full Scale Development Phase

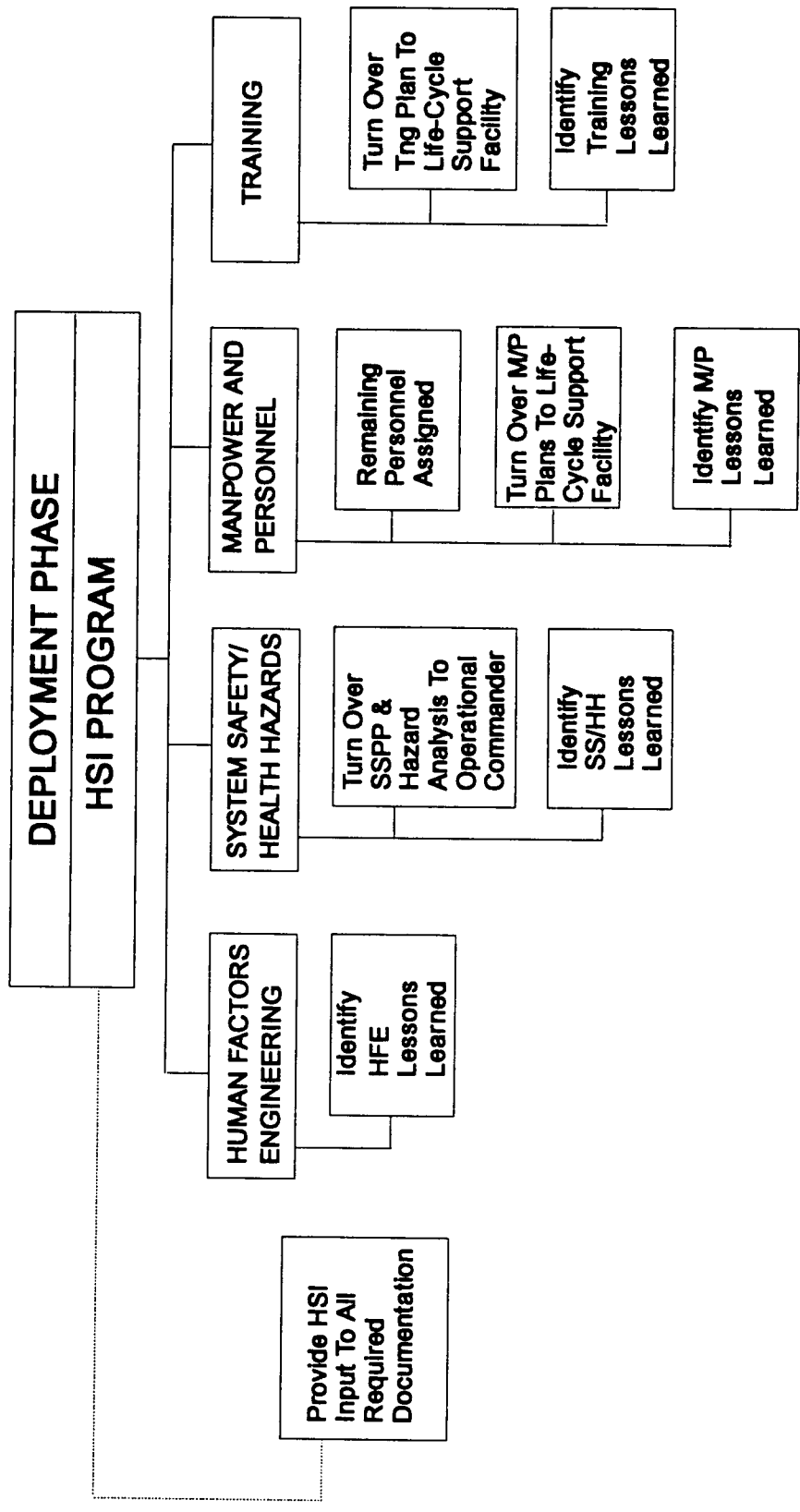


The major HSI contributions during the Production Phase are:

1. Detailed design for system production
2. System acceptance testing
3. Initial operational T&E

..... HSI Program actions not related to a single domain

Exhibit A-7. HSI Activities During Production Phase



The major objectives of the HSI Program Office in the Deployment Phase are:

1. Make system ready for unrestricted operations; hand off to operational commander, or life-cycle support facility
2. Predeployment testing and shakedown training
3. Record lessons learned

..... HSI Program actions not related to a single domain

Exhibit A-8. HSI Activities During Deployment Phase

PHASE	PROJECT INITIATION	REQUIREMENTS DEFINITION	CONCEPTS EXPLORATION	DEMONSTRATION & VALIDATION	FULL SCALE DEVELOPMENT	PRODUCTION	DEPLOYMENT
KDP REVIEWS							
P O R B O J G E R C A T M I V E	Develop justification for initiation of a major system acquisition project.	Develop Mission Need Statement (MNS); define system requirements.	Develop and evaluate alternative system design concepts; select preferred concept(s).	Develop and evaluate concept selected; reduce technical risk to acceptable level.	Complete system design; prepare for production.	Produce system; procure/hand-off logistic support materiel, personnel, facilities, and services.	Make system ready for unrestricted operations; hand off to operational commanders
P A R C O T G I R V A I T M Y	Mission and cost analysis; technology assessment. Define mission requirements.	Mission functional analysis; system cost/feasibility analysis. Define acquisition strategy objectives.	Establish working relationships with Support Program Managers; conduct engineering feasibility studies. Define system capability requirements, critical test and evaluation issues; prepare Acquisition Plan.	System design; subsystem engineering; subsystem compatibility/trade-off analysis. ADM demonstration & validation, test & evaluation. Define technical requirements. Pre-planned Product Improvement.	System/subsystem design; equipment compatibility/trade-off analysis. EDM/prototype development/operational test & evaluation requirements. Define production requirements.	Detailed design for system production; value engineering; system acceptance testing; first article development/operational test and evaluation.	Post acceptance availability; pre-deployment tests, qualification trials, and shakedown training.
P D R O C G U R M A E M N T	Mission Analysis Report Major System Acquisition Nomination Memorandum	Mission Functional Analysis (MFA) report, Mission Need Statement (MNS)	PORD/ORD, AP, PM Charter, PMP, Feasibility Study Reports, Trade-off Analysis, TEMP, DT Plan, ILSP, Project Baseline Document, MNS Update	Design Reports, PMP Update, ILSP Update, CMP Update, TEMP Update, DT Plan Update, CMP, AP Update, Risk Assessment Report, DMVAL Test Report, MNS Update	AP Update, PMP Update, ILSP Update, CMP Update, TEMP Update, DT Report, OT Plan, OT Report, Operational Deployment Plan, MNS Update	Operational Baseline Configuration Index (OCBI), Technical Data Follow-on, Production, RFP Package, ILSP Update, OLSP	PCA Report, ILSEA Report, ILSP Update, OLSP Update, FTP
H A S C T I I V I T I E S	Commence Front-End Analysis (including HSI objectives and constraints) Commence MAPTIDES analysis Commence HSI System Management Plan (HSISMP) Develop initial Estimate of Manpower (IEM) Identify Baseline Comparison System (BCS)	Update HSISMP Update IEM using BCS Initiate Training Analysis Provide HSI Input to MNS & Acquisition Objectives	Update HSISMP, IEM Develop HFE Program (HEPP) Plan Develop Trng Concept Develop Safety/Hazard Program Plan Evaluate each design alternative Initiate Equipment Facility Report (EFR) Plan Provide HSI Input to PORD/ORD, AP, PMP, TEMP, ILSP, and others as required	Update HSISMP Complete CG Training Plan Develop SS/HH Quality Plan Produce Preliminary Vessel Manpower Document (PVMD) Produce Preliminary Aircraft Manpower Document (PAMD) Provide HSI Input to update all required documentation Update HEPP, SSPP, EFR,	Update HSISMP Participate in all Design Interface Reviews Develop Training Evaluation Plan Provide HSI Input to all required documentation Finalize Personnel Allowance List (PAL) Update Manpower Plans, HEPP, SSPP, EFR, CG Training Plan	Update HSISMP Correct problems found in T&E Update SSPP Update CG Training Plan & EFR Plan Conduct Hazard Analysis of all major changes Provide HSI Inputs to all required documentation Conduct HFE Requirements Analysis	Provide HSI Input to all required documentation Identify lessons learned in all domains Turn over MPT Plan to life-cycle support facilities

Exhibit A-9. HSI Activities During Major System Acquisition Phases

HSI documentation to support the Coast Guard acquisition process in the early phases and at each Key Decision Point of the program. The following HSI documentation requirements are specified for each phase of the acquisition process.

3.3.1.1 Project Initiation and Requirements Definition.

- a. A rough Initial Estimate of Manpower (IEM), using the Manpower Estimate Report format (see page D-4 for format), will be an enclosure to the Major System Acquisition Project Nominating Memorandum in the Project Initiation Phase. A Manpower Estimate Report will also be submitted to the Coast Guard Acquisition Executive with all initial approval requests for smaller acquisition projects.
- b. HSI considerations should be included in each Mission Need Statement (MNS).
 - (1) The Department of Transportation (DoT) Order 4200.14C specifies the format for submission of the MNS. Item 3 of the MNS format requires a list of any known constraints (including budget, legal, personnel, operational, logistics and maintenance considerations, time factors, etc.). This item also requires a description of potential opportunities for cost savings.
 - (2) Each domain of HSI should be considered for inclusion in the MNS under one or both of the DoT criteria above.

3.3.1.2 Concepts Exploration.

- a. The following HSI requirements should be documented in both the Preliminary Sponsor Requirements Document (PSRD) and the Sponsor Requirements Document (SRD):
 - (1) Objectives and minimum acceptable requirements relating to operation, maintenance, training, and support of the system
 - (2) Projected manpower, personnel, training, and safety limitations, considering existing systems, programs, or force structure being traded off to support the new or modified system
 - (3) Objectives and minimum acceptable requirements for manpower and training that shall also be incorporated in the Project Baseline document
- b. The Acquisition Plan (AP) should include the following HSI requirements:
 - (1) Life-cycle costs associated with manpower, personnel, and training should be included.

- (2) HSI requirements should be included under the "Capability or Performance" paragraph.
 - (3) Risks associated with HSI domains should be included in the "Risks" paragraph.
 - (a) Summarize potential cost, schedule, and design risks that result from HSI domains.
 - (b) Highlight current human system cost drivers. Discuss the manpower impact of the most promising alternative system(s) as compared to its predecessor or comparable systems.
 - (c) Discuss major cost, schedule, and performance trade-off decisions to be made at current and subsequent Key Decision Points.
 - (4) The impacts of manpower, personnel, and training constraints will be included under the "Logistic Considerations" paragraph.
 - (5) System Safety/Health Hazards input may be required for the "Environmental Considerations" paragraph.
 - (6) Any relevant HSI requirements or considerations not shown elsewhere should be included in the "Other Considerations" paragraph, such as requirements of the Occupational Safety and Health Act (OSHA).
- c. The office executing the HSI Program should develop a Human Systems Integration Plan that:
- (1) Identifies critical human system factors that have a significant impact on readiness, life-cycle cost, schedule, or performance. It should include potential cost, schedule, and design risks, as well as trade-offs that concern HSI factors, and plans to manage and reduce program risks. These are defined as HSI "high drivers." The identification of high drivers is an essential HSI activity that must be accomplished as early as possible in the life-cycle. It is important to note that a high driver is a critical human system factor that has significant impact on system performance, etc., but is also amenable to change. A factor that has significant impact but cannot be modified is a constraint, not a high driver.
 - (2) Discusses the manpower impact of the new system as compared to its predecessor or comparable system(s) and states the sources of the manpower resources for the new system.

- (3) Discusses requirements for new occupational specialties, requirements for high quality personnel or "hard-to-fill" military and civilian occupations, and how these personnel requirements can be met.
 - (4) Highlights current system cost drivers and explains how these costs can be controlled in the new system.
 - (5) Describes how Human Factors Engineering will be applied to the design effort.
 - (6) Summarizes how lessons learned in all domains will be applied to the new system.
 - (7) Addresses the training requirements and effectiveness of the new training system. It should include requirements for new or additional training resources and identify critical points in the training schedule, thereby establishing a baseline for training plan development.
 - (8) Discusses the impact fielding the new system will have on unit readiness and whether the training base is adequate to meet surge and mobilization requirements.
- d. The Project Manager should include the following HSI requirements in the Project Management Plan (PMP):
- (1) HSI requirements included in the MNS and AP should be summarized in the PMP.
 - (2) The PMP should include the Human Systems Integration Plan as a Project Support Plan.
 - (3) The PMP should discuss the organizational structure set up to manage the project, including HSI.
- e. The office executing the HSI Program would provide the necessary inputs to the Test and Evaluation Master Plan (TEMP) to ensure each HSI domain receives adequate test and evaluation.
- f. The office responsible for the HSI Program should provide the necessary input from each domain to support Feasibility Studies, Trade-Off Analyses, Project Baseline Documents, Integrated Logistics Support Plans (ILSPs), Requirements Baselines, and updates to the MNS.

3.3.1.3 Demonstration/Validation.

- a. The office executing the HSI Program should provide inputs from all five domains to update the following documents:**
 - (1) PMP**
 - (2) ILSP**
 - (3) TEMP**
 - (4) Development Test Plan (DTP)**
 - (5) AP**
 - (6) MNS**

- b. HSI inputs should be provided by the HSI Program as necessary to the following documents:**
 - (1) Design Reports**
 - (2) Configuration Management Plan (CMP)**
 - (3) Risk Assessment Report**
 - (4) Demonstration/Validation (DEMVAL) Test Report**
 - (5) Allocated/Functional Baseline**

3.3.1.4 Full-Scale Development.

- a. The office responsible for the HSI Program should provide inputs from all five domains to update the following documents as required:**
 - (1) AP**
 - (2) PMP**
 - (3) ILSP**
 - (4) CMP**
 - (5) TEMP**

- (6) MNS
- b. HSI inputs should be provided by the HSI Program as necessary to the following documents:
 - (1) Development Test Report
 - (2) Operational Test Plan and Report
 - (3) Operational/Deployment Plan
 - (4) Product Baseline

3.3.1.5 Production. Updates and other inputs to the following documents should be provided as necessary by the office responsible for the HSI Program:

- a. Technical Data
- b. Follow-on Production
- c. Request for Proposals (RFP) Package
- d. ILSP
- e. Operational Logistics Support Plan (OLSP)
- f. Operational Baseline

3.3.1.6 Deployment. The office executing the HSI Program should provide inputs to the following documents as required:

- a. Project Transition Plan
- b. ILSP
- c. OLSP
- d. Post Contract Assessment Report
- e. Integrated Logistics Support Effectiveness Assessment Report

4. REQUIREMENTS.

4.1 REQUIREMENTS BY HSI DOMAIN.

4.1.1 Human Factors Engineering. The Coast Guard should establish a HFE program for each system acquisition to develop effective man-machine interfaces and preclude system characteristics that:

- a. Require highly cognitive, physical, or sensory skills.
- b. Require excessive or complex manpower- or training-intensive tasks.
- c. Result in frequent or critical errors.

The Human Factors Engineer coordinates the progress of each HSI domain as the system design moves through the various phases of development. When analysis reveals a problem in any domain that requires a design change, the Human Factors Engineer works with the domain specialist to develop an acceptable solution that is then coordinated with appropriate design engineers to correct the problem in the most efficient, least disruptive manner. Thus, the HSI Program brings together subject matter experts and engineering expertise to focus specifically on human considerations in the system design and life-cycle support process from project initiation to deployment of the new system.

4.1.2 System Safety/Health Hazards. System Safety engineering should identify, evaluate, and eliminate or control System Safety and Health Hazards in the design and development of materiel systems.

Appropriate System Safety and Health Hazards objectives should be established as early in the program as possible. These objectives are then used to guide safety and hazard considerations throughout the acquisition process.

- a. Initial objectives should be based on predecessor or similar systems and lessons learned.
- b. Objectives should be established prior to KDP-1, during development and assessment of the MNS.
- c. Objectives should be established to reduce the hazards to operating, maintenance, and rescue personnel in the event of equipment or facility fire or water intrusion.
- d. In acquisitions where System Safety or Health Hazards are of particular concern, enhanced safety/health can be a mission need element in the MNS.

With regard to hazardous materials, emphasis should be on reduced use of hazardous materials in processes and products rather than simply managing the hazardous waste created. Proposed systems should be analyzed for their potential environmental impacts in accordance with Federal Regulations. Each management decision to accept the risks associated with an identified hazard should be formally documented using MIL-STD-882 as a guide.

4.1.3 Manpower. The office responsible for the HSI Program should conduct an assessment of manpower requirements in the Project Initiation and Requirements Definition Phases and refine in each subsequent acquisition phase to:

- a. Influence system design to moderate operational, maintenance, training, and support manpower requirements
- b. Ensure the system can be operated and supported within the manpower limitations established for it
- c. Influence operations and support concepts to reduce inefficient manning and organization concepts
- d. Ensure required manpower is programmed in the Planning, Programming, Budgeting, and Evaluation System (PPBES) for support of the operational system when fielded

Manpower projections should consider resource limitations and manpower reduction goals. Manpower resource estimates and decisions should be based on results of a well-defined program of analyses/demonstrations, realistic estimates of initial and mature system reliability and maintainability values, and field experience on similar systems or subsystems. Uncertainty of early planning data should not delay the initial manpower assessment, and may be addressed in the manpower analysis. Manpower resource estimates are updated in each acquisition phase as more information becomes available on the design and test data.

At a point in the acquisition when the design is sufficiently complete to permit development of workload data, both skill and workload analyses should be conducted to refine manpower and training resources for life-cycle support.

4.1.4 Personnel. In conjunction with the manpower analyses, the office responsible for the HSI Program should conduct an assessment of personnel requirements to:

- a. Influence the system design to moderate skill requirements and limit or reduce the use of occupational specialties with high aptitude and skill requirements or with mobilization, rotation, or flow rate problems stemming from accession or retention limitations
- b. Ensure appropriate planning is accomplished for acquiring, training, or relocating personnel and skills to support the operational system

4.1.5 Training. The broad training objectives in the Coast Guard are to provide military training programs that effectively support required levels of force readiness and that efficiently use resources. The office executing the HSI Program should assess the training requirements of each new system to:

- a. Influence the system design to moderate training requirements, optimize the selection of training alternatives, and ensure that data is available to permit timely development of training system equipment and courseware
- b. Ensure appropriate training is being planned for support of the operational system
- c. Ensure required training resources (trainers, facilities, equipment) are programmed for support of the operational system

HSI can identify intensive training tasks and target such tasks for design trade-off analyses, assess existing training resources to determine the ability to support training needs, highlight the requirement for new or additional training resources, and minimize the inefficient use of operational equipment and munitions for training where possible.

HSI can integrate training materials and training devices into the total system. A total system training plan should be developed prior to KDP-3 that includes a description of the total training system and addresses the training and operational system development schedule.

4.2 TEST AND EVALUATION PLAN (TEMP). The TEMP should address human performance issues and provide data to validate that Human Engineering, Manpower, Personnel, Training, and System Safety/Health Hazards design requirements have been met. System testing should be accomplished under operationally realistic conditions using personnel deemed to be typical users.

Test and Evaluation programs should be structured to:

- a. Verify attainment of technical performance specifications and objectives, including all five HSI domains
- b. Verify that systems are operationally effective and suitable for intended use, including concerns in all five HSI domains

Test planning, at a minimum, must address all system components (hardware, software, and human interfaces) that are critical to the achievement and demonstration of contract technical performance specifications and minimum acceptable operational performance requirements specified in the Sponsor Requirements Document.

4.3 QUALITY ASSURANCE. A quality assurance program should be established to ensure that the Coast Guard's Human Systems Integration Program is fully incorporated into the material acquisition system. In addition, the quality assurance program should verify system conformance to the requirements of each HSI domain. The quality program should be documented and, when done by contract, will be subject to review by Government representatives.

5. HOW DOES THE COAST GUARD GET FROM THE CURRENT SYSTEM TO AN ACQUISITION PROCESS WITH HSI FULLY INTEGRATED?

This section describes possible organizational structures for Coast Guard consideration in implementing HSI and discusses the elements involved in implementing these options.

Major disruption to the existing organization is not necessary in order to integrate HSI into the acquisition process. Some relatively minor organizational changes will be necessary, but the advantages of fully integrating HSI into the system far outweigh the minor disruptions required to implement HSI.

A final recommendation on a specific organization to manage the HSI Program is withheld pending completion of the HSI Process Model in Task B of the current contract. The Process Model will contain a recommended management structure for the Coast Guard to use in managing HSI through each phase of individual acquisitions. This management structure may strengthen some organizational options and weaken others. We will, therefore, make a final recommendation on the specific organizational option in the Task B final report.

5.1 STAFF ORGANIZATION OPTIONS TO IMPLEMENT HSI. The Coast Guard has several potential organizational arrangements available for implementing the HSI Program. These options are delineated below and are based on assignment of management responsibility for the HSI Program during system acquisitions to the following organizations:

- a. Project Manager Organization -- PM would be responsible for all HSI analyses and data input using the matrix organization.
- b. Current matrix organizations responsible for HSI domains outside the acquisition process, e.g., G-P for personnel and training -- These are the institutional organizations with expertise in HSI subject areas that would be responsible for assigned domains, including all HSI analyses and inputs to PM documentation.
- c. HSI Program Office -- This is a small organization specifically assigned responsibility for all aspects of HSI.

The trade-offs to be considered in evaluating these options include:

- a. Effectiveness of the HSI Program under each organizational arrangement
- b. Workload considerations, e.g., does addition of the HSI Program to existing workload overburden that organization?
- c. Cost in additional manpower to develop the HSI capability verses the benefits to be derived from implementing HSI in system acquisition

- d. Contracting required -- While some contracting will be required in all options, some organizational arrangements make more contracting necessary than others

5.1.1 Project Manager Organization. Option one consists of tasking current Project Managers and matrix organizations to implement HSI into the acquisition process using existing staff. The PM and staff would be tasked to lead the HSI effort in each acquisition and to form a matrix organization supporting each domain from the following organizations:

- a. G-PWP for Manpower and Personnel
- b. G-PRF for Training
- c. G-K for System Safety/Health Hazards
- d. Coast Guard R&D Center for Human Factors Engineering

While this option is the least costly in terms of additional staff, there are major disadvantages to tasking the existing organization with implementing HSI.

- a. This is an added workload burden on an already heavily-burdened PM and staff. More contract services would be required for this option than the other two.
- b. Under this option, there is still a shortage of Human Factors Engineering and Safety Engineering expertise on the Headquarters Staff to support HSI.
- c. This option would require a substantial training effort to develop the expertise necessary to enable each PM to lead the HSI Program for their particular acquisition.
- d. A key advantage of HSI is that the process is initiated in the Project Initiation Phase and is very active in the Requirements Definition Phase. This advantage would be lost under this option since the PM is not assigned until the Concept Development Phase and then must devote full time to development of major program documents, such as the Acquisition Plan, Project Management Plan, and Test and Evaluation Plan.
- e. Another key advantage of HSI is that the Human Factors Engineer works with each domain expert to resolve design problems and then coordinates these solutions with design engineers to correct system design problems in all domains. This option would lose most of that advantage because the HFE needs closer daily contact with domain experts and design engineers for each acquisition than the R&D Center could provide on a matrix management basis.

- f. It would be difficult to maintain consistency between acquisitions because the PM and staff change with each new procurement.

The HSI Program would be ineffective under this basic option and very little would be gained over the current system.

5.1.2 Current Matrix Organization. Option two consists of tasking the domain experts on the Headquarters Staff with execution of the HSI Program. These domain experts would conduct all the analyses (or have it done by contractor) and provide inputs to the PM and program documentation at the appropriate times.

Since there is not a Human Factors Engineering Organization represented on the Headquarters Staff, this option would require the Coast Guard to establish such a position and to hire a Human Factors Engineer to assume responsibility for the HFE domain. The new position would probably be located in the Office of Acquisition. Under this scenario, the following organizations would execute their individual HSI domain responsibilities.

- a. G-PWP for Manpower and Personnel
- b. G-PRF for Training
- c. G-K for System Safety/Health Hazards
- d. New hire for Human Factors Engineering

This option is the second least costly in terms of additional staff and should not create an excessive workload, but it also has some major disadvantages:

- a. A shortage of Safety Engineering expertise on the Headquarters Staff still remains.
- b. With each staff domain expert acting independently, the HSI Program will remain fragmented and not be effectively integrated into the acquisition process. The synergism achieved by the reinforcing effect between domains when all HSI domains are applied simultaneously to the same acquisition would be degraded because of the independent actions of the domain experts.
- c. The advantage HSI achieves by having the Human Factors Engineer resolve design issues and coordinate the solution with system design engineers would be less effective under this option where each staff expert is responsible for implementing their individual domains. This option would require management by consensus since the HFE would have no authority to make design decisions in other than the HFE domain.

This option would probably be more effective than the existing system because the institutional experts could use HSI methods and techniques in satisfying requirements in their domains. The fragmented nature of this organizational structure, however, will degrade its effectiveness below the desired level.

5.1.3 HSI Program Office. Option three entails the formation of an HSI Program Office in the Office of Acquisition specifically to manage HSI in Coast Guard acquisitions. This office could be staffed in part by representatives from the Headquarters Staff, thereby exploiting the existing domain expertise. The HSI Program Office would develop (or contract) all HSI input for each domain. These inputs, coordinated with the PM, would be provided as necessary to decision makers; in addition, these inputs would be provided in a timely manner to insure inclusion within the appropriate program documentation. Since there are no Human Factors Engineers or Safety Engineers on the Staff, this option would require the Coast Guard to invest in the HSI Program by creating two positions and hiring a Human Factors Engineer and Safety Engineer.

All HSI domains could be covered by specialists assigned to the following four positions. Specialists in these positions would coordinate their domain requirements and products with the office indicated. This coordination is a way of focusing and utilizing Coast Guard institutional HSI domain expertise to ensure the best possible inputs for each system acquisition; additionally, this is a way to keep the coordinating offices advised of new HSI requirements in their areas of responsibility.

<u>Position</u>	<u>Coordinating Office</u>
Manpower and Personnel Specialist	G-PWP
Training Specialist	G-PRF
Human Factors Engineer	Coast Guard R&D Center
Safety Engineer	G-K

The HSI Program Office should be headed by a Human Factors Engineer because the HFE is specifically trained in all HSI domains. In addition, the HFE brings to the HSI team, an engineering perspective to resolve design issues in all domains and to coordinate those resolutions with system design engineers. The HFE understands systems engineering and design and will be a credible member of the acquisition team in resolving HSI domain problems and reflecting those corrections in the system design.

Advantages of an HSI Program Office assigned to the Office of Acquisition include the following:

- a. This option provides organizational streamlining by strategically placing a small cadre of HSI expertise in one organization to fully manage design and support elements that cost the Coast Guard well over 60 percent of the total life-cycle cost of each acquisition. Additionally, it provides the engineering

capability to design-in all applicable human considerations in the initial design, thereby improving system performance while achieving cost avoidance by eliminating or reducing alterations, redesigns, and equipment dysfunction.

- b. Assignment of the HSI Team to the Office of Acquisition would strategically position the Team to be cognizant of and involved in the analysis during the early stages of the Project Initiation Phase for each new acquisition.
- c. Each member of the HSI Team would be solely dedicated to managing HSI in each system acquisition, thereby providing continuity in requirements, documentation, and results from one acquisition to the next.
- d. Lessons learned would be developed for each acquisition, and lessons learned from previous procurements would be reviewed and used to improve each new design.
- e. This option reduces workload on the PM organization.
- f. Contracting some analyses will be required in each domain. This should be about the same as option two, the Current Matrix Organization option.

This organization option ensures by far the most effective HSI Program over the other options. For a relatively small investment in manpower, the Coast Guard will gain an HSI capability that is not present today. In addition to greatly improved system performance, this program will result in cost avoidance that is much greater than the manpower costs required to implement HSI.

5.1.4 Other Options. Variations and combinations of the above options are also possible. For example, one or both new hire Human Factors Engineer and Safety Engineer positions could be added to the first option, the PM Organization. These additions would resolve some, though not all, of the shortcomings inherent in that option; even then, the effectiveness of this option in implementing HSI would not nearly match the effectiveness of the third option, the HSI Program Office option.

Adding a Safety Engineer to the second option, the Current Matrix Organization, would not resolve most of the shortcomings and the low effectiveness noted for that option. There may be other possibilities for helping to resolve the issues in the first and second options, but neither option is likely to match the effectiveness of HSI under the HSI Program Office organization.

5.2 DEVELOPMENT OF THE COAST GUARD HSI MODEL. The various phases required to construct and implement a successful HSI Program in the Coast Guard acquisition system are outlined in Exhibit A-10. The three phases of work shown can be considered as developing a model of HSI actions and procedures that require documentation. The model consists of layers of effort that becomes the entire program when completed. The three

phases roughly equate to the three levels of detail shown: Program Management, Supervisor, and Analyst levels of detail. When the program is completed, there will be no distinct boundary between these levels of detail; instead, the detail will vary from one acquisition to the next depending upon the judgements and styles of the Coast Guard HSI managers, supervisors, and analysts. The following paragraphs will discuss the general content of each phase.

COAST GUARD HSI PROGRAM

<u>Phases</u>	HFE	MPR	PERS	TRNG	SS/HH	<u>Level of Detail</u>
I	HSI PROGRAM REQUIREMENTS					Program Mgmt
II	Mgmt Structure	HSI PROCESS MODEL				Super-visor
III	HSI SUPPORT					Analyst

Exhibit A-10. Model of HSI Documentation

5.2.1 Phase I -- HSI Program Requirements. This phase describes an HSI Program integrated into the Coast Guard acquisition process; it describes a capability the Coast Guard needs to improve system design and system performance while avoiding costs caused by alterations, redesigns, and dysfunction of new equipment. This HSI Program Requirements Document defines, by domain, the end results the Coast Guard wants this program to achieve. Benefits and advantages of implementing HSI are also included. Various kinds of standards are referenced to permit the Coast Guard to describe specific HSI requirements to whatever level of detail is desired in a given acquisition.

5.2.2 Phase II -- HSI Processes Model. Having defined the HSI Program for the Coast Guard acquisition process and specified end results desired in Phase I, the next step is to develop methodologies, processes, and techniques needed in each domain to satisfy Phase I requirements. To do this, we are analyzing how the DoD Military Services HSI Programs meet the DoD requirements. From these DoD programs, we will tailor a Process Model for each domain that describes the methodologies, processes, and techniques used by the DoD program that best fits the Coast Guard requirements in each domain. We will also identify

and reference the analyst guides and other how-to documentation for further development in Phase III of this project.

In addition, we will also recommend in Phase II, the management structure needed by the Coast Guard to manage HSI through each phase of an acquisition. This management structure will also be based on DoD Military Service HSI Programs, but like the rest of the model, this structure will be specifically tailored to meet Coast Guard needs in the acquisition process. Upon completion of Phase II, we will have determined and documented both the Coast Guard HSI requirements and the individual domain processes. At that time, we will have additional justification to recommend a specific organizational structure for managing the HSI Program.

5.2.3 Phase III -- HSI Support. Phase III support will include documenting and tailoring analytical tools (which can range from simple checklists to automated models), analyst's guides, technical manuals, handbooks, and procedural guides (sometimes called "road maps" or "cook books"). Phase III will also include updating existing Coast Guard instructions to promulgate HSI policy and procedures, as well as developing a decision support system to track HSI actions in each acquisition and to maintain a lessons learned data base for use in future procurements.

In addition, Phase III should include one or more tests of the new HSI Program to evaluate how effective the Program is and whether changes are necessary. This would involve applying HSI procedures to one or more on-going acquisitions to satisfy HSI domain requirements for that acquisition in whatever acquisition phase that particular procurement is in at that time.

SECTION B HUMAN FACTORS ENGINEERING PROGRAM

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SECTION B

HUMAN FACTORS ENGINEERING PROGRAM

1. SCOPE

1.1 **Purpose.** This section defines the Coast Guard's requirements for applying Human Factors Engineering to the development and acquisition of Coast Guard systems (vessels, aircraft, and equipment). Section B is based primarily upon MIL-H-46855B, *Human Engineering Requirements for Military Systems, Equipment and Facilities*, and has been adapted for use within the Coast Guard's materiel acquisition system. These requirements include work that may be accomplished by either in-house Government personnel, a contractor, or a subcontractor in conducting Human Engineering efforts integrated with the total system engineering and development process. These requirements should be the basis for including Human Engineering during proposal preparation, systems analysis, task analysis, system design (including computer software design), equipment design, testing, documentation, and reporting.

1.2 **Applicability.** It is not intended that all the requirements contained herein should be applied to every program or program phase. To achieve cost effective acquisition and life-cycle ownership of Coast Guard materiel, this requirements document should be tailored to specific phases and the germane Key Decision Points (KDP) of the program within the overall life-cycle. This tailoring should include the selected application of methods, tables, sections, individual paragraphs or sentences, or a combination thereof, to be placed on contracts in order to impose only the minimum essential needs to preclude unnecessary and unreasonable program costs. Guidance on tailoring this document for contract use, as well as partial and incremental application of these requirements in the various phases of the Coast Guard acquisition process, are contained in the appendix at the end of this section.

2. APPLICABLE DOCUMENTS

2.1 The following documents form a part of these requirements to the extent specified herein:

- a. MIL-H-46855B - *Human Engineering Requirements for Military Systems, Equipment and Facilities*
- b. MIL-Q-9858A - *Quality Program Requirements*
- c. MIL-STD-280 - *Definition of Item Levels, Item Interchangeability, Models and Related Terms*
- d. MIL-STD-1472D - *Human Engineering Design Criteria for Military Systems, Equipment and Facilities*
- e. DoD-HDBK-763 - *Human Engineering Procedures Guide*

- f. American Society for Testing and Materials (ASTM) F1166-88 - *Standard Practice for Human Engineering Design for Marine Systems, Equipment and Facilities*.

3. HUMAN FACTORS ENGINEERING PROGRAM

3.1 Program Implementation. Human Factors Engineering should be an integral part of planning and conceptual efforts, developmental projects, and acquisition programs to include modifications. Management responsibility for Human Factors Engineering should transfer along with the system in inter-command transition agreements.

- a. A Human Factors Engineering Program should be established for each system acquisition. The capabilities and limitations of the operator, maintainer, trainer, and other support personnel should be identified early enough to impact the design.
- b. Human Factors Engineering design requirements should be established to develop effective man-machine interfaces and preclude system characteristics that:
 - (1) Require extensive cognitive, physical, or sensory skills;
 - (2) Require complex manpower- or training-intensive tasks; or
 - (3) Result in frequent or critical errors.
- c. This Coast Guard Human Factors Engineering Requirements Document should be tailored to adapt to specific program characteristics.
- d. MIL-STD-1472D, *Human Engineering Design Criteria for Military Systems, Equipment, and Facilities*, should be used as the basis for effective and appropriate Human Factors Engineering design. MIL-STD-1472D should also be a part of the selection criteria for determining the suitability of non-developmental items (NDIs).
- e. ASTM F116-88, *Standard Practice for Human Engineering Design for Marine Systems, Equipment, and Facilities*, should be used as applicable to achieve mission success through integration of the human into the acquisition and design of vessel systems, subsystems, and equipment with the goals of effectiveness, simplicity, efficiency, reliability, and safety for operation, training, and maintenance.

3.2 Human Systems Integration (HSI) in Systems Engineering. Concerns in each HSI domain, Human Factors Engineering, System Safety/Health Hazards, Manpower, Personnel, and

Training, should be translated into man-machine interface design issues to be addressed during systems engineering. This should include efforts to:

- a. Review human-system interface characteristics that require extensive cognitive, physical, or sensory skills; require complex manpower- and training-intensive tasks, or adversely affect human performance.
 - (1) Identify those elements that will be targeted for human factors Engineering changes.
 - (2) Identify how such human-system interface characteristics and factors can be avoided or corrected through system design and Human Factors Engineering efforts.
- b. Review System Safety/Health Hazard issues and lessons learned. Identify factors that result in frequent or critical human performance errors.

3.3 Human Factors Engineering Program Documentation. Human Factors Engineering, input should be required for the following program documentation:

- a. Mission Need Statement (MNS)
- b. Preliminary Sponsor Requirements Document/Sponsor Requirement Document (PSRD/SRD)
- c. Test and Evaluation master Plan (TEMP)
- d. Risk Assessment Report

3.3.1 Mission Need Statement. The MNS should specify any expected or existing Human Factors Engineering constraints.

3.3.2 Preliminary Sponsor Requirements Document/Sponsor Requirements Document. The PSRD/SRD should:

- a. Translate Human Factors Engineering concerns into man-machine interface design issues to be addressed during systems engineering
- b. Review human-system interface characteristics that require complex manpower and training intensive tasks or adversely affect human performance, identifying those elements that will be targeted for HFE changes
- c. Identify how such human-system interface characteristics and factors can be circumvented through system design and HFE efforts

3.3.3 Test and Evaluation Master Plan. The TEMP should:

- a. Address critical human issues to provide data to validate the results of Human Factors Engineering analyses
- b. Require identification of mission critical operation and maintenance tasks.

3.3.3.1 Test and Evaluation. Test and evaluation activities should include efforts to:

- a. Assess the integration of Human Factors Engineering into the design of hardware, software, and procedures
- b. Include performance of operational tasks by typical users
- c. Provide human performance and error rate data
- d. Verify that Human Factors Engineering design requirements have been satisfied

3.3.4 Risk Assessment Report. Based on an assessment of predecessor or comparable systems and new technologies, the Risk Assessment Report should identify high risk areas in HSI that are targeted for mitigation to:

- a. Improve system performance
- b. Reduce MPT requirements and ownership costs
- c. Reduce or eliminate critical human performance errors

4. REQUIREMENTS

4.1 Human Factors Engineering General Requirements.

4.1.1 Scope and Nature of Work. Human Engineering should be applied during development and acquisition of Coast Guard systems (vessels, aircraft, and equipment) to achieve effective integration of Coast Guard personnel into system design. A Human Engineering effort should be provided to develop or improve the personnel-equipment/software interface, to achieve required effectiveness of human performance during system operation/maintenance/control, and to make economical demands upon personnel resources, skills, training, and costs. The Human Engineering effort should include, but is not limited to, active participation in three interrelated areas of system development: analysis, design and development, and test and evaluation.

- a. **Analysis. Beginning with a mission analysis developed from a baseline scenario, the functions that should be performed by the system in achieving its mission**

objectives should be identified and described. These functions should be analyzed to determine the best allocation of functions to personnel, equipment, software, or combinations thereof. Allocated functions should be further dissected to define specific tasks that should be performed to accomplish the functions. Each task should be analyzed to determine human performance parameters, system/equipment/software capabilities, and the mission/environmental conditions under which tasks should be conducted. Where possible, task parameters should be quantified and in a form permitting effectiveness studies of crew-equipment/software interfaces in relation to total system operation. Identification of Human Engineering high risk areas should be initiated as part of the analysis.

- b. **Design and Development.** Design and development of the system equipment, software, procedures, and work environments associated with system functions requiring personnel interaction requires a Human Engineering effort. Human Engineering should convert the mission, system, and task analyses data into detailed design or development plans. This effort should create a personnel-system interface operable within human performance capabilities, meet system functional requirements, and accomplish Coast Guard mission objectives. The final developed design should be the culmination of the initial planning, system analyses, criteria and requirements application, and engineering effort.
- c. **Test and Evaluation.** Test and evaluation should be conducted to verify that equipment design, software, and system environment meet Human Engineering and life support criteria and are compatible with overall system requirements.

4.1.2 **Human Engineering Program Planning.** In accordance with the proposed requirements of this document and the equipment specifications, Human Engineering program planning should include the tasks to be performed, Human Engineering KDPs, level of effort, methods to be used, design concepts to be utilized, and the test and evaluation program in terms of an integrated effort within the total project.

4.1.3 **Nonduplication.** The efforts performed to fulfill the Human Engineering requirements specified by this document should be coordinated with, but not duplicate, efforts performed in accordance with other contractual requirements. Necessary extensions or transformations of the results of other efforts for use in the Human Engineering program should not be considered duplication.

4.2 **Detail Requirements.** The contractor should be tasked with the following specific functions.

4.2.1 **Analysis.** Mission analysis should be developed from a baseline scenario. Analysis should include application of Human Engineering techniques as follows:

- a. **Defining and Allocating System Functions.** The functions to be performed by the system in achieving its objective(s) within specified mission environments should

be analyzed. Human Engineering principles and criteria should be applied to specify personnel-equipment/software performance requirements for system operation, maintenance and control functions, and to allocate system functions to:

- (1) Automatic operation/maintenance,
- (2) Manual operation/maintenance, or
- (3) Some combination thereof.

Functional allocation is an iterative process ultimately achieving the level of detail appropriate for the level of system definition. From projected operator/maintainer performance data, estimated cost data, and known constraints, the contractor should conduct analyses and trade-off studies to determine which system functions should be machine-implemented or software-controlled and which should be reserved for the human operator/maintainer.

- b. Information Flow and Processing Analysis. Analyses should be performed to determine basic information flow and processing required to accomplish the system objective and include decisions and operations without reference to any specific machine implementation or level of human involvement.
- c. Estimates of Potential Operator/Maintainer Processing Capabilities. Plausible human roles (e.g., operator, maintainer, programmer, decision maker, communicator, monitor) required in the system should be identified. Estimates of processing capability in terms of mental workload, accuracy, rate, and reaction time should be prepared for each potential operator/maintainer information processing function. These estimates should be used initially in determining allocation of functions and should be later refined at appropriate times for use in definition of operator/maintainer information requirements and control, display, and communication requirements. In addition, estimates should be made of the effects on these capabilities likely to result from implementation or nonimplementation of Human Engineering design recommendations. Results from studies in accordance with the tests paragraphs below may be used as supportive inputs for these estimates.
- d. Equipment Selection. Human Engineering principles and criteria should be applied along with all other design requirements to identify and select the particular equipment to be operated/maintained/controlled by personnel. The selected design configuration should reflect Human Engineering inputs, expressed in quantified or "best estimate" quantified terms, to satisfy the functional and technical design requirements and to insure that the equipment should meet the applicable criteria contained in MIL-STD-1472D, as well as other Human Engineering criteria specified by the contract.

e. Analysis of Tasks. Human Engineering principles and criteria should be applied to analyses of tasks.

(1) Gross Analysis of Tasks. This analysis should provide one of the bases for making design decisions, e.g., determining to the extent practicable before hardware fabrication, whether system performance requirements can be met by combinations of anticipated equipment, software, and personnel, and assuring that human performance requirements do not exceed human capabilities. These analyses should also be used as basic information for developing preliminary manning levels; equipment procedures; skill, training, and communication requirements; and for Logistic Support Analysis (LSA) and other documentation inputs, as applicable. Gross tasks that are related to end items of equipment to be operated or maintained by personnel and which require critical human performance, reflect possible unsafe practices, or are subject to promising improvements in operating efficiency should be further analyzed.

(2) Analysis of Critical Tasks. Further analysis of critical tasks is designed to identify the following:

- (a) Information required by operator/maintainer, including cues for task initiation
- (b) Information available to operator/maintainer
- (c) Evaluation process
- (d) Decision reached after evaluation
- (e) Action taken
- (f) Body movements required by action taken
- (g) Work space envelope required by action taken
- (h) Work space available
- (i) Location and condition of the work environment
- (j) Frequency and tolerances of action
- (k) Time base

- (l) Feedback informing operator/maintainer of the adequacy of actions taken
- (m) Tools and equipment required
- (n) Number of personnel required, their specialty, and experience
- (o) Job aids or references required
- (p) Communications required, including type of communication
- (q) Special hazards involved
- (r) Operator interaction where more than one team member is involved
- (s) Operational limits of personnel (performance)
- (t) Operational limits of machine and software

The analysis should be performed for all affected missions and phases including degraded modes of operation.

- (3) Workload Analysis. Individual and crew workload analysis should be performed and compared with performance criteria.
- (4) Concurrence and Availability. Analyses of tasks should be updated as required to remain current with the design effort and should be available to those responsible for the HSI Program.

4.2.2 Preliminary System and Subsystem Design. Human Engineering principles and criteria should be applied to system and subsystem designs represented by design criteria documents, performance specifications, drawings and data (such as functional flow diagrams), system and subsystem schematic block diagrams, interface control drawings, overall layout drawings, and related applicable drawings provided in compliance with contract data requirements. The preliminary system and subsystem configuration and arrangement should satisfy personnel-equipment/software performance requirements and comply with applicable criteria specified in MIL-STD-1472D, as well as other Human Engineering criteria specified by the contract.

4.2.3 Human Engineering in Equipment Detail Design. During detail design of equipment, the Human Engineering inputs, made in complying with the analysis requirements of the test paragraph herein, as well as other appropriate Human Engineering inputs, should be converted into detail equipment design features. Design of the equipment should meet the applicable criteria of MIL-STD-1472D and any other Human Engineering criteria specified by the contract.

Human Engineering provisions in the equipment should be evaluated for adequacy during design reviews. Personnel assigned Human Engineering responsibilities by the contractor should participate in design reviews and engineering change proposal reviews of equipment and items involving personnel interfaces. Human Engineering requirements during equipment detail design are specified in paragraphs 4.2.4 through 4.2.8 herein.

4.2.4 Studies, Experiments, and Laboratory Tests. The contractor should conduct experiments, tests (including dynamic simulation), and studies required to resolve Human Engineering and life support problems specific to the system. Human Engineering and life support problem areas should be brought to the attention of the office responsible for the HSI Program and include the estimated effect on the system if the problem is not studied and resolved. These experiments, tests, and studies should be accomplished in a timely manner, i.e., such that the results may be incorporated in equipment design. The performance of any major study effort should require approval by the office responsible for the HSI Program.

- a. **Mockups and Models.** At the earliest practical point in the development program and well before fabrication of system prototypes, full-scale three-dimensional mockups of equipment involving critical human performance should be constructed. The proposed Human Engineering Program Plan should specify the construction of mockups, where warranted, and should require the office responsible for the HSI Program to approve any proposed modification. The workmanship should be no more elaborate than is essential to determine the adequacy of size, shape, arrangement, and panel content of the equipment for human use. The most inexpensive materials practical should be used for fabrication. These mockups and models provide a basis for resolving access, work space, and related Human Engineering problems, and incorporating these solutions into systems design. Upon approval by those responsible for the HSI Program, scale models may be substituted for mockups. In those design areas where systems/equipment are necessary, functional mockups should be provided, subject to prior approval by the office responsible for the HSI Program. The mockups should be available for inspection as determined by the office responsible for the HSI Program. Disposition of mockups and models, after they have served the purposes of the contract, should be as determined by the office responsible for the HSI Program.
- b. **Dynamic Simulation.** Dynamic simulation techniques should be utilized as a Human Engineering design tool when necessary for the detail design of equipment requiring critical human performance. Consideration should be given to use of various models for the human operator, as well as man-in-the-loop simulation. While the simulation equipment is intended for use as a design tool, its potential relationship to, or use as, training equipment should be considered in any plan for dynamic simulation.

4.2.5 Equipment Detail Design Drawings. Human Engineering principles and criteria applied to the design of systems and equipment should be reflected by the detail design drawings for these systems and equipment to assure that the final product can be efficiently, reliably, and safely operated and maintained. The following drawings are included: panel layout drawings, communication system drawings, overall layout drawings, control drawings, and other drawings depicting equipment important to system operation and maintenance by human operators. The system design should comply with applicable criteria of MIL-STD-1472D and other Human Engineering criteria specified by the contract.

4.2.6 Work Environment and Crew Station Design. Human Engineering principles and criteria should be applied to detail design work environments and crew stations to be used by system personnel. Drawings, specifications, and other documentation of work environment and crew stations should reflect incorporation of Human Engineering requirements and compliance with applicable criteria of MIL-STD-1472D and other Human Engineering criteria specified by the contract. Design of work environments and crew stations that affect human performance, under normal, unusual, and emergency conditions, should consider at least the following where applicable:

- a. Atmospheric conditions, such as composition, volume, pressure, and control for decompression, temperature, humidity, and air flow
- b. Weather and climate aspects, such as hail, snow, mud, arctic, desert, and tropic conditions
- c. Range of accelerative forces, positive and negative, including linear, angular, and radial
- d. Acoustic noise (steady state and impulse), vibration, and impact forces
- e. Provision for minimizing disorientation
- f. Adequate space for personnel, their movement, and their equipment
- g. Adequate physical, visual, and auditory links between personnel and their equipment, including eye position in relation to display surfaces, control, and external visual areas
- h. Safe and efficient walkways, stairways, platforms, and inclines
- i. Provisions for minimizing psychophysiological stresses
- j. Provisions to minimize physical or emotional fatigue, or fatigue due to work-rest cycles

- k. Effects of clothing and personal equipment, such as full and partial pressure suits, fuel handler suits, body armor, polar clothing, and temperature-regulated clothing
- l. Equipment handling provisions, including remote handling provisions and tools when materiel and environment require them
- m. Protection from chemical, biological, toxicological, radiological, electrical, and electromagnetic hazards
- n. Optimum illumination commensurate with anticipated visual tasks
- o. Sustenance and storage requirements (i.e., oxygen, water, and food) and provision for refuse management
- p. Crew safety protective restraints (shoulder, lap, and leg restraint systems, inertia reels, and similar items) in relation to mission phase and control and display utilization

4.2.7 Human Engineering in Performance and Design Specifications. The provisions of performance and design specifications, prepared by the contractor, should conform to applicable Human Engineering criteria of MIL-STD-1472D and other Human Engineering criteria specified by the contract.

4.2.8 Equipment Procedure Development. Based upon the human performance functions and tasks identified by Human Engineering analyses (4.2.1 herein), the contractor should apply Human Engineering principles and criteria to the development of procedures for operating, maintaining, or otherwise using the system equipment. For computer systems where operating and maintenance procedures are largely determined by software programs, Human Engineering should be applied throughout the software program planning and development. This effort should be accomplished to assure that the human functions and tasks identified through Human Engineering analysis are organized and sequenced for efficiency, safety, and reliability; to provide inputs to the Logistic Support Analysis and other plans where required; and to assure that the results of this effort are reflected in the development of operational, training, and technical publications.

4.2.9 Human Engineering in Test and Evaluation. The contractor should establish and conduct a test and evaluation program to:

- a. Assure fulfillment of the applicable requirements herein
- b. Demonstrate conformance of system, equipment, and facility design to Human Engineering design criteria

- c. Confirm compliance with performance requirements where personnel are a performance determinant
- d. Secure quantitative measures of system performance that are a function of the human interaction with equipment
- e. Determine whether undesirable design or procedural features have been introduced

The fact that these functions may occur at various stages in system, subsystem, or equipment development does not preclude final Human Engineering verification of the complete system. Both operator and maintenance tasks should be performed during the final system test as described in approved test plans.

4.2.9.1 Test Planning. Human Engineering testing should be incorporated into the system test and evaluation program and should be integrated into engineering design and development tests, contractor demonstrations, flight tests, R&D acceptance tests, and other development tests. Compliance with Human Engineering requirements should be tested as early as possible. Human Engineering findings from design reviews, mockup inspections, demonstrations, and other early engineering tests should be used in planning and conducting later tests. Human Engineering test planning should be directed toward verifying that the system can be operated, maintained, supported, and controlled by user personnel in its intended operational environment. Test planning should include methods of testing (e.g., use of checklists, data sheets, test participant descriptors, questionnaires, operating procedures, and test procedures), schedules, quantitative measures, test criteria, and reporting processes.

4.2.9.2 Implementation. The Human Engineering Test and Evaluation Plan should be implemented upon approval by the office responsible for the HSI Program. Test documentation (e.g., checklists, data sheets, test participant descriptors, questionnaires, operating procedures, and test procedures) should be available at the test site. Human Engineering portions of all tests should include the following:

- a. A simulation (or actual conduct where possible) of mission or work cycle.
- b. Tests in which human participation is critical as defined in paragraph 6.2.1.
- c. A representative sample of non-critical scheduled and unscheduled maintenance tasks that do not duplicate the tasks selected for the maintainability demonstration.
- d. Proposed job aids, new equipment training (NET) programs, training equipment, and special support equipment.
- e. Utilization of personnel who are representative of the range of Coast Guard personnel intended to man the system in terms of skills, size, and strength. Test

personnel should wear suitable Coast Guard garments and equipment that are appropriate to the tasks and approved by the office responsible for the HSI Program. Use of Coast Guard personnel from the intended user population is preferred where feasible.

- f. Collection of task performance data in simulated or, where possible, actual operational environments.
- g. Identification of discrepancies between required and actual task performance.
- h. Criteria for acceptable performance of the test.

4.2.9.3 Failure Analysis. All failures occurring during test and evaluation should be subject to a Human Engineering review to differentiate between failures due to equipment alone, personnel-equipment incompatibilities, and those due to human error alone. The contractor should notify the office responsible for the HSI Program of design conditions that may contribute substantially to human error and should propose appropriate solutions to these conditions.

4.2.10 Cognizance and Coordination. The Human Engineering program should be coordinated with maintainability, System Safety/Health Hazards, reliability, survivability/vulnerability, integrated logistic support, and other Human Factors Engineering functions including biomedical, life support, personnel and training, and should be integrated into the total system program. Results of Human Engineering test and evaluation should be incorporated into the Logistic Support Analysis Record (LSAR), and other documentation as applicable. The Human Engineering portion of any analysis, design, or test and evaluation program should be conducted under the direct cognizance of personnel assigned Human Engineering responsibility by the contractor.

4.2.11 Data Requirements. All Human Engineering data requirements should be specified in the contract.

- a. **Traceability.** The contractor should appropriately document Human Engineering efforts to provide traceability from the initial identification of Human Engineering requirements during analysis and/or system engineering through design and development to the verification of these requirements during test and evaluation of approved design, software, and procedures.
- b. **Access.** All data (such as plans, analyses, design review results, drawings, checklists, design and test notes, and other supporting background documents reflecting Human Engineering actions and decision rationale) should be maintained and made available by the contractor to the office responsible for the HSI Program for meetings, reviews, audits, demonstrations, test and evaluation, and related functions.

4.2.12 Drawing Approval. Personnel assigned Human Engineering responsibility by the contractor should approve all layouts and drawings having potential impact on the human interface with the system or equipment.

5. QUALITY ASSURANCE

Compliance with the requirements of this specification and other Human Engineering requirements specified by the contract should ultimately be demonstrated by the systems's ability to meet its mission and operational objectives. During the development program, compliance with the Human Engineering requirements, as they pertain to system design and effectiveness, should be demonstrated at the scheduled design and configuration reviews and inspections as well as during development test and evaluation inspections, demonstrations, and tests.

5.1 Quality Assurance. The in-house activity or contractor should maintain a quality assurance program to substantiate conformance to all the requirements of this specification and the requirements as specified by the contract. The quality program should be documented and should be subject to review by Government representatives. The program should assure adequate quality when applying Human Factors Engineering requirements to the development and acquisition of new Coast Guard systems.

5.2 Test and Evaluation. Test and evaluation should be conducted on the newly designed equipment, software, facilities, and environment to verify that they meet Human Engineering and life support criteria and are compatible with the overall system requirements. This should include periodic on-site checks of the platform, systems, equipment, software, or facilities during construction to ensure that changes that would degrade earlier Human Engineering efforts are not made during construction.

6. USING THIS HUMAN FACTORS ENGINEERING REQUIREMENTS DOCUMENT

6.1 Intended Use. These requirements may be invoked in their entirety or selectively as prescribed by the office responsible for the HSI Program. or its designate. The primary use of this document for procurement does not preclude its utilization for in-house efforts, where desired. Compliance with this document should provide the office responsible for the HSI Program with assurance of positive management control of the Human Engineering effort required in the development and acquisition of Coast Guard systems, equipment, and support. Specifically, use of this Human Factors Engineering Requirements Document is intended to assure that:

- a. System requirements are achieved by appropriate use of the human component.
- b. Through proper design of equipment, software, and environment, the personnel-equipment/software combination meets system performance goals.
- c. Design features should not constitute a hazard to personnel.

- d. Trade-off points between automated vs. manual operation have been chosen for peak system efficiency within appropriate cost limits.
- e. Human Engineering applications are technically adequate.
- f. The equipment is designed to facilitate required maintenance.
- g. Procedures for operating and maintaining equipment are efficient, reliable, and safe.
- h. Potential error-inducing equipment design features are minimized.
- i. The layout of the facility and the arrangement of equipment afford efficient communication and use.
- j. The contractors provide the necessary manpower and technical capability to accomplish the above objectives.

6.2 Explanation of Terms. For purposes of this specification, the following definitions are applicable.

6.2.1 Critical. That human performance which, if not accomplished in accordance with system requirements, should most likely have adverse effects on one or more of the following elements: cost, system reliability, efficiency, effectiveness, or safety. Critical performance is usually part of a "single" line of flow in the operation or maintenance cycle of the system. An example of a "single" line of flow involving human performance is the transmission of a message that must be passed for operations or maintenance cycles to commence or to continue, such as an order to prepare a missile for launching. If this order is not passed, or if it is garbled, the entire missile operation cycle may cease to function as required. Human performance should also be considered critical whenever equipment design characteristics demand performance that exceeds human capabilities or approaches limitations. For example, human performance functions and tasks are too demanding, information presented to personnel is inadequate to meet human performance requirements, appropriate information displayed is not perceived, or controls provided cannot be efficiently operated. Critical Human performance contributes to the occurrence of one or more, but not limited to the following conditions:

- a. Jeopardized performance of an authorized mission.
- b. Degradation of the circular error probability (CEP) to an unacceptable level.
- c. Delay of a mission beyond acceptable time limits, e.g., human time to react should not meet required system reaction time.

- d. Improper operation resulting in a system "no-go," inadvertent weapons firing, or failure to achieve operational readiness alert.
- e. Measured Mean Time to Repair (MTTR) significantly exceeds maintainability estimates.
- f. Degradation of system equipment below reliability requirements, i.e., Mean Time Between Failures (MTBF) is reduced.
- g. The damaging of system equipment, resulting either in a return to a maintenance facility for major repair, or in unacceptable costs, spare requirements, or system downtime.
- h. The false removal rate exceeds predicted values and compromises mission success due to repair parts availability.
- i. A serious compromise of system security.
- j. Injury or illness to personnel.

6.2.2 Overall Layout Drawings. System design drawings include, but are not limited to:

- a. The configuration and arrangement of major items of equipment for manned stations, such as a pilot's or shipboard command station
- b. The configuration and arrangement of items of equipment, such as modular rack or maintenance ground equipment, which may not be a part of a manned station for operation, but require human access for maintenance
- c. The arrangement of interior lighting for operating or maintaining the equipment
- d. Labels identifying general panel content (e.g., flight mission panel, communications panel, or malfunction status panel)

6.2.3 Panel Layout Drawings. Equipment detail drawings include, but are not limited to the following:

- a. A scale layout of the controls and displays on each panel or an item of equipment, such as a pilot's or shipboard command console
- b. A description of all symbols used
- c. Identification of the color coding used for displays and controls

- d. The labeling used on each control or display
- e. The identification of control type (e.g., alternate action or momentary) and a clear differentiation between controls and indicators

6.2.4 System Engineering. A basic tool for systematically defining the equipment, personnel, and procedural data required to meet system objectives. It is an iterative process, requiring updating and having feedback loops to insure that each component developed contributes to the system meeting mission objectives. A system engineering analysis may include, but is not necessarily limited to, the following:

- a. Preparation of operationally realistic mission profiles and mission scenarios
- b. Preparation of functional flow block diagrams for the system
- c. Functional analysis of each flow block
- d. Preparation of system and subsystem schematic block diagrams
- e. Study of detailed functions, environment and technical design requirements to allocate assignment of tasks to personnel, equipment, software, or some combination thereof
- f. Preparation of timeline analyses (operation/maintenance/control) to determine system reaction time
- g. Preparation and analysis of operational and maintenance workload data to determine equipment quantities, personnel loads, and system downtime for scheduled and unscheduled maintenance
- h. Training implications

6.2.5 Task Analysis. A systematic method used to develop a time-oriented description of personnel-equipment/software interactions brought about by an operator, controller, or maintainer in accomplishing a unit of work with a system or item of equipment. It shows the sequential and simultaneous manual and intellectual activities of personnel operating, maintaining, or controlling equipment in addition to a sequential operation of the equipment. It is a part of system engineering analysis where system engineering is required. The following taxonomy is used to inventory or analyze tasks, with level a. and b. (shown below) stated by the office responsible for the HSI Program and the remaining levels dependent on the current phase of system development and purpose (e.g., gross analysis of critical tasks) for which the analysis is being conducted. The taxonomy is arranged in levels:

- a. **Mission**. The specific capability the system is designed to accomplish or support, e.g., search and rescue.
- b. **Scenario/Conditions**. Categories of factors or constraints under which the system should be expected to operate and should be maintained, e.g., search a given sector under prevailing weather conditions.
- c. **Function**. A broad category of activity performed by a system, e.g., transportation.
- d. **Job**. The combination of all human performance required for operation and maintenance of one personnel position in a system, e.g., driver.
- e. **Duty**. A set of operationally-related tasks within a given job, e.g., driving, operator maintenance, communicating, target detection, self protection.
- f. **Task**. A composite of related activities (perceptions, decisions, and responses) performed for an immediate purpose, written in operator/maintainer language, e.g., change a tire.
- g. **Subtask**. Activities (perceptions, decisions, and responses) that fulfill a portion of the immediate purpose within a task, e.g., remove lug nuts
- h. **Task Element**. The smallest logically and reasonably definable unit of behavior required in completing a task or subtask, e.g., apply counterclockwise torque to the lug nuts with a lug wrench.

6.2.6 **Human Factors Engineering**. The area of human factors engineering that applies scientific knowledge to the design of items to achieve effective user-system integration.

6.2.7 **Human Factors**. A body of scientific facts about human characteristics. The term covers all biomedical and psychosocial considerations; it includes, but is not limited to, principles and applications in the areas of Human Engineering, personnel selection, training, life support, job performance aids, and human performance evaluation.

6.2.8 **Human Performance**. A measure of Human Functions and actions in a specified environment.

6.2.9 **Life Support**. The area of human factors Engineering that applies scientific knowledge to items that require special attention or provisions for health promotion, biomedical aspects of safety, protection, sustenance, escape, survival, and recovery of personnel.

6.2.10 **System**. A composite of equipment, skills, and techniques capable of performing and/or supporting an operational role. A complete system includes all equipment, material, software,

services, and personnel required for its operation and support to the degree that it can be considered self-sufficient for its intended operating environment.

**APPENDIX
APPLICATION TAILORING GUIDE FOR
COAST GUARD HUMAN FACTORS ENGINEERING REQUIREMENTS**

1. SCOPE

This appendix provides guidance and criteria for selection by the office responsible for the HSI Program of this requirements document for contract use and, when invoked, the partial and incremental application of these requirements depending on the specific application.

2. APPLICABLE DOCUMENTS

The following document forms a part of this requirements document to the extent specified herein:

MIL-STD-280 - Definition of Item Levels, Item Interchangeability, Models and Related Terms

3. APPLICATION TAILORING GUIDE (see Exhibit 1)

3.1 General. Selection of this requirements document for application to contracts for vessels, aircraft, and equipment is dependent upon the nature of the materiel in terms of operational and mission maintenance/support functions, the degree to which human interface is involved with materiel, including software, and the acquisition phase involved. Selection of this Coast Guard Human Factors Engineering Requirements Document is generally independent of system complexity, equipment duty cycles and, within practical limits, contract type, cost and duration, and size of production lots.

3.2 Selection for Use. Prior to applying the application guide, described by paragraph 4, a decision must be made whether or not to use the provisions of this requirements document as mandatory contract provisions or prescribe this document as a guide. Only after a carefully considered decision is made to invoke use of these requirements should the application matrix be applied. Selection for use by the office responsible for the HSI Program should consider the following provisions, as shown in Exhibit 1.

3.2.1 Nature of the Materiel. Selection or non-selection of this requirements document for a specific contract is dependent upon the nature of the end-item, materiel, or system in terms of its ability to perform operational and mission maintenance/support functions. Generally, these requirements:

- a. Should not be considered for use in contracts for parts, subassemblies, or units as defined in MIL-STD-280.

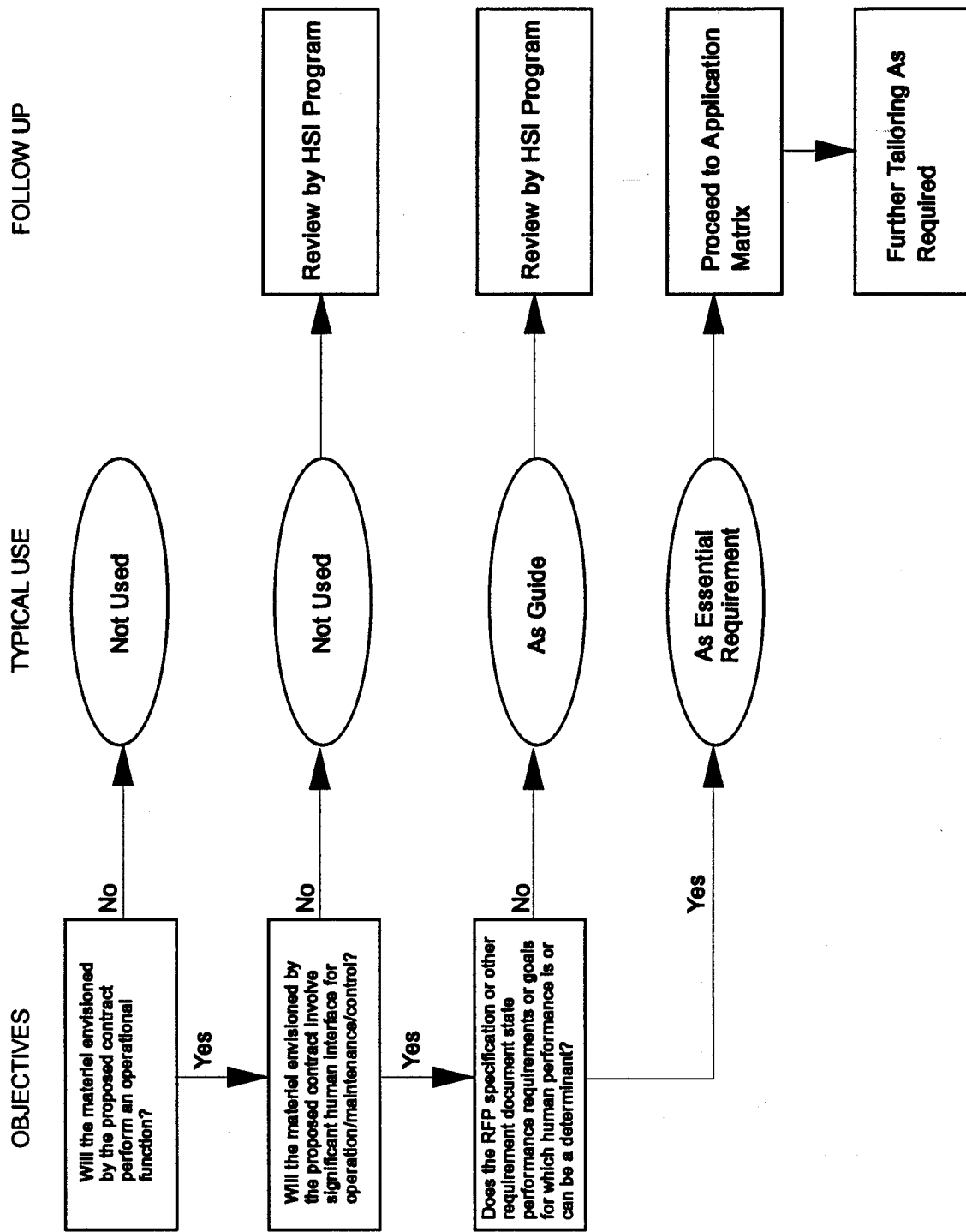


Exhibit 1. Application Tailoring Guide for Coast Guard Human Factors Requirements

- b. Should be considered for use in contracts for sets, subsystems, and systems, as defined in MIL-STD-280

The rationale for this initial screening is that parts, subassemblies, assemblies, and units typically are not produced to perform an operational function, but can be used as elements of different sets, subsystems, etc., which produce different desired operational functions. The contractor furnishing such items (e.g., transformers, wheel bearings, amplifiers) has no control over the myriad uses to which his products should be applied or knowledge of the human performance requirements implicit in such uses. Accordingly, it should not be considered reasonable to invoke this requirements document for parts, subassemblies, assemblies, or units.

3.2.2 Extent of Human Interface Involved. Selection or non-selection of the Human Factors Engineering requirements should be sensitive to the extent of human involvement or interface for operation, maintenance, control, transport, and/or shelter. The requirements should not be considered for use in contracts where human involvement or interface is not anticipated or is obviously insignificant.

3.2.3 Nature of Stated Performance Requirements. If, for a specific RFP or similar procurement action, this requirements document has survived the tests of 4.2.1 and 4.2.3, its selection or non-selection should be based on stated performance requirements. If the RFP, specification, or other requirements document states performance requirements or goals, such as time and error, for which human performance can reasonably be considered as a determinant or contributor, this requirements document should be employed. On the other hand, if such performance requirements to which human performance contributes are not stipulated, the specification should be considered for use as a guide.

3.2.4 Selection Review. At this point, the decision to use this document as a requirement guide, or not at all, has been tentatively determined. If the Human Engineering specialists designated by the office responsible for the HSI Program have not already been involved in this decision making process, they must be consulted at this point to insure that the requirements document is not erroneously invoked or waived. If results of this review disclose that this document should not be used or should be employed only as a general guide, the process is complete; however, if results of this review conclude that these requirements should be invoked, the tailoring process of paragraph 4 should be pursued.

4. APPLICATION MATRIX (Exhibit 2)

4.1 Description and Use

4.1.1 The field of the application matrix utilizes coded symbols to describe use of the general requirements and detailed requirements during the acquisition phase indicated by the location of the symbol. These symbols are defined as follows:

Requirements Paragraph	Significant Program Factors	Project Initiation/ Requirements Definition				Concepts Exploration				Demonstration/ Validation				Full Scale Development				Production				Deployment					
		KDP 1	KDP 2	KDP 3	KDP 4	KDP 1	KDP 2	KDP 3	KDP 4	KDP 1	KDP 2	KDP 3	KDP 4	KDP 1	KDP 2	KDP 3	KDP 4	KDP 1	KDP 2	KDP 3	KDP 4	KDP 1	KDP 2	KDP 3	KDP 4		
HUMAN FACTORS ENGINEERING REQUIREMENTS																											
1. Scope																											
1.1 Purpose						E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E
1.2 Applicability						E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E
2. Applicable Documents						E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E
4.1 General Requirements																											
4.1.1 Scope & Nature of Work																											
4.1.1.a Analysis										E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E
4.1.1.b Design & Develop										M	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E
4.1.1.c Test & Evaluation										-	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E

LEGEND
 Modification where noted by "M"
 Required where noted by "E"
 Optional where noted by "-"

To the extent specified in Section B

VALIDATION 4.1.1.a. Delete first three sentences.
 Change 6th line to: Each task which must be performed to accomplish allocated functions should be analyzed to determine the human involvement.
FULL SCALE DEV. Same change as for VALIDATION
CONCEPTUAL 4.1.1.b. Revise title to read "Preliminary design and development." In first line, insert "Preliminary" at the beginning of the first sentence. In 4th line, change "detail" to "preliminary"

SEE SECTION 4.2.6

SEE SECTION 4.2.6

Exhibit 2. Application Matrix

Requirements Paragraph	Significant Program Factors	Project Initiation/ Requirements Definition					Concepts Exploration			Validation Demonstration/		Full Scale Development	Production	Deployment	LEGEND Modification where noted by "M" Required where noted by "E" Optional where noted by "."
		KDP 1	KDP 2	KDP 3	KDP 4										
4.1.2 HFE Program Planning		M	M	M	E	M	M	E						CONCEPTUAL 4.1.2 Delete "equipment specification" and substitute "mission need". VALIDATION 4.1.2 Delete "equipment specification," and substitute "overall program objectives."	
4.1.3 Nonduplication						E	E	E							
4.2 Detail Requirements						E	E	E							
4.2.1 Analysis						E	E	E							
4.2.1.a Defining & Allocating						E	E	E							
4.2.1.b Info Flow						E	E	E							
4.2.1.c Estimates of... Allocation...						M	E	E						CONCEPTUAL 4.2.1.c line 10. Delete "design".	
4.2.1.d Equipment Selection						M	E	E						CONCEPTUAL 4.2.1.d line 2. Change "all other design" to "concept." Line 4, change "configuration" to "concept."	
4.2.1.e Analysis of Tasks						E	E	E							
4.2.1.e (1) Gross Analysis						M	E	E						CONCEPTUAL 4.2.1.e (1) line 6. Change "all other design" to "concept." Line 4, change "configuration" to "concept."	
4.2.1.e (2) Analysis of Critical Tasks						-	E	E							
4.2.1.e (3) Workload Analysis						E	E	E							
SEE SECTION 4.2.6													SEE SECTION 4.2.6		

Exhibit 2. Application Matrix (Continued)

Significant Program Factors	Requirements Definition/Project Initiation/	KDP 1	Concepts Exploration	KDP 2	Demonstration/Validation	KDP 3	Full Scale Development	KDP 4	Production	Deployment	LEGEND Modification where noted by "M" Required where noted by "E" Optional where noted by "-"
									SEE SECTION 4.2.6		
4.2.1.e(4) Concurrence and...			M	M	M	E	E				CONCEPTUAL 4.2.1.e(4) line 2, change "design" to "conceptual." VALIDATION 4.2.1.e(4) line 2, change "design" to "validation." VALIDATION 4.2.2 Line 2. Change "designs" to "concept demonstration" and delete that portion of lines 2-5 which read "represented...with contract data requirements." Line 7, add "can" before "comply." VALIDATION 4.2.2 Line 7. Change "comply" to "facilitate compliance." Delete line 10 after "1472D." CONCEPTUAL 4.2.3 Revise line to read "Human Engineering in Conceptual design." Delete lines 1-9 through "personnel interfaces." Line 10, revise "equipment detail" to "conceptual."
4.2.2 Preliminary System			M	M	M	E	E				
4.2.3 HFE in Equipment Detail			M	E	E	E	E				
4.2.4 Studies, Experiments			E	E	E	E	E				
4.2.4.a Mockups & Models			-	E	E	E	E				
4.2.4.b Dynamic Simulation			-	E	E	E	E				
4.2.5 Equipment Detail Design			-	E	E	E	E				
4.2.6 Work Environment...			M	E	E	E	E				CONCEPTUAL 4.2.6. Delete lines 2-4 and words "by the contract." Design of in line 6.
4.2.7 HFE In... Specs			-	E	E	E	E				

Exhibit 2. Application Matrix (Continued)

Significant Program Factors	Requirements Paragraph	Project Initiation/ Requirements Definition					Concepts Exploration				Validation Demonstration/			Full Scale Development		Production		Deployment	
		KDP 1	KDP 2	KDP 3	KDP 4		KDP 1	KDP 2	KDP 3	KDP 4									
4.2.8	Equipment Procedures Development		-																
4.2.9	HFE in T&E		-																
4.2.9.1	Test Planning		-																
4.2.9.2	Implementation		-																
4.2.9.3	Failure Analysis		-																
4.2.10	Cognizance & Coordination		E																
4.2.11	Data Requirements		E																
4.2.11.a	Traceability		M																
4.2.11.b	Access		E																
4.2.12	Drawing Approval		E																
5.	Quality Assurance		E																

LEGEND
 Modification where noted by "M"
 Required where noted by "E"
 Optional where noted by "."

VALIDATION 4.2.9, lines 3-6. Change (e) to "demonstrate that human performance technical risks have been identified and that solutions are identified."

VALIDATION 4.2.9.1, change line 2 to "validation and demonstration test planning."

CONCEPTUAL 4.2.11.a lines 3-4. Delete "design and development" to the end of the sentence and insert "concept submission."

VALIDATION 4.2.11.a line 3. Insert "preliminary" after "through"; lines 4-6, delete "the verification" through end of sentence and substitute "validation and demonstration."

SEE SECTION 4.2.6

SEE SECTION 4.2.6

Exhibit 2. Application Matrix (Continued)

Significant Program Factors Requirements Paragraph	Project Initiation/ Requirements Definition	KDP 1	Concepts Exploration	Demonstration/ Validation	KDP 2	KDP 3	KDP 4	Full Scale Development	Production	Deployment	LEGEND Modification where noted by "M" Required where noted by "E" Optional where noted by "."
									SEE SECTION 4.2.6	SEE SECTION 4.2.6	
6. Using this Document											
6.1 Intended Use		E	E	E	E	E	E	E			
6.2 Explanation of Terms		E	E	E	E	E	E	E			
6.2.1 Critical		E	E	E	E	E	E	E			
6.2.2 Overall Layout Drawings		E	E	E	E	E	E	E			
6.2.3 Panel Layout Drawing		E	E	E	E	E	E	E			
6.2.4 System Engineering		E	E	E	E	E	E	E			
6.2.5 Task Analysis		E	E	E	E	E	E	E			

Exhibit 2. Application Matrix (Continued)

- a. E Provision in effect.
- b. — Provision used at contractor's option.
- c. M Modification of provision.

4.1.2 **Left Column**. The numbers shown in the left column represent paragraph numbers of the requirements document.

4.1.3 **Top**. The top of the matrix provides a description for grouping of requirements. The acquisition phase designators establish a basis for determining applicability to each phase of the acquisition process.

4.1.4 **Right Column**. The right column shows the modifications of provisions applicable to the acquisition phase for which "M" is shown in the field.

4.2 **Contractual Applicability**.

4.2.1 **Requirements Affected**. The citation of the application matrix constitutes a required change in application of this requirements document.

4.2.2 **Further Tailoring**. The office responsible for the HSI Program may alter the matrix field by identifying the specific symbol change in the RFP or contract.

4.2.3 **Contractor Use**. Unless otherwise specified by the office responsible for the HSI Program, contractors utilize the appropriate tailored versions of the requirements document, as indicated by the matrix, as a baseline in the preparation of RFP responses and Human Engineering program planning. This does not preclude the contractors from proposing further tailoring.

4.2.4 **Evolutionary Development**. For evolutionary development of older or existing systems, equipment, and software, this requirements document should generally apply only to new design and procedures involving human interfaces and old designs, procedures, and interfaces that may be impacted thereby. Old systems undergoing improvement through evolutionary means should generally not have the requirements applied to components retained and unaffected by such evolutionary development techniques. It is important to understand that there may be exceptions to this general rule; therefore, evaluation by the Human Factors Engineering staff in each case is advisable.

4.2.5 **Product Improvement**. Recognizing that product improvement actions may occur during more than one acquisition phase and that product improvements can involve conceptual, validation, or full-scale engineering tasks or a combination of these, the office responsible for the HSI Program or its designate should tailor applicable portions of the matrix to the specific performance objectives of the product improvement program.

4.2.6 Production and Deployment Phase. Design changes affecting human performance during the production and deployment phase can, like product improvement actions, involve conceptual, validation, or full-scale engineering development Human Engineering tasks; therefore, the office responsible for the HSI Program should tailor applicable portions of the matrix to the specific performance objectives of the design changes. Particular attention should be directed toward failure analysis, quality assurance, drawing review, and software considerations.

4.3 Human Factors Engineering Review. The office responsible for the HSI Program should assume or designate responsibility for assuring that the matrix to be applied to specific contracts has been subject to a Human Engineering review to insure consistency of the tailored requirements with human performance requirements based on the nature of the contracts.

SECTION C
SYSTEM SAFETY/HEALTH HAZARD PROGRAM

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LIST OF EXHIBITS

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SECTION C

SYSTEM SAFETY/HEALTH HAZARD PROGRAM

1. SCOPE

1.1 **Scope.** This document establishes and defines the Coast Guard's requirements for addressing System Safety/Health Hazard issues in the development and acquisition of Coast Guard systems (vessels, aircraft, and equipment). This section is based upon MIL-STD-882B *System Safety Program Requirements*, and has been adapted for use within the Coast Guard's materiel acquisition system. These requirements apply to Coast Guard systems including test, maintenance and support, and training equipment.

1.2 **Applicability.** It is not intended that all the requirements contained herein should be applied to every program or program phase. To achieve cost effective acquisition and life-cycle ownership of Coast Guard materiel, this requirements document should be tailored to specific programs and the germane Key Decision Points of the program within the overall system life-cycle. This document provides uniform requirements for developing and implementing a System Safety Program of sufficient comprehensiveness to identify the hazards of a system and to impose design requirements and management controls to prevent mishaps by eliminating hazards or reducing the associated risk to a level acceptable by the the office responsible for the HSI Program. The system safety tasks described herein should be selectively applied to Coast Guard contract-definitized procurements, requests for proposal (RFPs), statements of work (SOWs), and Coast Guard in-house developments requiring System Safety programs for the development, production, and initial deployment of Coast Guard systems and equipment.

2. APPLICABLE DOCUMENTS

2.1 The following documents form a part of these requirements to the extent specified herein:

- a. MIL-STD-882B - *System Safety Program Requirements*
- b. MIL-Q-9858A - *Quality Program Requirements*

3. SYSTEM SAFETY/HEALTH HAZARDS PROGRAM

This section establishes the following items of recommended Coast Guard policy:

3.1 **System Safety/Health Hazards Considerations in Coast Guard System Acquisition.** Scientific and engineering principles should be applied during design and development to identify and reduce hazards associated with system operation and support with the objective of designing the safest possible systems consistent with mission requirements and cost-effectiveness.

- a. Appropriate System Safety and Health Hazard objectives should be established early in the program and used to guide System Safety and Health Hazard activities with respect to the decision process.
- b. With regard to hazardous materials, emphasis should be on reduced use of hazardous materials in processes and products rather than simply managing the hazardous waste created.
- c. Proposed systems should be analyzed for their potential environmental impacts in accordance with Title 40, Code of Federal Regulations, Parts 1500-1508, *National Environmental Policy Act Regulations* and Executive Order 12114, *Environmental Effects Abroad of Major Federal Actions*.
- d. System safety engineering programs should be designed to work in harmony with other comprehensive Coast Guard programs (e.g, human factors engineering, manpower, personnel, training/system programs).
- e. Each management decision to accept the risks associated with an identified hazard should be formally documented using MIL-STD-882 as a guide to establish criteria for defining and categorizing "high" and "serious" risks.
- f. The Coast Guard Vice Commandant (or designate) should be the final approval authority for acceptance of high-risk hazards.
- g. Serious risks should be approved for acceptance at the Project Manager or equivalent level.

3.2 System Safety/Health Hazard Program Implementation. A System Safety/Health Hazard Program should be established through the tailored application of MIL-STD-882B, *System Safety Program Requirements*, aimed at identifying, evaluating, and eliminating or controlling system hazards.

- a. System Safety/Health Hazard programs should be applied to in-house research, development, production, modification, and test programs. For non-developmental items, a thorough safety assessment for the intended use should be performed and documented prior to purchase.
- b. The *total system*, including hardware, software, testing, manufacture, and support, should be evaluated for safety.
- c. The design of the system should reduce the probability and severity of all hazards to a level specified by those responsible for the HSI Program.

- d. Evaluation should include both known and potential hazards over the *entire life-cycle* of the system.
- e. System Safety/Health Hazard lessons learned from predecessor and similar systems should be addressed during the Project Initiation and Requirements Definition Phases.
- f. Actual and potentially significant hazards and associated risks should be identified prior to Key Decision Point (KDP)-1.
- g. Hazards should be eliminated or controlled prior to KDP-3.
 - (1) The predominate means of controlling risk should be hazard elimination.
 - (2) Where hazards cannot be eliminated, they should be effectively controlled.
 - (3) Warning devices and procedures should not be relied on as the sole means of controlling catastrophic and critical hazards.

3.3 Test and Evaluation. The TEMP should address System Safety/Health Hazard issues to provide data to validate the results of safety/hazard analyses. When normal testing cannot demonstrate safe system operation, special safety tests and evaluations should be prepared and monitored.

3.4 Hazardous Materials. The environmental, safety, and occupational health impacts associated with the use of hazardous materials should be carefully evaluated during system acquisition, including impacts associated with system manufacture, operation, maintenance, and disposal.

- a. Hazardous material use should be managed over the *entire life-cycle* so that the Coast Guard incurs the lowest cost required to protect human health and the environment.
- b. The preferred method of doing this should be to avoid or reduce the use of hazardous materials.
- c. Where the use of hazardous materials cannot be reasonably avoided, procedures for identifying, tracking, storing, handling, and disposing of such materials should be developed and implemented in accordance with DoDD 4210.15, *Hazardous Material Pollution*, and DoDD 5050.5, *Hazard Communication Program*.
- d. Life-cycle cost estimates should include the cost of acquiring, handling, using, and disposing of any hazardous materials.

3.5 Environmental Protection. Coast Guard systems should be designed, developed, tested, fielded, and disposed of in compliance with applicable environmental protection laws and regulations, treaties, and agreements.

3.6 Risk Assessment. As part of risk assessment planning, the Acquisition Plan should assess System Safety/Health Hazards and environmental risks that can not be corrected or mitigated through system design changes or new technology. The Acquisition Plan should also identify what residual hazards and impacts should be accepted by formal decision.

4. REQUIREMENTS

4.1 System Safety Requirements.

4.1.1 System Safety Program. The contractor should establish and maintain a system safety program to support efficient and effective achievement of overall objectives.

4.1.2 System Safety Program Objectives. The System Safety Program should define a systematic approach to insure that:

- a. Safety, consistent with mission requirements, is designed into the system in a timely, cost effective manner.
- b. Hazards associated with each system are identified, evaluated, and eliminated, or the associated risk is reduced to a level acceptable to the managing activity throughout the entire life-cycle of the system.
- c. Historical safety data, including lessons learned from other systems, are considered and used.
- d. Minimum risk is sought in accepting and using new designs, materials, production, and test techniques.
- e. Actions taken to eliminate hazards or reduce risk to a level acceptable to the managing activity are documented.
- f. Retrofit actions required to improve safety are minimized through the timely inclusion of safety features during research and development and acquisition of the system.
- g. Changes in design, configuration, or missing requirements are accomplished in a manner that maintains a risk level acceptable to the managing activity.
- h. Consideration is given to safety, ease of disposal, and demilitarization of any hazardous materials associated with the system.

- i. Significant safety data are documented as lessons learned and are submitted to data banks or as proposed changes to applicable design handbooks and specifications.

4.1.3 System Safety Design Requirements. Specific System Safety design requirements for a system should be specified after review of pertinent standards, specifications, regulations, design handbooks, and other sources of design guidance for applicability to the design of the system under consideration. General System Safety design requirements are:

- a. Eliminate identified hazards or reduce associated risk through design.
- b. Isolate hazardous substances, components, and operations from other activities, areas, personnel, and incompatible materials.
- c. Locate equipment such that access during operations, servicing, maintenance, repair, or adjustment minimizes personnel exposure to hazards.
- d. Minimize risk resulting from excessive environmental conditions.
- e. Design to minimize risk created by human error in the operation and support of the system.
- f. Consider alternate approaches to minimize risk from hazards that cannot be eliminated.
- g. Protect the power sources, controls, and critical components of redundant subsystems by physical separation or shielding.
- h. When alternative design approaches cannot eliminate the hazard, provide warning and caution notes in assembly, operations, maintenance, and repair instructions, and distinctive markings on hazardous components, materials, equipment, and facilities.
- i. Minimize the severity of personnel injury or damage to equipment in the event of a mishap.
- j. Design software-controlled or software-monitored functions to minimize initiation of hazardous events or mishaps.
- k. Review design criteria for inadequate or overly restrictive requirements regarding safety.

4.1.4 **System Safety Precedence.** The order of precedence for satisfying System Safety requirements and resolving identified hazards is:

- a. **Design to Eliminate Risk.** Design to eliminate or obviate the hazard from the beginning.
- b. **Design for Minimum Risk.** If an identified hazard cannot be eliminated, reduce the associated risk to an acceptable level through design selection.
- c. **Incorporate Safety Devices.** If a hazard cannot be eliminated or the associated risk reduced to an acceptable level through design, use fixed, automatic, or other protective safety design features or devices to reduce risks to an acceptable level.
- d. **Provide Warning Devices.** When neither design nor safety devices can effectively eliminate identified hazards or adequately reduce associated risk, use devices to detect the condition and to produce an adequate warning signal to alert personnel of the hazard. Design warning signals and their application to minimize the probability of incorrect response to the signal and standardize within like types of systems.
- e. **Develop Procedures and Training.** Where it is impractical to eliminate hazards through design selection or to adequately reduce the associated risk with safety and warning devices, use special safety procedures and training. However, without a specific waiver, no warning, caution, or other form of written advisory should be used as the only risk reduction method for Category I or II hazards. Procedures may include the use of personal protective equipment. Precautionary notations should be standardized. Tasks and activities judged critical by the managing activity may require certification of personnel proficiency.

4.1.5 **Risk Assessment.** Decisions regarding priority and resolution of identified hazards are based on an assessment of the risk associated with the hazard. Hazards are characterized in terms of severity and probability. Hazard severity categories are defined to provide a qualitative measure of the most severe mishaps resulting from personnel error; environmental conditions; design inadequacies; procedural deficiencies; or system, subsystem, component failure, or malfunction as follows:

<u>Description</u>	<u>Category</u>	<u>Definition</u>
Catastrophic	I	Death or system loss
Critical	II	Severe injury, severe occupational illness, or major system damage
Marginal	III	Minor injury, minor occupational illness, or minor system damage
Negligible	IV	Less than minor injury, occupational illness, or system damage

The probability that a hazard should be created during the planned life expectancy of the system can be described in terms of potential occurrences per unit time, events, population, items, or activity. A hazard risk index (HRI) can be obtained from matrixing severity and probability ratings. These qualitative hazard probability ratings are presented as follows:

<u>Description</u>	<u>Individual Item</u>	<u>Fleet or Inventory</u>
Frequent	Likely to Occur Frequently	Continuously Experienced
Probable	Will Occur Several Times in Life of an Item	Will Occur Frequently
Occasional	Likely to Occur Sometime in Life of an Item	Will Occur Several Times
Remote	Unlikely But Possible to Occur in Life of an Item	Unlikely But Can Reasonably Expected to Occur
Improbable	So Unlikely It Can Be Assumed Occurrence May Not Be Experienced	Unlikely to Occur, But Possible

4.1.6 Action On Identified Hazards. Action should be taken to eliminate identified hazards or reduce the associated risk. Catastrophic and Critical hazards should be eliminated or their associated risk reduced to a level acceptable to the managing activity. Marginal hazards should be "guard(ed) against."

4.1.7 System Safety Program Tasks. The bulk of MIL-STD-882B is a collection of system safety "tasks" that may be imposed on contractors or Government activities in order to require and define the conduct of a System Safety Engineering Program. Task descriptions, contained in Section 5 of MIL-STD-882B, should be tailored by the office responsible for the HSI Program. as required by governing regulations and as appropriate to particular systems or equipment program type, magnitude, and funding. The System Safety Engineering (SSE) tasks

are divided into two types: (1) Program Management and Control, and (2) Design and Evaluation.

- a. **Program Management and Control**. The following tasks constitute the MIL-STD-882B SSE Program Management and Control tasks:

<u>Task</u>	<u>Title</u>
100	System Safety Program
101	System Safety Program Plan
102	Integration/Management of Associate Contractors, Subcontractors, and Architect and Engineering Firms
103	System Safety Program Reviews
104	System Safety Group/System Safety Working Group Support
105	Hazard Tracking and Risk Resolution
106	Test and Evaluation Safety
107	System Safety Progress Summary
108	Qualifications of Key Contractor System Safety Engineers/Managers

Task 100 is imposed in order to require a SSE program. Paragraph 4.1 of MIL-STD-882B calls for the establishment and maintenance of an SSE program.

Task 101 defines the System Safety Program Plan (SSPP) that should serve as the basic tool used by those responsible for the Coast Guard HSI Program to assist in managing an effective SSE program. The SSPP identifies all safety program activities specified by the managing activity and shows how the safety program should provide input or preclude duplication of effort.

Task 102 provides the authority for management surveillance needed by the integrating or facilities acquisition contractor by assigning the various System Safety roles of associate contractors, subcontractors, integrators, and construction firms.

Special System Safety reviews may be needed to fulfill requirements of munitions safety boards, first flight readiness reviews, or other safety certification authorities. **Task 103** specifies these reviews in the SOW.

Contractor support of a System Safety Group/System Safety Working Group Support (SSG/SSWG) is detailed in the contract through imposition of **Task 104**.

Task 105 defines requirements for documenting actions taken to eliminate hazards or reduce associated risk.

Task 106 provides needed contractor management activities to ensure that all test safety requirements are met prior to and during testing.

Task 107 requires a periodic written report on the status of SSE and management activities.

Task 108 lists special qualifications for key Systems Safety engineers and managers that may be imposed on the contractor organization as required.

- b. **Design and Evaluation.** The following tasks constitute the MIL-STD-882B SSE Design and Evaluation tasks:

<u>Task</u>	<u>Title</u>
201	Preliminary Hazard List
202	Preliminary Hazard Analysis
203	Subsystem Hazard Analysis
204	System Hazard Analysis
205	Operating and Support Hazard Analysis
206	Occupational Health Hazard Analysis
207	Safety Verification
208	Training
209	Safety Assessment
210	Safety Compliance Assessment
211	Safety Review of Engineering Change Proposals (ECPs) and Waivers
212	--- Reserved ---
213	GFE/GFP System Safety Analysis

Task 201 requires a Preliminary Hazard List (PHL), a listing of hazards that may require special safety design emphasis or hazardous areas where in-depth analyses need to be done.

Task 202 requires a Preliminary Hazard Analysis (PHA), the initial effort in hazard analysis during the system design phase of the programming and requirements development phase for facilities acquisition.

Task 203 requires a Subsystem Hazard Analysis (SSHA), which looks at each subsystem or component and identifies hazards associated with operating or failure modes. It is especially intended to determine how operation or failure of components affects the overall safety of the system.

Task 204 requires a System Hazard Analysis (SHA), which examines how system operation and failure modes can affect the safety of the system and its subsystems. The SHA examines all subsystem interfaces.

Task 205 requires an Operating and Support Hazard Analysis (O&SHA), which identifies and evaluates the hazards associated with the environment, personnel, procedures, and equipment involved throughout the operation of a system/element.

Task 206 requires an Occupational Health Hazard Assessment (OHHA), which:

- (1) Identifies and determines quantities of potentially hazardous materials or physical agents involved with the system and its logistical support
- (2) Analyzes how those materials or physical agents are used in the system and for its logical support
- (3) Estimates where and how personnel exposures may occur and the degree or frequency of exposure involved
- (4) Incorporates cost effective controls into the design of the system and its logical support to reduce exposures to acceptable levels

Task 207 outlines how verification of safety requirements should be performed.

Task 208 imposes required certification training for personnel involved in development, test, and operation of the system.

Task 209 imposes the requirement to develop a Safety Assessment Report (SAR).

Task 210 imposes the requirement to perform a Safety Compliance Assessment (SCA) to verify the safe design of the system and obtain a comprehensive evaluation of the safety risk being assumed prior to test or operation of the system. The SCA is typically reported as part of the SAR.

Task 211 imposes the requirement to assess ECPs and requests for deviations/waivers for any possible safety impacts to the system.

Task 212 is not currently assigned but is reserved for future use.

Task 213 is imposed to permit the contractor to integrate Government Furnished Equipment/Government Furnished Property (GFE/GFP) items into the system design with full knowledge of the associated hazards and risk controls by requiring acquisition of existing analysis documentation.

4.1.8 System Safety Program Requirements in the Life Cycle Systems Management Model (LCSMM).

- a. Mission Need Determination. The SSE effort should support the justification of the materiel need by identifying safety deficiencies in existing or projected capability and by identifying opportunities for system safety to improve mission capability or reduce life-cycle costs.
- b. Concepts Exploration. Evaluate the alternative system concepts under consideration for development and establish the system safety program, consistent with the identified mission need and life-cycle requirements. Specific tasks should include:
 - (1) Preparation of a System Safety Program Plan
 - (2) Perform a Preliminary Hazard Analysis to identify hazards associated with each alternative
 - (3) Review safe and successful design of predecessor or similar systems for consideration in alternative concepts
 - (4) Define the SSE requirements based on past experience with similar systems
 - (5) Evaluate all considered materials, design features, maintenance, servicing, operational concepts, and environments that should affect safety throughout the life-cycle
 - (6) Highlight special areas of safety considerations, such as system limitations, risks, and man-rating requirements
 - (7) Identify safety requirements that may require a waiver during the system life-cycle
 - (8) Identify safety design analysis, test, demonstration, and validation requirements

- (9) Document the System Safety analyses, results, and recommendations for each promising alternative system concept
 - (10) Prepare a summary report of the results of the SSE tasks conducted during the phase to support the decision making process
 - (11) Tailor the SSE program for subsequent phases and include detailed requirements in the appropriate contractual documents
- c. Concept Demonstration and Validation. SSE tasks during this phase should be tailored for programs ranging from extensive study and analyses through hardware development to prototype testing, demonstration, and validation. Specific tasks should include:
- (1) Complete preparation or update the SSPP.
 - (2) Establish SSE requirements for system design and criteria for verifying that these requirements have been met.
 - (3) Participate in trade-off studies to reflect the impact on system safety requirements and risk.
 - (4) Recommend system design changes based on these studies to ensure optimum safety consistent with performance and system requirements.
 - (5) Complete preparation or update the PHA to evaluate the configuration to be tested.
 - (6) Prepare a System Hazard Analysis (SHA) report of the test configuration considering the planned test environment and methods.
 - (7) Perform detailed hazard analyses (SHA or SSHA) of the design to assess the risk involved in test operation of the system hardware and software.
 - (8) Recommend redesign or other corrective action based on evaluation of the results of safety tests, failure analyses, and mishap investigations.
 - (9) Perform Operating and Support Hazard Analyses of each test, and review all test plans and procedures. Make sure hazards identified by analyses and tests are eliminated or the associated risk minimized.
 - (10) Identify critical parts and assemblies, production techniques, assembly procedures, facilities, testing, and inspection requirements that may affect safety and ensure:

- (a) Adequate safety provisions are included in the planning and layout of the production line.
 - (b) Adequate safety provisions are included in inspections, tests, procedures, and checklists for quality control of the equipment being manufactured.
 - (c) Production and manufacturing control data contain required warnings, cautions, and special safety procedures.
 - (d) Testing and evaluation are performed on early production hardware to detect and correct safety deficiencies.
 - (e) Minimum risk is involved in accepting and using new design, materials, and production and test techniques.
- (11) Establish analysis, inspection, and test requirements for GFE or other contractor-furnished equipment to verify prior to use that applicable SSE requirements are satisfied.
 - (12) Review logistics support publications for adequate safety considerations, and ensure the inclusion of applicable Department of Transportation (DoT), Environmental Protection Agency (EPA), and Occupational Safety and Health Administration (OSHA) requirements.
 - (13) Ensure SSE requirements are incorporated into the system specification/design document.
 - (14) Prepare summary report of the results of SSE tasks conducted to support the decision making process.
 - (15) Continue to tailor the SSE program.

d. Full-Scale Development. System Safety/Engineering tasks should include:

- (1) Complete preparation or update of the SSPP.
- (2) Review preliminary engineering designs to ensure safety design requirements are incorporated and hazards identified are eliminated or reduced to an acceptable level.
- (3) Review appropriate engineering documentation to ensure safety considerations have been incorporated.

- (4) Identify, evaluate, and provide safety considerations for trade-off studies.
- (5) Perform or update the SSHA, SHA and O&SHA and safety studies concurrent with the design/test effort to identify design and/or operating and support hazards. Recommend any required design changes and control procedures.
- (6) Perform an O&SHA for each test, and review all test plans and procedures.
- (7) Participate in technical design and program reviews and presents of the SHA, SSHA, and/or O&SHA.
- (8) Recommend redesign or other corrective actions based on identification and evaluation of the effects of storage, shelf-life, failure analyses and mishap investigations.
- (9) Review logistic support publications for adequate safety considerations and ensure the inclusion of applicable DOT, EPA, and OSHA requirements.
- (10) Verify the adequacy of safety and warning devices, life support equipment, and personal protective equipment.
- (11) Identify the need for safety training and provide safety inputs to training courses.
- (12) Provide system safety surveillance and support of test unit production and of plan for production and employment. Identify critical parts and assemblies, production techniques, assembly procedures, facilities, testing, and inspection requirements which may affect safety and ensure:
 - (a) Adequate safety provisions are included in the planning and layout of the production line.
 - (b) Adequate safety provisions are included in inspections, tests, procedures, and checklists for quality control of the equipment being manufactured.
 - (c) Production and manufacturing control data contain required warnings, cautions, and special safety procedures.
 - (d) Testing and evaluation are performed on early production hardware to detect and correct safety deficiencies.

- (e) Minimum risk is involved in accepting and using new design, materials, and production and test techniques.
- (13) Ensure that procedures developed for system test, maintenance, operation, and servicing provide for safe disposal of expendable hazardous materiel.
- (14) Update SSE requirements in system specification/design documents.
- (15) Prepare a summary report of the results of the SSE tasks to support the decision making process.
- (16) Tailor SSE program requirements for the Production and Deployment Phase.

e. Production and Deployment.

- (1) Complete preparation or update the SSPP.
- (2) Identify critical parts and assemblies, production techniques, assembly procedures, facilities, testing, and inspection requirements that may affect safety and ensure:
 - (a) Adequate safety provisions are included in the planning and layout of the production line.
 - (b) Adequate safety provisions are included in inspections, tests, procedures, and checklists for quality control of the equipment being manufactured.
 - (c) Production and manufacturing control data contain required warnings, cautions, and special safety procedures.
 - (d) Testing and evaluation are performed on early production hardware to detect and correct safety deficiencies.
 - (e) Minimum risk is involved in accepting and using new design, materials, and production and test techniques.
- (3) Verify that test and evaluation are performed on early production hardware to detect and correct safety deficiencies.
- (4) Perform O&SHA for each test and review all test plans and procedures. Ensure that hazards identified by test and analysis are eliminated or associated risk reduced to an acceptable level.

- (5) Review technical data for warnings, cautions, and special procedures identified as required in the O&SHA for safe operation, maintenance, servicing, storage, packaging, handling, and transportation.
 - (6) Perform O&SHA of deployment operation, and review all deployment plans and procedures. Ensure that hazards identified by analysis are eliminated or associated risk reduced to an acceptable level.
 - (7) Review procedures and monitor results of periodic field inspections to ensure acceptable levels of safety are maintained. Identify major or critical characteristics of safety significant items that deteriorate with age, environmental conditions, or other factors.
 - (8) Perform or update hazard analyses to identify new hazards that may result from design changes. Ensure that safety implications of the changes are considered in all configuration control plans.
 - (9) Evaluate results of failure analyses and mishap investigations. Recommend corrective actions.
 - (10) Monitor the system throughout the life-cycle to determine the adequacy of the design and operating/maintenance/emergency procedures.
 - (11) Conduct a safety review of proposed new operating and maintenance procedures, or changes, to ensure the procedures, warnings, and cautions are adequate and inherent safety is not degraded.
 - (12) Document hazardous conditions and system deficiencies for development of follow-on requirements for modified or new systems.
 - (13) Update safety documentation to reflect safety lessons learned.
 - (14) Evaluate the adequacy of safety and warning devices, life support equipment, and personal protective equipment.
- f. SSE Tasks in Program Phases. Exhibit 1 provides an application matrix providing guidance on task selection to establish an acceptable and cost effective SSE program. This matrix can be used to initially identify those tasks that typically are included in an effective SSE program for a particular acquisition phase. The matrix is optional guidance only and not to be construed as covering all procurement situations.

<u>Task</u>	<u>Title</u>	<u>Phase</u>			
		<u>0</u>	<u>I</u>	<u>II</u>	<u>III</u>
100	System Safety Program	G	G	G	G
101	System Safety Program Plan		G	G	GG
102	Integration/Management of Associate Contractors, Subcontractors, and Architectural and Engineering (AE) Firms	S	S	S	S
103	System Safety Program Reviews	S	S	S	S
104	SSG/SSWG Support	G	G	G	G
105	Hazard Tracking & Risk Resolution	S	G	G	G
106	Test and Evaluation Safety	G	G	G	G
107	System Safety Progress Summary	G	G	G	G
108	Qualifications of Key SSE Personnel	S	S	S	S
201	Preliminary Hazard List	G	S	S	NA
202	Preliminary Hazard Analysis	G	G	G	GC
203	Subsystem Hazard Analysis	NA	G	G	GC
204	System Hazard Analysis	NA	G	G	GC
205	Operating and Support Hazard Analysis		S	G	GGC
206	Occupational Health Hazard Assessment	G	G	G	GC
207	Safety Verification	S	G	G	S
208	Training	NA	S	S	S
209	Safety Assessment		S	S	SS
210	Safety Compliance Assessment	S	S	S	S
211	Safety Review of ECPs and Waivers	NA	G	G	G
212	--- Reserved ---	--	--	--	--
213	GFE/GFP System Safety Analysis	S	G	G	G
301	Software Requirements Hazard Analysis	S	G	G	GC
302	Top-Level Design Hazard Analysis	S	G	G	GC
303	Detailed Design Hazard Analysis	S	G	G	GC
304	Code-Level Software Hazard Analysis	S	G	G	GC
305	Software Safety Testing	S	G	G	GC
306	Software User Interface Analysis	S	G	G	GC
307	Software Change Hazard Analysis	S	G	G	GC

S -- Selectively Applicable G -- Generally Applicable
NA -- Not Applicable GC -- Generally Applicable to Design Changes Only

Exhibit 1. System Safety/Health Hazards Application Matrix

5. QUALITY ASSURANCE

5.1 Quality Assurance. The Coast Guard's HSI Program designate, or contractor, should maintain a quality assurance program to substantiate conformance to all the requirements of this section and other requirements as specified by the contract. The quality program should be documented and subject to review by Government representatives. The program should assure application of System Safety/Health Hazard requirements in the development and acquisition of new Coast Guard systems.

5.2 Program Management and Control. The System Safety Quality Plan (SSQP) should describe the techniques and procedures to be utilized by those responsible for the HSI Program, its designate, or contractor, to ensure accomplishment of the System Safety/Health Hazards objectives. The SSQP requirements should include:

- a. Analysis, inspection, test, and audit procedures required to demonstrate that the safety requirements are adequately addressed.
- b. Procedures for ensuring that test information is transmitted to the office responsible for the HSI Program for review and analysis.
- c. Procedures for ensuring the safe conduct of all tests.

5.3 Design and Evaluation. The in-house activity or contractor should define and perform inspection and tests used to verify safety critical hardware, software, and to verify compliance with safety requirements.

5.4 Software System Safety. The office responsible for the HSI Program, its designate, or contractor should test the software to ensure that all hazards have been eliminated or controlled to an acceptable level of risk. The following should be included in the testing of the software and system: safety-related test descriptions, procedures, and cases; and the associated qualification criteria. The office responsible for the HSI Program or the contractor should verify that the software functions safely, both within its specified environment and under abnormal conditions.

**SECTION D
MANPOWER AND PERSONNEL PROGRAM**

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LIST OF EXHIBITS

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D-1	Manpower Estimate Report	D-4

SECTION D MANPOWER AND PERSONNEL PROGRAM

1. SCOPE

1.1 **Purpose.** This document provides manpower requirement considerations and mandatory procedures necessary to determine and document the quantity and quality of manpower (i.e., military billets and civilian positions) required to support new systems procured through the Coast Guard acquisition process. Additionally, this document defines the personnel management requirements necessary to ensure adequate quantity and quality of personnel with appropriate skills are available to support new materiel systems when delivered.

1.2 **Applicability.** These requirements are applicable to both internal and contractual development efforts for the purpose of determining manpower requirements and personnel constraints for all Coast Guard materiel system acquisitions.

2. APPLICABLE DOCUMENTS

2.1 The following documents form a part of these requirements to the extent specified herein:

- a. MIL-STD-1388-1A - Logistics Support Analysis
- b. MIL-STD-1388-2B - DoD Requirements for a Logistics Support Analysis Record
- c. MIL-Q-9858A - Quality Program Requirements

3. MANPOWER AND PERSONNEL PROGRAM

3.1 **Manpower and Personnel Considerations in the Coast Guard Acquisition Process.** Manpower and Personnel are major cost drivers in the acquisition of new materiel systems. Affordability considerations make early manpower requirements determinations essential in holding down the cost of ownership for new materiel systems. Early manpower estimates also permit additional time to resolve personnel issues and facilities planning.

3.1.1 **Overview of Manpower Determination Process.** To determine manpower requirements for system acquisitions, the following steps are required.

- a. **Manpower Requirements for Aircraft and Equipment/Systems/Subsystems (E/S/S).**
 - (1) Develop an Initial Estimate of Manpower (IEM) for decision making and planning purposes in the Project Initiation Phase.

- (2) Refine the IEM by selecting one or more Baseline Comparison Systems (BCS) and conducting both a system analysis and a comparative analysis to estimate manpower requirements for the new project.
 - (3) Develop manpower concepts for the new project. Manpower concepts include defining the system configuration and installation schedule, as well as determining optimal approaches to maintenance, operator, and other support functions for this project.
 - (4) Determine manpower requirements for each of the following categories of manpower. A manpower document is developed to record manpower requirements of the system by fiscal year.
 - (a) Develop organizational/non-training manpower requirements by fiscal year for each of the following:
 - 1 Maintenance manpower
 - 2 Operator manpower
 - 3 Other non-training manpower
 - (b) Develop training-associated manpower requirements.
 - (5) Develop program documentation input.
- b. Manpower Requirements for Vessels. This requirement differs from aircraft and E/S/S in that the process must account for manpower cross-utilization, habitability constraints, non-hardware based manpower (e.g., watch station requirements and organizational support), and the impact of multiple E/S/S configurations.
- (1) Develop an IEM for decision making and planning purposes in the Project Initiation Phase.
 - (2) Collect and analyze preliminary vessel data, including mission constraints and specific requirements of the new vessel, and major program milestones.
 - (3) Conduct a Manpower Engineering Study. This study includes developing a BCS model, conducting a Crew Size Feasibility Analysis, and producing a Preliminary Manpower Report (PMR). The PMR reflects a more accurate manpower estimate than the IEM and will provide input to program documentation until a more thorough workload analysis is completed.

- (4) Determine operational manpower requirements, using workload measurement techniques, for the following categories of manpower. A Preliminary Vessel Manpower Document (PVMD) should be developed to document these requirements for budget justification.
 - (a) Planned maintenance
 - (b) Corrective maintenance
 - (c) Facility maintenance
 - (d) Own Unit Support (OUS)
 - (e) Watch stations
- (5) Develop program documentation input based on the PVMD.

3.1.2 Initial Estimate of Manpower. IEM requirements should be made during the Project Initiation Phase based on a comparison of a single unit of the new materiel system relative to the manpower requirements of the predecessor system. This will be a gross estimate derived from program goals or engineering estimates, where changes in new system reliability, maintainability, and intensity of operation are used to modify the manpower requirements of the predecessor system to estimate the manpower requirements of the new system. Such estimates should be used as part of the program initiation decision process, as a means of directing concept evaluation or as a method for ranking initial system design alternatives. Several iterations of the IEM may be required. A Manpower Estimate Report (see Exhibit 1 for format) should be included along with the Mission Analysis Report as enclosures to the Major System Acquisition Project Nominating Memorandum. A Manpower Estimate Report should also be submitted to the Coast Guard Acquisition Executive with all initial approval requests for smaller acquisition projects.

3.1.3 Baseline Comparison System (BCS). In the Requirements Definition Phase (and in some cases, extending into the Concepts Evaluation Phase), the IEM should be updated using a BCS consisting of the predecessor system or a composite of several existing subsystems that best matches the new system requirements, concepts, functions, and performance standards. This update should use the Manpower Estimate Report format (Exhibit 1) and should be used as an input to the Mission Need Statement (MNS), Preliminary Sponsor Requirements Document (PSRD), and Acquisition Plan (AP).

MIL-STD-1388-1A tasks 201 (Use Study) and Task 203 (Comparative Analysis) should be used for BCS studies and documentation.

MANPOWER ESTIMATE REPORT (FORMAT)¹
(Program Title)

FYxx² FYxx+1 FYxx+2 FYxx+3 FYxx+4.....(Until Fielding Complete)

OPERATE:³

- Military
- Officers
- Enlisted
- Civilian
- Contractor

MAINTAIN:³

- Military
- Officers
- Enlisted
- Civilian
- Contractor

SUPPORT³

- Military
- Officers
- Enlisted
- Civilian
- Contractor

TRAIN³

- Military
- Officers
- Enlisted
- Civilian
- Contractor

TOTALS:

¹ Provide separate estimates by Active and Reserve Components.
² Begin with initial production and continue through full operational deployment. Estimates should be cumulative from fiscal year to fiscal year.
³ Provide estimates for required billets/positions (or man-years for contractors) for each fiscal year.

3.1.4 Workload Development. In the Concepts Exploration Phase, various iterations of the updated IEM should be required to evaluate each design alternative. The initial manpower concept can be formulated as the favored design begins to emerge (i.e., the number of units to be built, the location of each unit, and both the maintenance and training concepts). When the design approach is approved for the system at KDP-2, enough information should be available to start developing workload estimates on which to base final vessel manpower quantity and quality. This initial analysis should be complete in the Demonstration/Validation Phase using the Manpower Estimate Report format (Exhibit 1). This information should be used to update all required acquisition documentation. Manpower should continue to be updated as necessary for KDP-3 and KDP-4. Both design and operational testing of the manpower plan should occur in the Full-Scale Development and Production Phases.

Manpower and workload estimates should be documented as prescribed in MIL-STD-1388-2A and used as inputs to Logistic Support Analysis manpower, skill, and task analyses.

3.1.5 Manpower, Personnel, and Training (MPT) Advisory Board. The office responsible for the HSI Program should formally establish an MPT Advisory Board in writing at the beginning of each acquisition. The size of the Board should be based on the size and complexity of the acquisition. The MPT Advisory Board is composed of subject matter experts from the Coast Guard MPT establishment. The Board serves two primary functions. First, it provides the Project Management Office (PMO) with points of contact for obtaining data and technical advise in the system design process. Second, it provides the PMO with review and comment services on plans, strategies, and approaches to MPT issues.

The Advisory Board should include representatives from such organizations as Major Program Offices on the Headquarters Staff; the Coast Guard Research and Development Center; the Coast Guard Yard (for vessel acquisitions); the Coast Guard Aircraft Repair and Supply Center, (for aircraft acquisitions); Coast Guard Training Centers; and the Programs Division (G-CPA) for manpower issues. The Advisory Board should review all MPT documentation for completeness and acceptability. Note that the Board may, but does not have to, meet to carry out their duties.

3.1.6 Personnel Supportability. Systematic supportability analysis is necessary in the early stages of system acquisition to ensure that, if the Coast Guard commits significant budgetary resources to a proposed materiel system, the personnel resources required to operate, maintain, and support the system should be available when the system is fielded. This requires engaging in long-range force structure and support planning by projecting the total Coast Guard personnel supply and demand over time by occupation, special skills, and paygrade levels. Supportability analysis permits the Coast Guard to channel manpower (billet) resources in the optimal directions, restructure career fields as necessary, implement appropriate recruitment and retention policies, and thereby provide the Coast Guard with the best possible manpower and personnel resources. In addition, this process permits the Coast Guard to determine personnel supportability for each system acquisition.

4. REQUIREMENTS

4.1 Manpower and Personnel Requirements. Manpower estimates must document the total number of billets (military officers/enlisted, civilian, and contractors) that are needed to operate, maintain, support, and provide training for the system upon full operational deployment. The validity of the manpower estimate is dependent upon force structure, personnel management, and readiness requirements, as well as on the size of the system buy. Although considerations affecting the manpower estimate may vary, in general, they should adhere to the following principles.

- (a) **Manpower requirements should be determined for each fiscal year and should be based upon the number of units being procured, the delivery and installation schedules, the number of training sites and scheduled Ready-for-Training (RFT) date, the number of support units (e.g., bases, teams), and the expected repair facility start-up date and workload.**
 - (1) **Manpower totals should include allocations for operational use, reserves, and pre-positioned sets. These quantities and schedules must be consistent with the program schedule in the AP and the life-cycle cost estimate.**
 - (2) **Total system manpower estimates should be calculated for each system acquisition. The office responsible for the HSI Program should calculate or contract manpower estimates for the operators, maintainers, and other support directly associated with the new materiel system. The office responsible for the HSI Program should then coordinate the estimate with the Office of Personnel to include additional manpower associated with General Detail and other Coast Guard-wide manpower requirements resulting from the new system.**
- b. **The manpower requirements should be derived from a comprehensive assessment of the projected force structure and should include considerations such as the number and type of units to be equipped; the number of individual components of the total system to be provided at each organizational activity; the quantity and quality (skill level) of each occupational specialty or job series of personnel in each manpower category; and required manning levels per site.**
- c. **Operator requirements should be derived from an assessment of the total number of personnel needed to operate the system in normal and peak performance periods. Considerations should include crew size; command, control, and intelligence; shore or duty rotation; general purpose users; and peak performance requirements.**
- d. **Maintenance and support manpower requirements should be based on an assessment of the total number of personnel needed to maintain and support all**

elements of the total system. Maintenance and support manpower requirements should be consistent with the maintenance concept contained in the Integrated Logistics Support Plan (ILSP) and should consider annual operating requirements (wartime and peacetime), maintenance ratios, system reliability, direct and indirect maintenance times, and the use of interim contractor support.

- e. Training personnel requirements should be derived from an assessment of the total number of personnel needed to support the total training system. Training personnel requirements should be consistent with Coast Guard training plan(s) and training system schedules, and they should consider course and training pipeline throughput, instructor-to-student ratios, subject matter expertise for development of training devices/materials, training device/simulation operators and support personnel, surge capacity for mobilization, and use of contractor support.
- f. After baseline manpower requirements have been identified, the input and "steady state" levels required to ensure the availability of each military occupational specialty should be assessed. Personnel flow rate considerations include accession rate, retention rate, loss rate, training rate, and non-availability rate. The required quantity of each manpower category should be modified to reflect flow rate considerations.
- g. The manpower requirement is the basis for determining manpower programming. Programmed manning, expressed as end strengths for military personnel and Coast Guard civilians, involves the coordination, appropriation, and deployment of manpower resources in concert with Coast Guard-wide personnel management activities. Programmed manning levels should be consistent with the life-cycle cost estimate.

4.2 Manpower Requirements Format. The Manpower Estimate Report format is provided at Exhibit 1. This spreadsheet represents the official statement of manpower requirements for the total system, starting with initial production and continuing until all units of the system are deployed.

- a. Manpower requirements should be stated as billets/positions for military and civilian personnel, and as man-years of effort for contractors. All manpower requirements should be organized by manpower category (i.e., operate, maintain, support, and train). Total quantities should be provided by each category for each fiscal year commencing with initial production. Separate spreadsheets are required for Active and Reserve estimates.
- b. An addendum to this report should explicitly state whether or not end strength increases are required, or whether end strength savings can be realized as a result of fielding the system. Additionally, an increase in military and civilian personnel

end strengths required to attain full operational deployment of the system should be specifically addressed. Fielding options must be described in the event that end strength increases are not approved.

- c. A summary of the planning factors used to develop the estimates should be provided in the addendum to this report. The addendum should include the methodology used to develop the report; system deployment plans; force structure and readiness goals; and other information helpful in clarifying the report. Information need not be duplicated. Where up-to-date information has already been provided, cite the document/report name, date, page number, etc.

5. QUALITY ASSURANCE

5.1 Quality Assurance. The in-house activity or contractor should maintain a quality assurance program to substantiate conformance to all the requirements of this document specification and the requirements as specified by the contract. The quality program should be documented and should be subject to review by Government representatives. The program should assure adequate quality throughout all phases of determining manpower and personnel requirements for new systems procured through the Coast Guard acquisition process.

SECTION E TRAINING PROGRAM

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SECTION E TRAINING PROGRAM

1. SCOPE

1.1 **Purpose.** The purpose of this document is to describe the Training Program required to develop and execute training plans to successfully train operators, maintainers, and support personnel associated with new materiel system acquisitions. The document is primarily based upon DoDD 1322.18, *Military Training*, and has been adapted for use within the Coast Guard's materiel acquisition system.

1.2 **Applicability.** It is not intended that all the requirements contained herein shall be applied to every program or program phase. To achieve cost effective acquisition and life-cycle ownership of Coast Guard materiel, the office responsible for the HSI Program should tailor this requirements document to accommodate specific programs, phase of system development, and the germane Key Decision Points (KDP) of the program within the overall life-cycle.

2. APPLICABLE DOCUMENTS

2.1 The following documents have been used to define terms, specify requirements, and further expand training procedures.

- a. DoDD 1322.18 - *Military Training*
- b. DoDD 1430.13 - *Training Simulators and Devices*
- c. MIL-STD-1379D - *Military Training Programs*
- d. MIL-Q-9858A - *Quality Program Requirements*

3. TRAINING PROGRAM

3.1 **Training Development for Coast Guard Acquisitions.** The following training policy statement should be implemented in the Coast Guard acquisition process.

- a. Appropriate training should be planned for support of the operational system.
- b. Required training resources (trainers, facilities, equipment) should be programmed for support of the operational system.
 - (1) Existing training resources should be assessed to determine ability to support anticipated training needs.

- (2) Requirements for new or additional training resources based on operating tempos, as well as possible surge, should be highlighted.
- c. Tasks that require extensive training should be identified and targeted for trade-off analyses.
- d. Training materials and training devices should be integrated into the total system acquisition process.

3.1.1 Training Support Analysis. The training required by operators, maintainers, and support personnel to meet the training qualifications of any given acquisition is determined by analyzing the quantity and quality of manpower to support the system. Initial manpower estimates are made in the Project Initiation Phase, permitting the Training Support Analysis to begin immediately thereafter and to develop initial training estimates required as input to the Mission Need Statement. The manpower and training estimates are both determined by iterative processes that must continue to refine the estimates throughout the acquisition process.

3.1.2 Training Approaches. Various training approaches are determined and evaluated for the new system in an effort to define the optimum approach to meet the training requirement in the most cost effective manner. Training approaches include statements of training objectives, interservice training, team training, skill progression training, factory training, and industrial personnel training. On-the-job training and technology-assisted formal or informal training may also be used. Training location, collocation, integration, training support materials, and training paths are additional training data that must be developed for each training approach. Training approaches are developed to accomplish the identified training objectives.

- a. Training objectives are broad statements about why the training is to be conducted. The objectives are based on the new system operator and maintainer tasks and should be the basis for developing overall training strategy.

Training objectives should not be confused with learning objectives. The latter are related to course content and to skills and knowledge. The former are related to the need for a particular course of instruction. A training objective might be stated "Provide planned and corrective maintenance for a specific piece of equipment," while a learning objective might be stated "Isolate and replace a faulty logic card."

- b. Training approaches are how the training should be conducted through the use of the following training methods.
 - (1) Interservice training is training currently being conducted by the DoD Military Services. Applicable interservice training is identified through commonality of a training objective.

- (2) Team training is training for a group within a single dedicated work center (intragroup training) or for two or more dedicated centers working together (intergroup training).
- (3) Skill progression training provides the advanced knowledge, skills, and techniques necessary for an individual to operate and/or maintain the new system.
- (4) Factory training is training or instruction provided by a vendor or manufacturer on how to maintain and/or operate a specific piece of equipment. Training can be conducted at the factory, at a Coast Guard school, or aboard a vessel. Factory training is also known as Contractor Plant Services (CPS) and contract-specialized training.
- (5) Industrial training is also normally provided by a vendor. It is the training given to Coast Guard civilians so they may install or inspect the new system at the Coast Guard Yard or depot.

A comprehensive Training Plan should be developed for each acquisition. The Training Plan should describe, at a minimum, the overall training approach to be used, the training equipment and course materials required, the location and schedule for each training course, and the required completion dates of each segment of training.

- c. Training data development expands on the preliminary training approaches to include the following considerations.
 - (1) Training location is determined for skill progression training in cases where:
 - (a) That particular skill progression training is not currently being conducted.
 - (b) The training is currently being conducted, but an alternative site would be more appropriate.
 - (c) Existing training should be revamped.
 - (2) Training collocation is the use of the same location for more than one course. This can reduce requirements for training facilities and training support materials.
 - (3) Training integration is the use of one course to train students of one rating in both operational and maintenance functions of a system.

- (4) Training support materials include training devices, technical training equipment, training equipment, and other training material (training aids, training aid equipment, and instructional literature). The need for system-related training support materials for all training in the training path is identified.
- d. The MPT Concept Training Path is a graphic training path that must be developed to show the sequence and course duration of initial skill prerequisite and skill progression training courses required of a system trainee.

3.1.3 Develop Program Documentation Input. Planning data for training should be developed to support the Mission Need Statement and the Preliminary Sponsor Requirements Document prior to KDP-1. Training Plan requirements by phase are as follows:

- a. In the Concepts Exploration Phase, the initial training concept is developed and used to create and evaluate design alternatives. Preliminary Sponsor Requirements Document/Sponsor Requirements Document Training data inputs are developed by the office responsible for the HSI Program to support the PSRD/SRD, Integrated Logistics Support Plan (ILSP), Logistics Support Analysis (LSA), Project Management Plan (PMP), Acquisition Plan (AP), Test and Evaluation Master Plan (TEMP), and other documentation as required.
- b. In the Demonstration/Validation Phase, the training concept is refined and used in the decision making process to evaluate and select the most cost effective design alternative. The training plan is completed and training inputs are developed by the office responsible for the HSI Program to support the Risk Assessment and DEMVAL Test Report and to update the ILSP, LSA, PMP, AP, TEMP, and other documentation as required.
- c. The training plan is further refined and tested as necessary in the Full-Scale Development Phase. Training inputs are provided as necessary to the Operational Development Plan and to update all program documentation.
- d. In the Production Phase, any training deficiencies noted in test and evaluation activities are corrected, training is validated to meet deployment needs, and all program documentation is updated. Training inputs are made to the Operational Logistics Support Plan (OLSP).
- e. In the Deployment Phase, all support items including training are turned over to operational commanders and life-cycle support facilities. Training input is provided by the office responsible for the HSI Program to update the ILSP, OLSP, and other documentation as required.

3.1.4 MPT Advisory Board. The complete training plan should be submitted to the Coast Guard MPT Advisory Board for review and comment prior to KDP-3. See Section D, Manpower and Personnel Program (Subsection 3.1.5), for further description of the MPT Advisory Board.

4. REQUIREMENTS

4.1 Training Requirements for Acquisition. Development of training approaches is one of the first training tasks required to support the early HSI front-end analysis for new acquisitions. Training approaches should be developed in support of the training objectives identified for the new system. This includes development of concepts for interservice, team, skill progression, and contract training. Contract training includes industrial and factory training.

- a. Determine those functions requiring training in each training approach.
- b. Identify training schedule requirements according to published course length, installation schedule, and planning documents.
- c. Determine training requirements.
 - (1) Potential for interservice training may be identified through commonality of training objectives with a DoD Military Service where appropriate training already exists.
 - (2) Team training requirements are derived from methods of operating and maintaining the system. Team training may be necessary to assure coordination with a single dedicated work center (intragroup) or between two or more dedicated centers (intergroup). While team training at a training facility may be expensive, team training conducted on-board the unit may unacceptably degrade mission accomplishment. If team training is not required, it should be so noted in the documentation.
 - (3) Skill progression training provides the advanced knowledge, skills, and techniques necessary for an individual to operate and/or maintain the system. As used here, "skill progression training" refers to all operator and/or maintenance training directly related to the system. Determination must also be made regarding what type of training will be used for the skill progression training required for categories of personnel supporting the system. The training can be in the form of a formal school, formal training, or informal training.
 - (4) Factory training is training or instruction provided by a vendor or manufacturer on how to maintain and/or operate a specific piece of equipment, a system, or device that is furnished to the Coast Guard.

Training can be conducted at the factory, at a Coast Guard school, or aboard the unit receiving the new system. The need for factory training arises when trained personnel are required before the Coast Guard develops the ability to conduct in-house training. Factory training can also be used as an alternative to establishing a school.

- (5) Industrial personnel training is most common with equipment that is to be retrofitted or installed during a vessel's regular overhaul. Since industrial training must be conducted prior to normal installation, it should start at the same time or before factory training, consequently making it a contract matter. Scheduling of this training should be consistent with the installation schedule developed earlier.
- d. Identify optimal training locations. Various alternatives for the siting of training associated with the system must be examined and optimal locations for the training identified.
- (1) The training location requirement must be addressed early in the acquisition process since facility construction requirements may be affected by the decision. Associated considerations for site identification include requirements for: learning center(s) for equipment, media, and materials; trainer- and system-related facilities; and administrative and office facilities.
 - (2) If system organizational level maintenance and operator skill progression training is required and there will be maintainers, operators, and/or operator/maintainers of the same quality, the possibility of developing integrated operator/maintenance training should be examined. There are three training combinations that should be examined:
 - (a) Separate maintenance and operator training
 - (b) Separate maintenance/operator and integrated operator training
 - (c) Integrated maintenance/operator training

- e. Determine what training can be collocated.
- (1) Collocation refers to the location of two or three types of training (maintenance, operator, or team) at the same site. The objective is to determine which, if any, of the collocation possibilities should be used to support system training.
 - (2) The items to be considered in order to determine the reasons for and the degree of collocation are:
 - (a) Anticipated training load
 - (b) Suitability of facility (space and base support)
 - (c) Availability of training devices/training equipment (cost,size, transportation, installation)
 - (d) Location of system configuration
 - (e) Travel costs, Temporary Additional Duty (TAD) costs, and Permanent Change of Station (PCS) costs
 - (f) Manpower quality for operators and maintainers
 - (g) Operating unit requirements for refresher and/or reinforcement training

f. Develop training support materials concept approach.

- (1) Identify requirements for training material to support the new system skill progression training, team training, and contract training. If training material requirements are not identified in a timely manner, it may adversely affect the Coast Guard's ability to effectively operate and maintain the new system.
- (2) Training support materials should be identified for skill progression formal school(s), formal and informal training, "A" School training, advanced training, and contract training.

Training support material includes material prepared, procured, and made use of in a course or program as part of the teaching and learning process. This includes the general categories of training devices (simulators); actual equipment developed in the acquisition process for Coast Guard use, but dedicated to training; equipment used by the Coast Guard units, other than

actual, which is dedicated to training; and instructional aids (i.e., mockup or audiovisual aid); instructional aid equipment (i.e., film projectors); and instructional literature (i.e., texts or training manuals).

- g. Develop and illustrate the training path. A training path is the sequence of training courses for an individual starting from entry level and progressing to the manpower quality specified in the new system billet requirements. A training path is identified for each system maintainer, operator, rating, and special skill.**

 - (1) The training path should include "A" School training, advanced training, prerequisite, and skill progression training. It should also include required assignments to duty stations after completion of a training phase. The training path should illustrate the sequence of training and assignments required for assignment to the new system.**
 - (2) Each block of the training path should include:**

 - (a) Course title**
 - (b) Course identification number**
 - (c) Length of course (in days)**
 - (d) Special skill designators awarded, if any**
 - (e) Required duty station assignment, if any.**
- h. Develop annual training input requirements. This involves adjustment for the number of trained personnel required to compensate for school attrition and account for backout. A backout factor is applied to shift a percentage of student input from one year back to the previous year to ensure the required student output is available when needed. Billets for the General Detail Account must also be included in the annual training input requirements. The training plan should be costed for Project Manager (PM) use.**
- i. Prepare training facility requirements and training resource documentation. Facility requirements include space requirements for training and training support determined to be required by the system. Two principal types of training facilities must be considered: training buildings and training facilities other than buildings. Requirements for site preparation as well as construction must be identified. Costs associated with facility requirements are necessary for PM planning.**

4.2 General Training.

4.2.1 Scope and Nature of Work. Training materials and devices should be integrated into total system development in the acquisition process to achieve effective integration of Coast Guard personnel into the new system. Objectives for the human element of the system should be considered as soon as a manned materiel solution to the mission need is established. A total system training plan should be developed by KDP-3 and include training and operational system development schedules.

4.2.2 Training Procedures. General, individual, and collective training procedures should be considered within the Coast Guard's training requirements framework.

4.2.2.1 Training Definitions.

- a. Training. Instruction and applied exercises to acquire and retain the necessary personal skills, knowledge, and attitudes required to accomplish Coast Guard tasks.
- b. Collective or Team Training. Instruction and applied exercises that prepare an organizational team (such as an aircrew, unit, etc.,) to accomplish required Coast Guard tasks as a unit.
- c. Individual Training. Instruction provided to an individual Coast Guardsman, either in a centralized training organization or in an operational unit, which prepares the member to perform specified Coast Guard tasks.
- d. Institutional Training. Individual training conducted in a school or training center of a centralized training organization.
- e. On-the-Job Training (OJT). Individual or collective/team training conducted by an operational unit.
- f. Unit Training. Individual or collective/team training conducted by an operational unit.

4.2.3 General Procedures.

4.2.3.1 Training as a System. All types of Coast Guard training should be considered as interdependent parts of an overall training system. Possible effects on other parts of the training system should be considered when decisions are made that primarily concern one part of the system (e.g., the effects on unit training will be a key consideration in decisions concerning institutional training).

4.2.3.2 Allocation of Training Resources. Allocation of resources for the training of Coast Guard individuals and units, including those of the Coast Guard Reserve component, should be consistent with assigned missions, employment and deployment schedules, and related requirements for training. Planning training support for new equipment and weapon systems, including the timely development and procurement of simulators and other training devices, should be a consideration in the materiel acquisition process.

4.2.3.3 Application of Simulation. Simulators and other training devices for Coast Guard systems and equipment should be developed, procured, distributed, and used when they are capable of effectively and economically supplementing training on actual equipment. Particular emphasis should be placed on simulators that provide training that might be limited by safety considerations or constraints on training space, time, or other resources. When deciding on simulation issues, the primary consideration should be improving the quality of training and, consequently, the state of readiness. Potential savings in operating and support costs normally should be an important secondary consideration.

4.2.3.4 Reserve Training Technology Application. The use of technology should be emphasized in developing solutions to the unique training problems of the Coast Guard Reserve components that are related to geographical location and to limited time and training facilities. Research programs should be conducted for developing innovative uses of training technology to make Coast Guard training programs more effective and efficient.

4.2.3.5 Contractor Support. Contractors should be used to support and/or conduct instruction in Coast Guard training programs when such support is advantageous to the Coast Guard. Contractors may also be used in developing training plans.

4.2.4 Other Related Considerations.

- a. Since Coast Guard trainees and students must be paid and supported and are unavailable to operational units while they are in school, institutional training courses should be no longer than required to fulfill course objectives as identified through a systematic needs analysis. Instructional methods such as individualized instruction, which satisfy course objectives and compress time in training status, should be considered for use when determined to be effective and economical and when student capabilities make these teaching methods feasible. Minimal time should be spent awaiting training or waiting reassignment subsequent to training.
- b. The satisfactory performance of identified learning tasks, when feasible, should be the criterion for graduating from school courses.
- c. The ability of operational units to conduct effective OJT should be considered when dividing responsibility for teaching tasks between schools and operational units during the development of training programs. Where significant differences

exist between active and Reserve component units, these differences also should be considered.

- d. Computer-based instruction should be considered as a medium for delivery or management of instruction when front-end analysis determines that its use is effective and efficient.

4.2.5 Inter-Service Training Cooperation. The Coast Guard should maintain liaison with the Department of Defense Services to determine effective and affordable solutions to common training problems. Inter-Service consolidation or collocation of training should be considered when applicable.

5. QUALITY ASSURANCE

5.1 Quality Assurance. The office responsible for the HSI Program or contractor should maintain a quality assurance program to substantiate conformance to all the requirements of this specification and the requirements as specified by the contract. The quality program should be documented and should be subject to review by Government representatives. The program should assure adequate quality in the integration of training materials and devices into the design of new Coast Guard systems.

5.2 Training Evaluation Planning. A Training Evaluation Plan should be developed and reviewed to diagram the following tasks:

- a. Evaluation of the effectiveness of training
- b. Evaluation of training capabilities
- c. Evaluation of personnel organization and functions
- d. Evaluation of procedures and instructions
- e. Establishment of a schedule for evaluations

5.3 Training Evaluation. Evaluation of training should be conducted in accordance with the Training Evaluation Plan to determine conformance to the training requirements specified in the contract. The following tasks should be performed:

- a. Execute the evaluation plan
- b. Describe how the training program was evaluated
- c. Identify who conducted the evaluation and the resources used for the evaluation (personnel, materials, and special equipment)

- d. Describe the training deficiencies that were identified as a result of the evaluation
- e. Identify necessary changes to curricula materials during the Coast Guard's initial conduct of training courses
- f. Provide guidance and assistance to the Coast Guard instructor during course conduct
- g. Conduct training materials validation
- h. Conduct test items validation and reliability
- i. Develop and submit for approval change control procedures

5.4 Monitoring/Inspection. The in-house activity or contractor's facilities and training site may be visited at any time by representatives of the contracting activity to inspect, monitor, or appraise the development and conduct of the training program.

5.5 Monitoring of the Training Program. The contracting activity may request that a sample topic (lesson) or topics (lessons) be taught by the proposed instructor(s) before the start of the training program(s). The contracting activity has the right to reject an instructor, using the critique of the instructor's topic (lesson) presentation as one of the factors. Representatives of the contracting activity and other designated Government activities may monitor and evaluate the training program to ensure that objectives and training requirements are met.

5.6 Inspection of Facilities. Designated representatives of the contracting activity or other designated Government activities may visit the training facility prior to the start of the training program(s) to determine the adequacy of the classroom and laboratory spaces.

SECTION F LIST OF ACRONYMS

AE	Architectural Engineering
AP	Acquisition Plan
ASTM	American Society for Testing and Materials
BCS	Baseline Comparison Systems
CEP	Circular Error Probability
CMP	Configuration Management Plan
CPS	Contractor Plant Services
DEM/VAL	Demonstration/Validation
DOD	Department of Defense
DOT	Department of Transportation
DTP	Development Test Plan
ECP	Engineering Change Proposals
EPA	Environmental Protection Agency
E/S/S	Equipment/Systems/Subsystems
GFE	Government Furnished Equipment
GFP	Government Furnished Property
HFE	Human Factors Engineering
HRI	Hazard Risk Index
HSI	Human Systems Integration
HSIP	Human Systems Integration Program
IEM	Initial Estimate of Manpower
ILS	Integrated Logistics Support
ILSP	Integrated Logistics Support Plans
KDP	Key Decision Point
LCSMM	Life-Cycle System Management Model
LSA	Logistics Support Analysis
LSAR	Logistics Support Analysis Record
MA	Managing Activity
MGE	Maintenance Ground Equipment
MNS	Mission Needs Statement
MOE	Measures of Effectiveness

LIST ACRONYMS (Continued)

MPT	Manpower, Personnel, and Training
MTBF	Mean Time Between Failure
MTTR	Mean Time to Repair
NDI	Non-Developmental Items
NET	New Equipment Training
PCS	Permanent Change of Station
PHA	Preliminary Hazard Analysis
PHL	Preliminary Hazard List
PM	Project Manager
PMO	Project Management Office
PMP	Project Management Plan
PMR	Preliminary Manpower Report
PPBES	Planning, Programming, Budgeting and Evaluation System
PSRD	Preliminary Sponsor Requirements Document
PVMD	Preliminary Vessel Manpower Document
OHHA	Occupational Health Hazard Assessment
OJT	On-the-Job Training
OLSP	Operational Logistics Support Plan
OSHA	Occupational Safety and Health Act
O&SHA	Operating and Support Hazard Analysis
OUS	Own Unit Support
RFP	Request for Proposal
RFT	Ready for Training
SAR	Safety Assessment Report
SCA	Safety Compliance Assessment
SHA	System Hazard Analysis
SOW	Statement of Work
SRD	Sponsor Requirements Document
SSE	System Safety Engineering
SSG	System Safety Group
SSHA	Subsystem Hazard Analysis
SSPP	System Safety Program Plan
SSQP	System Safety Quality Plan
SSWG	System Safety Working Group
TAD	Temporary Additional Duty
TEMP	Test and Evaluation Master Plan

CARLOW



**HUMAN SYSTEMS INTEGRATION
IN THE
DEPARTMENT OF DEFENSE
AND THE
MILITARY DEPARTMENTS**



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**PART 1.0
INTRODUCTION**

The US military is currently experiencing fundamental changes in its mission array, size, organization, and financing. The effectiveness of future US military endeavor will be determined in large part by how effectively transition is made from the cold-war and preparation for super-power confrontation of yesterday to the flexible, high-speed, high-intensity power projection operation of the future.

The success of that transition will be determined in part by how effectively the military can identify materiel needs, design and acquire the equipment to satisfy those needs, and insure that newly acquired systems will function as "force-multipliers", i.e. systems which achieve enhanced fire-power from reduced resources. The accomplishment of force-multiplication, in turn, is largely dependent on the successful integration of the human, hardware, software, procedural, logistical, and training elements of the system.

Military system acquisition within the Department of Defense (DoD) was revolutionized in February, 1991 with the release of DoD Directive (DODD) 5000.1, *Defense Acquisition*, DoD Instruction (DODI) 5000.2, *Defense Acquisition Management Policies and Procedures*, and DoD Manual (DODM) 5000.2M, *Defense Acquisition Management Documents and Reports*. The impact of the acquisition philosophy embodied in these documents on the activities of the military departments is profound.

The policies in DODD 5000.1 address three major objectives: (1) translating operational needs into stable affordable programs; (2) acquiring quality products; and (3) emphasizing efficiency and effectiveness in acquisition management. Translating operational needs into stable, affordable programs involves a process of phases and milestones, and emphasizes affordability in acquisition. The acquisition of quality products emphasizes early identification of performance objectives, coupled with the requirement that the user participate in the

development of operational performance objectives. A second thrust in the concern for quality products is the assessment and reduction of risks, notable cost, schedule, and design risks. Finally, in organizing for efficiency and effectiveness, the DoD is seeking to facilitate decision making and foster uniformity in acquiring military systems.

The stated purpose of the 5000-series is to establish a disciplined management approach for acquiring military systems and materiel that satisfy the operational user's needs. Within DODI 5000.2, the DoD has embraced the position that the human is indeed an element of the system and has gone beyond simply conceding that concern for the human user is important in system acquisition. With DODI 5000.2, the DoD is explicitly and clearly establishing the needs of the user as the first priority in system acquisition. The impact of this acquisition philosophy is that not only must the user be considered in the design of the system, but that the requirements of the user must be pivotal in determining the direction that the system design will follow.

To accomplish this goal, DODI 5000.2 introduced the concept of Human Systems Integration (HSI) which is based on the policy that human considerations shall be effectively integrated into the design effort for military systems to improve total system performance and to reduce the costs of ownership by focusing attention on the capabilities and limitations of the soldier, sailor, airman, or marine. "Human considerations", as established by DODI 5000.2, include:

- Physical and Mental Capabilities and Limitations
- Anthropometric and Biomedical Criteria
- Man-Machine Interface
- Mission, Function, and Human Requirements Analyses
- Human Error Analysis
- System Reliability Analyses
- Skills, Knowledges, and Aptitudes
- Force Structure
- Operating Strengths
- Manning Concepts
- Personnel Classification and Selection
- Demographics
- Accession, Attrition and Retention Rates
- Promotion and Training Flows
- Training Concept and Strategy
- Simulation
- Environmental Considerations

These factors are to be incorporated into objectives for the human element of the system at Milestone I of the Life Cycle System Management Model (LCSMM) and must be traceable to readiness, force structure, affordability, and wartime operational objectives.

This effort involved in this report is part of a program intended to design and implement a Human-System Integration (HSI) program for each component (i.e., Ship, Aviation, and Shore Installation) of the U.S. Coast Guard (USCG) acquisition process.

The purpose of this report is to:

- review DoD system acquisition documentation, especially DODD 5000.1, DODI 5000.2, and DODM 5000.2M and describe the explicit and implicit requirements for HSI contained therein;
- identify and review the three military department programs implementing the DoD HSI initiative, to wit;
 - the Army **MANPRINT** program,
 - the Navy **HSI** program, including **HARDMAN**, and
 - the Air Force **IMPACTS** program;
- detail and describe the specific Human Factors Engineering (HFE), System Safety/Health Hazard Engineering (SS/HH), and Manpower, Personnel and Training (MPT) program and process requirements of each of these three military service programs; and
- evaluate the strengths and weaknesses of each of the three military service programs relative to their own stated objectives.

PART 2.0
DEPARTMENT OF DEFENSE
HUMAN-SYSTEM INTEGRATION PROGRAM

The DoD HSI program is specifically established in DODI 5000.2, Part 7 Section B, *Human Systems Integration*. However, there are implications for HSI in other parts and sections of DODI 5000.2, as well as in additional DoD rules, regulations and guidance.

Part 2.0 of this report, in 8 sections, will present an overview and analysis the following DoD documents impacting or impacted by the HSI program.

2.1	DODI 5000.2 Part 7 Section B Human System Integration
2.2	DODI 5000.2 Part 6 Section H Human Factors
2.3	DODI 5000.2 Part 6 Section I System Safety, Health Hazards, and Environmental Impact
2.4	DODI 5000.2 Part 8 Test and Evaluation
2.5	MIL-H-46855B Human Engineering Require- ments for Military Systems, Equipment and Facilities
2.6	MIL-STD-882B System Safety Program Requirements
2.7	DODD 1322.18 Military Training
2.8	ASD (FM&P) Memo, Human System Integration Plan Implementation Procedures

Table 1 presents a summary of the HSI-related elements of each of these documents. Table 2 presents a summary of the HSI-related elements of 7 additional documents which, while not in the direct reference sequence originating in DODD 5000.2 Part 7 Section B, contain implicit requirements for or impacts on HSI issues.

**Table 1
DoD HUMAN SYSTEM INTEGRATION PROGRAM**

<u>DODI 5000.2 7B</u> <u>HSI</u>	<u>DODI 5000.2 6H</u> <u>HFE</u>	<u>DODI 5000.2 6I</u> <u>SS/HH</u>	<u>DODI 5000.2 8</u> <u>Training</u>
<ul style="list-style-type: none"> • Establishes HSI Program • Defines Objectives • Establishes Documentation Requirements MNS, ORD, HSIP, ISP • Requires Manpower Assessment • Requires Personnel Assessment • Requires Training Assessment • Requires SS/HH Program • Human Performance Issues in TEMP • Testing Under Realistic Conditions with Representative Users • Requires MER 	<ul style="list-style-type: none"> • HFE Integral Part of Conceptual Efforts, Development, and Acquisition Programs • HFE Design Requirements Established to Develop Effective Man-Machine Interface • Requires HFE Program IA MIL-H-46855B • MIL-STD-1472D and DOD-HDBK-762 to be used as Design Criteria • T&E to Assess Integration of HFE into Design • TEMP Will Address Critical Human Issues • TEMP Will Require ID of Mission Critical Op. & Maint. Tasks • IPS Will ID High Risk Areas of HSI 	<ul style="list-style-type: none"> • SS/HH Efforts Employed to ID and Reduce Hazards • Requires SS Program IAW MIL-STD-882B • SS & HH Lessons Learned Addressed in Phase I • Hazards Identified Prior to MS II • Hazards Eliminated or Controlled Prior to MS III • TEMP Will Address SS & HH Issues • Hazardous Materials Will Be Avoided • Systems in Compliance With Env. Protection Regulations • IPS Will Assess SS, HH, & Env. Risks 	<ul style="list-style-type: none"> • Verify Attainment of Technical Performance Specs & Objectives • Verify System Operationally Effective & Suitable for Intended Use • DT&E ID: Potential Op. & Tech. Limitations of Alternative Concepts/Options: Cost-Performance Trade-Offs; Design Risks • OT&E Determine: Op Effectiveness & Suitability of Systems; Min. Acceptable Op Performance Reqs. of ORD Satisfied • TEMP Prepared for All Acquisition Programs

**Table 1 cont.
DoD HUMAN SYSTEM INTEGRATION PROGRAM**

<p align="center"><u>MIL-H-46855B</u> <u>HFE</u></p>	<p align="center"><u>MIL-STD-882B</u> <u>SS/HH</u></p>	<p align="center"><u>DODD 1322.18</u> <u>Training</u></p>	<p align="center"><u>ASD (FM&P) MEMO</u> <u>28 MAY 91</u></p>
<ul style="list-style-type: none"> • HFE to be Applied to Military Acquisitions • Requires HFE Program Planning • HFE to be Applied to System & Sub-system Designs • HFE Involved in T&E • Failures During T&E to be Subjected to T&E Analysis • MIL-STD-1472 Establishes as Principles & Criteria Document 	<ul style="list-style-type: none"> • SSE to be Applied to Military Acquisitions • Requires Contractor SSE Program • Establishes Precedence for Eliminating/Controlling Hazards • Establishes 27 SSE Tasks Which May be Imposed on Contractor or Government Activities • Requires System Safety Program Plan • Requires Performance of Various Hazard Analyses • Establishes Requirements for Software System Safety 	<ul style="list-style-type: none"> • Training viewed as a system • Planning of training to be integrated in acquisition process • Wartime missions considered when allocating training resources • Individual training based on MOS required skills and knowledges • A structured process to be used for developing training programs • Collective training will be based on wartime missions 	<ul style="list-style-type: none"> • Guides the formulation of implementation procedures concerning HSIP • HSIP satisfy program documentations requirements of six HSI domains • PM/PEO develop HSIP after Concept Studies Approval • HSI goals, objectives, constraints, trade-offs, risk & cost drivers in plan serve as basis for HSI reporting requirements in other documentation • Plan formats left to discretion of component program offices

Table 3
DoD HUMAN SYSTEM INTEGRATION PROGRAM

<p><u>DODD 5000.1</u></p> <ul style="list-style-type: none"> • Concurrent Engineering approach essential to balance systems design requirements such as HFE, safety, and standardization • Maximum potential use of commercial and other NDI's and maximum use of non-government standards and commercial item descriptions 	<p><u>DODI 5000.2.6a</u> <u>Systems Engineering</u></p> <ul style="list-style-type: none"> • Ensure compatibility of all functional and physical interfaces • Ensure design reflects requirements for all system elements: hardware, software, data, facilities & people • Technical process identified in MIL-H-46855 is major element of technical development process and must be integrated into system development 	<p><u>DODI 5000.2.6C</u> <u>Reliability & Maintainability</u></p> <ul style="list-style-type: none"> • Emphasis on managing the contribution to system R&M made by hardware, software, and human elements of system • Maintainability objectives address manpower and skill level required • R&M objectives include support and training equipment 	<p><u>DODI 5000.2.6D</u> <u>Computer Resources</u></p> <ul style="list-style-type: none"> • Policies apply to computer resources used for training and simulation • Computer resources life-cycle management identify risk areas including people and training • In Phases O and I, analyze requirements and constraints for human interfaces 	<p><u>DODI 5000.2.7A</u> <u>Integrated Logistics Support</u></p> <ul style="list-style-type: none"> • Manpower, personnel, training, & safety are essential design, human system integration, and support considerations 	<p><u>DODI 5000.2.9B</u> <u>Technical Data Management</u></p> <ul style="list-style-type: none"> • Tech data providing instructions for installation, operation, maintenance, training, and support of system can be formatted into a technical manual • Tech manuals must be written to the reading and skill levels of the people for whom they are intended 	<p><u>DODI 5000.2.10B</u> <u>Selection of Contractual Sources</u></p> <ul style="list-style-type: none"> • Solicitations may include an assessment of the degree to which the system can be used satisfactorily in operation, considering HFE safety, manpower and training requirements
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2.1 DODI 5000.2 PART 7 SECTION B HUMAN SYSTEMS INTEGRATION

DODI 5000.2, Part 7 Section B, *Human Systems Integration* is the seminal document for the DoD HSI program. This section of this report (2.1) will outline and discuss the HSI purpose, policies, and procedures outlined in Part 7 Section B. Subsequent sections of Part 2 of this report will outline and discuss related or implied HSI policies and procedures which were referenced in DODI 5000.2 Part 7 Section B.

2.1.1 PURPOSE

Human Systems Integration establishes the policies and procedures which form the basis for the effective integration of human factors engineering, manpower, personnel, training, health hazards, and safety considerations into the acquisition of defense systems.

The section cancels and replaces DODD 5000.53 *Manpower, Personnel, Training, and Safety (MPTS) in the Defense System Acquisition Process*.

2.1.2 POLICIES

The section establishes the following two items of policy:

- “Human considerations shall be effectively integrated into the design effort for defense systems to improve total system performance¹ and reduce costs of ownership² by focusing attention on the capabilities and limitations of the soldier, sailor, airman, or marine.”
- “Objectives for the human element of the system shall be initially established at Milestone I, Concept Demonstration Approval, and be traceable to readiness, force structure, affordability, and wartime operational objectives³. They shall be subsequently refined and updated at successive milestone decision points.”

2.1.3 PROCEDURES

Part 7 Section B establishes procedures for the integration of HSI through six discipline areas (five when safety is considered to encompass both system safety and health hazards), acquisition program documentation, and special MPT

data requirements, as follows:

- Program Documentation [cr 2.5]
- HFE [cr 2.2/2.6]
- Manpower
- Personnel
- Training [cr 2.6/2.7]
- Safety [cr 2.3/2.7]
- Test and Evaluation (T&E) [cr 2.4]
- MPT Data Requirements.

2.1.3.1 Program Documentation. HSI program documentation requirements are established for four acquisition documents:

- Mission Needs Statement (MNS)
- Operational Requirements Document (ORD)
- Human Systems Integration Plan (HSIP)
- Integrated Program Summary (ISP)

2.1.3.1.1 Mission Needs Statement (MNS). Any existing human systems constraints are to be identified in the MNS.

2.1.3.1.2 Operational Requirements Document (ORD). The ORD will include:

- Objectives and minimum acceptable requirements relating to operation, maintenance, training, and support of the system,
- Projected manpower, personnel, training, and safety limitations, considering existing systems, programs, or force structure being traded off to support the new or modified system, and
- Objectives and minimum acceptable requirements for manpower and training which may be incorporated, as appropriate, in the acquisition program baseline.

2.1.3.1.3 Human Systems Integration Plan (HSIP)⁴ The HSIP will document the proposed HSI program and its implementation, to include:

- Identifying critical human system factors that have a significant impact on readiness, life-cycle cost, schedule, or performance⁵;
- Listing and discussing potential cost, schedule and design risks and trade-offs which concern HSI factors⁶ and plans for managing and reducing program risks⁷;

- Discussing the manpower impact of the new system as compared to its predecessor or comparable system(s) and stating the sources of the manpower resources for the new system⁸;
- Discussing the requirements for new occupational specialties, requirements for high quality personnel or “hard to fill” military and civilian occupations, and how these personnel requirements will be met;
 - Describing how HFE will be applied to the system design effort;
 - Summarizing how safety and health hazard lessons learned are being applied to the new system;
 - Addressing the training requirements and effectiveness of the new training system, including requirements for new or additional training resources and identifying critical points in the training schedule;
 - Discussing the impact fielding the new system will have on unit readiness and whether the training base is adequate to meet surge and mobilization requirements.

2.1.3.1.4 Integrated Program Summary (IPS). The Risk Assessment Annex of the IPS will:

- Summarize potential cost, schedule, and design risks that result from HSI factors⁹;
- Highlight current HSI cost drivers and discuss the manpower cost impact of the most promising alternative system(s) as compared to the predecessor or comparable systems;
- Discuss major HSI cost, schedule, and performance trade-off decisions to be made by the milestone decision authority .

2.1.3.2 Human Factors Engineering. Part 7 Section B directs that an HFE program will be established for each system acquisition (and directs the reader to DODI 5000.2 Part 6 Section H*)¹⁰.

2.1.3.3 Manpower. Manpower requirements for the new system will be assessed to:

- Influence the system design to moderate operational, maintenance, training, and support manpower requirements;
- Ensure the system can be operated and supported within the

* See Section 2.2 of this report.

manpower limitations established for it;

- Influence operations and support concepts to reduce inefficient manning and organizational concepts;
- Ensure required manpower is programmed for support of the operational system¹¹.

In addition, manpower projections will consider resource limitations and manpower reduction goals¹¹.

2.1.3.4 Personnel. Personnel requirements for the new system will be assessed to:

- Influence the system design to moderate skill requirements and limit or reduce the use of occupational specialties with high aptitude and skill requirements or with mobilization, rotation or flow rate problems stemming from accession or retention limitations;
- Ensure appropriate planning is being done for acquiring, training, and reallocating personnel and skills to support the operational system¹².

2.1.3.5 Training. Training requirements for the new system will be assessed to:

- Influence the system design to moderate training requirements, optimize the selection of training alternatives, and ensure that the prime system data is available to permit timely development of training system equipment and courseware;
- Ensure appropriate training is being planned for support of the operational system¹³;
- Ensure required training resources (trainers, facilities, equipment) are programmed for support of the operational system¹³.

Part 7 Section B further directs that existing training resources should be assessed to determine ability to support training need. The requirements for new or additional training resources based on peacetime operating tempos, as well as surge and mobilization, will be highlighted.

Tasks which require extensive training will be identified and targeted for design trade-off analyses¹⁴.

Training materials and training devices will be integrated into the total system using the procedures in DODD 1322.18, *Military Training*, and DODD 1430.13, *Training Simulators and Devices*. In accordance with these directives, a total system training plan should be developed by Milestone II.

2.1.3.6 Safety. Part 7 Section B directs that SSE will identify, evaluate and eliminate or control safety and health hazards (and directs the reader to DODI 5000.2 Part 6 Section I*)¹⁵.

2.1.3.7 Test and Evaluation. The Test and Evaluation Master Plan (TEMP) will address human performance issues to provide data to validate that MPT and SS/HH design requirements have been met¹⁶. System testing will be accomplished under operationally realistic conditions using personnel representative of the typical users.

2.1.3.8 Manpower, Personnel, and Training Data Requirements. For Acquisition Category (ACAT) I programs, a Manpower Estimate Report is required by Title 10, U.S. Code, Section 2434, *Independent Cost Estimates; Operational Manpower Requirements*, and will be submitted at Milestones II and III.

2.1.4 DISCUSSION OF DODI 5000.2 PART 7 SECTION B REQUIREMENTS

1. Human System Integration effort is aimed primarily at enhancing *total system performance*. It is not simply an exercise to make operation, maintenance, or support easier for the human element. HSI work and associated costs should result in a more effective and efficient total system. The way this primary goal is achieved is by integrating human considerations into the system design.

2. HSI effort and front-end costs should also result in a more affordable system, i.e. should reduce the life-cycle cost of ownership. This is accomplished by enhanced performance, reduced maintenance costs, reduced training costs, reduced manpower and personnel skill requirements, and reduced demilitarization costs.

3. This policy is a weakness in the DoD HSI program requirements. Objectives for the human element of the system should begin to be considered as soon as a manned materiel solution to the mission need is established, i.e. during the pre-concept phase, and should be initially established by Milestone 0. Extensive HSI activity is required during Phase 0, Concept Exploration and Definition, and initial human element objectives must be available during that time to guide development of alternative system concepts. Waiting for the end of

*See Section 2.3 of this report.

Phase 0 to establish initial objectives for the human element of the system is simply too late.

4. This policy sets the requirement for the development and use of an HSIP for every system. Of special interest here is that the HSIP is to document the *implementation* of the HSI program as well as its' planning. This requires the HSIP to be a "living document", which develops along with the abuilding system.

5. These are defined as HSI "high drivers". The identification of high drivers is an essential HSI activity which must be accomplished as early as possible in the system life cycle. It is important to note that a high driver is a critical human system factor which has significant impact on system performance, etc., but is also amenable to change. A factor which has significant impact but cannot be modified is a constraint, not a high driver.

6. The requirement to list risks and trade-offs concerned with HSI factors within the HSIP is the equivalent of a Preliminary Hazard List (PHL) being included in a System Safety Plan. The purpose of a PHL, or listing of HSI risks/trades, is to identify potential hazards/issues inherent in the design, which are of special initial concern, must be ameliorated, and must be tracked throughout the life cycle development of the system.

7. Plans for managing and reducing program risks are essentially initial schemes for ameliorating the identified risks/trades. The HSIP becomes a living document as these plans are carried out throughout the life cycle. Alternative approaches to resolution must be developed and documented in the initial plan is not successful and the final, successful resolution of individual items should be documented.

8. This point, and the next five, require individual discussions of the MANPRINT domains, generally including requirements and proposed approaches to and scope of implementation.

9. This requirement is essential in that it ensures that HSI considerations are included in the IPS, and therefore are brought to the attention of the Milestone Decision Authority.

10. The requirement here is for an HFE program for *each system acquisition*. There is no limitation as to size, cost or complexity of the system -- every DoD system acquisition will include an HFE program element, in

accordance with Part 6 Section H of DODI 5000.2.

11. These two procedure elements are obviously linked and extend the HSI implementation effort beyond the traditional aspects of system acquisition. These elements require the departments to assess *future* manpower availability, taking into account on-going efforts at down-sizing, and to ensure that sufficient manpower will be available to operate, maintain and support the system when it is introduced into the inventory. This is beyond a design effort.

12. This has the same implications as item 11 above. However, the use of the term "support" is unfortunate in this context; the intent of the procedure element is to require appropriate personnel planning to operate/maintain/support the fielded system, not just support it.

13. These elements have the same implications as items 11 and 12 for the training domain. Again, these are HSI program elements which transcend the system design effort.

14. The identification of these tasks should be accomplished through the HFE task analysis effort. The system tasks specified here are those which require complex or critical human performance; i.e. high driver tasks. After identification, design trades should initially aim at amelioration through design efforts; high driver tasks which cannot be ameliorated through design changes should be identified for extensive training.

15. This requirement does not explicitly state that a system safety program will be undertaken for each system, as does the requirement for HFE. The procedure element does direct that safety and health hazards will be identified, evaluated, and eliminated or controlled, however. The referenced section of DODI 5000.2 does explicitly state that a system safety program, in accordance with MIL-STD-882B, will be established, but in order to maintain consistency, a similar statement should appear here.

16. HFE design requirements should also be explicitly referenced for inclusion in the TEMP in this section.

2.2 DODI 5000.2 PART 6 SECTION H HUMAN FACTORS

This section of DODI 5000.2 establishes the DoD-wide requirements for HFE activity in systems acquisition.

2.2.1 PURPOSE

Human Factors establishes the policies and procedures which ensure that the required technology development, engineering, and management tasks are accomplished during system design to provide for effective and efficient operator and maintainer performance.

2.2.2 POLICIES

This section establishes the following two items of policy:

- “Human factors engineering shall be an integral part of planning and conceptual efforts, development projects, and acquisition programs to include modifications¹. Management responsibility for human factors engineering will transfer along with the system in inter-command transition agreements.”

- “Human factors design requirements shall be established to develop effective man-machine interfaces and preclude system characteristics that:

- (1) Require extensive cognitive, physical, or sensory skills;
- (2) Require complex manpower or training intensive tasks; or
- (3) Result in frequent or critical errors”.

2.2.3 PROCEDURES

Part 6 Section H establishes procedures for the application of HFE in three general areas.

- | |
|--|
| <ul style="list-style-type: none">• Human Factors Program• Test and Evaluation• Integrated Program Summary |
|--|

2.2.3.1 Human Factors Program. An HFE program will be established for each system acquisition². The capabilities and limitations of the operator, maintainer, trainer, and other support personnel should be identified early enough in the design effort to impact the design.

- MIL-H-46855B, *Human Engineering Requirements for Military Systems, Equipment and Facilities* and/or MIL-STD-1800, *Human Factors Engineering Performance Requirements* will be tailored to adapt to specific

program characteristics*.³

- MIL-STD-1472D, *Human Engineering Design Criteria for Military Systems, Equipment, and Facilities* and DoD-HDBK-763, *Human Engineering Procedures Guide* should be used as the basis for effective and appropriate human factors design⁴. MIL-STD-1472D will be part of the selection criteria for determining the suitability of NDIs⁵.

Manpower, personnel, training, health hazard, and safety concerns will be translated into man-machine interface design issues to be addressed during systems engineering⁶. This includes efforts to:

- Review human-system interface characteristics which require extensive cognitive, physical, or sensory skills; require complex manpower and training intensive tasks; or adversely affect human performance, identifying those elements that will be targeted for HFE changes.

- Review SS/HH issues and lessons learned. Identify factors which result in frequent or critical human performance errors.

- Identify how such human-system interface characteristics and factors can be avoided or corrected through system design and HFE efforts.

2.2.3.2 Test and Evaluation. Test and evaluation activities will include effort to:

- Assess the integration of HFE into the design of hardware, software, and procedures⁷;

- Include performance of operational tasks by typical users;

- Provide human performance and error rate data; and

- Verify that HFE design requirements have been satisfied.

The TEMP will:

- Address critical human issues to provide data to validate the results of HFE analyses⁷; and

- Require identification of mission critical operation and maintenance tasks.

2.2.3.3 Integrated Program Summary. Based on an assessment of predecessor or comparable systems and new technologies⁸, the IPS will identify high risk areas in HSI targeted for mitigation and how such mitigation will:

- Improve system performance;

* See Section 2.5 of this report.

- Reduce MPT requirements and ownership costs; and
- Reduce or eliminate critical human performance errors.

2.2.4 DISCUSSION OF DODI 5000.2 PART 6 SECTION H REQUIREMENTS

1. This policy requires HFE to be included in all phases of the LCSMM.
2. This restates the requirement of DODI 5000.2 Part 7 Section B Paragraph 3b. The requirement here is for an HFE program for *each system acquisition*. There is no limitation as to size, cost or complexity of the system -- every DoD system acquisition will include an HFE program element.
3. This procedure element establishes MIL-H-46855B and MIL-STD-1800 as the requirements standards for conducting a HFE program. The requirement to tailor the general requirements to specific program characteristics is directly implemented in the MIL-H-46855B Appendix.
4. MIL-STD-1472D and DoD-HDBK-763 are design and procedural guidance documents, respectively, and are not requirements documents per se. These documents are to be employed to determine appropriate or acceptable HFE design and procedures.
5. NDI acquisitions, by definition, reduce the ability of HFE to influence design during the development process. This procedure element requires that HFE design criteria be part of the decision process in determining the suitability of a previously designed and developed NDI.
6. This is a crucial statement for defining the function of HFE and the interrelationships of the HSI domains. The MPT, SS and HH domains identify concerns. Those concerns are to be addressed by HFE during system engineering efforts, in order to be solved or ameliorated by effective man-machine interface design. In essence, HFE solves the design problems identified by the other five HSI domains.
7. This aspect of T&E is not mentioned in DODI 5000.2 Part 7 Section B, nor explicitly (i.e., in terms of HFE) in DODI 5000.2 Part 8. This cross walk should be completed.
8. This is true for the early phases of system development only. Once alternative design concepts are established, the IPS should identify high risk areas in HSI targeted for mitigation based on the alternative concepts or developing system themselves.

2.3 DODI 5000.2 PART 6 SECTION I SYSTEM SAFETY, HEALTH HAZARDS, AND ENVIRONMENTAL IMPACT

This section of DODI 5000.2 establishes the DoD-wide requirements for SS/HH activity in system acquisition.

2.3.1 PURPOSE

This section cancels and replaces DODI 5000.36, *System Safety Engineering and Management*. The policies and procedures establish the basis for effectively integrating system safety, health hazard, and environmental considerations into the system engineering process.

2.3.2 POLICIES

The following four items of policy are established by this section.

(1) "Scientific and engineering principles shall be applied during design and development to identify and reduce hazards associated with system operation and support with the objective of designing the safest possible systems consistent with mission requirements and cost-effectiveness¹.

- Appropriate system safety and health hazard objectives shall be established early in the program and used to guide system safety and health hazard activities and the decision process².

- With regard to hazardous materials, emphasis shall be on reduced use of hazardous materials in processes and products rather than simply managing the hazardous waste created³."

(2) "Proposed systems shall be analyzed for their potential environmental impacts in accordance with Title 40, Code of Federal Regulations, Parts 1500-1508, *National Environmental Policy Act Regulations* and Executive Order 12114, *Environmental Effects Abroad of Major Federal Actions*."

(3) "System safety engineering programs shall be designed to work in harmony with other comprehensive DoD product improvement programs (e.g., manpower, personnel, and training programs; logistics support analysis (LSA) programs; reliability and maintainability (R&M) programs; software quality assurance programs)⁴.

(4) "Each management decision to accept the risks associated with an identified hazard shall be formally documented using MIL-STD-882 as a guide to

establish criteria for defining and categorizing "high" and "serious" risks."⁵

- The DoD Component Acquisition Executive (or designee at the Deputy Assistant Secretary or three star level) shall be the final approval authority for acceptance of high risk hazards⁶.

- All participants in Joint-Service programs must approve acceptance of high risk hazards⁶.

- Serious risks may be approved for acceptance at the Program Executive Officer or equivalent level⁶."

2.3.3 PROCEDURES

Part 6 Section I establishes procedures in five areas of system development:

- | |
|---|
| <ul style="list-style-type: none">• System Safety• Test and Evaluation• Hazardous Materials• Environmental Protection• Integrated Program Summary |
|---|

2.3.3.1 System Safety. A SS program will be established through the tailored application of MIL-STD-882B, *System Safety Program Requirements*, aimed at identifying, evaluating, and eliminating or controlling system hazards^{*7}.

- SS programs will be applied to inhouse research, development, production, modification, and test programs⁸. For NDIs, a thorough safety assessment for the intended use will be performed and documented prior to purchase⁹.

- The *total system*, including hardware, software, testing, manufacture, and support, will be evaluated for safety.

- The design of the system will reduce the probability and severity of all hazards to a level specified by the program office.

- Evaluation will include both known and potential hazards over the *entire life cycle* of the system.

- Health hazards and safety lessons learned from predecessor and similar systems should be addressed during Phase I¹⁰.

* See Section 2.6 of this report.

- Actual and potential significant hazards and associated risks should be identified prior to Milestone II¹¹.
- Hazards will be eliminated and controlled prior to Milestone III¹²:
 - The predominate means of controlling risk will be hazard elimination¹³.
 - Where hazards cannot be eliminated, they will be effectively controlled¹³.
 - Warning devices and procedures will not be the sole means of controlling catastrophic and critical hazards.

2.3.3.2 Test and Evaluation.

- The TEMP will address HH and safety critical issues to provide data to validate the results of SS analyses¹⁴.
- When normal testing cannot demonstrate safe system operation, special safety tests and evaluations will be prepared and monitored.

2.3.3.3 Hazardous Materials. The environmental, safety, and occupational health impacts associated with the use of hazardous materials will be carefully evaluated during system acquisition, including impacts associated with system manufacture, operation, maintenance and disposal.

- Hazardous material use will be managed over *the entire life cycle* so that DoD incurs the lowest cost required to protect human health and the environment¹⁵.
- The preferred method of doing this is to avoid or reduce the use of hazardous materials.
- Where the use of hazardous materials cannot be reasonably avoided, procedures for identifying, tracking, storing, handling, and disposing of such materials will be developed and implemented in accordance with DODD 4210.15, *Hazardous Material Pollution*, and DODI 6050.5, *Hazard Communication Program*.
- Life cycle cost estimates must include the cost of acquiring, handling, using, and disposing of any hazardous materials.

2.3.3.4 Environmental Protection. Defense systems will be designed, developed, tested, fielded, and disposed of in compliance with applicable environmental protection laws and regulations, treaties, and agreements.

2.3.3.5 Integrated Program Summary. As part of risk assessment and environmental analysis, the IPS will assess SS, HH, and environmental risks that can not be corrected or mitigated through system design changes or new technology and identify what residual hazards and impacts must be accepted by formal decision.

2.3.4 DISCUSSION OF DODI 5000.2 PART 6 SECTION I REQUIREMENTS

1. The goal of system safety and health hazard efforts, i.e. the safest possible system, is constrained by the realities of mission requirements and cost-effectiveness. This implies that even safety and health considerations *can be* the object of trade-offs; obviously, however, safety and health should be the last resort in making trades to achieve mission and cost requirements.

2. "... early in the program. . ." should be expanded to "... as early as possible in the program. . .". Initial SS/HH objectives should be based on predecessor/similar systems and lessons learned, and can/should be established prior to Milestone 0, in the Mission Needs Assessment Phase. Enhanced safety/health can, in fact, be a mission need element.

3. This requirement is in line with the general safety approach of elimination of hazards where possible and control of hazards where elimination is not possible.

4. HSI is obviously a "comprehensive DoD product improvement program". Why it is not explicitly listed here is unclear.

5. This policy element requires that the guidance contained in MIL-STD-882B be employed in categorizing risks as "high" or "serious". It also requires that decisions to accept risk be formally documented. It should be more explicit that such documentation is also to be in accordance with the requirements of MIL-STD-882B.

6. These elements establish acceptance authority levels for high and serious hazards.

7. This procedure element does explicitly require the establishment of a SS program, tailored through MIL-STD-882B. This element should be linked to the safety paragraph in DODI 5000.2 Part 7 Section B.

8. This expands SS program efforts to government-only, i.e. non-contractor, efforts.

9. NDI acquisitions, by definition, reduce the ability of SS/HH to

influence design during the development process. This procedure element requires that safety design criteria be part of the decision process in determining the suitability of a previously designed and developed NDI and that the results of that assessment be documented.

10. This is a serious procedural flaw. SS/HH lessons learned should be addressed prior to Phase I -- preferably during the determination of mission need, since SS/HH issues can themselves be mission need elements.

11. This does not imply that SS/HH analysis efforts should be *limited* to Phase I, Concept Demonstration and Validation. Rather, this procedure element indicates that all analysis efforts should be *completed*, i.e. all hazards identified, by Milestone II.

12. Likewise, this does not imply that hazard elimination and control efforts should be *limited* to Phase II, Engineering and Manufacturing Development. Rather, this procedure element states that all hazards must be eliminated/controlled prior to Production Approval -- a system can not enter production with unresolved hazards.

13. These restate the preferred system safety approach of elimination of hazards by design action and control, by design action, of hazards which can not be eliminated.

14. This statement is somewhat weak. It should include a statement to the effect of the TEMP providing data to verify SS efforts -- i.e., were the proposed corrections/design solutions actually effected.

15. Again here, the goal of the management of hazardous materials is not simply to protect human health and safety, but to incur the lowest life-cycle cost to achieve that protection.

2.4 DODI 5000.2 PART 8 TEST AND EVALUATION

DODI 5000.2 Part 8, *Test and Evaluation* establishes the basis for conducting test and evaluation activities in support of the acquisition process. It replaces DODD 5000.3, *Test and Evaluation*. A number of elements of T&E impact the DoD HSI program.

- | |
|---|
| <ul style="list-style-type: none">• General Policies• Developmental Test and Evaluation Policies• Operational Test and Evaluation Policies• Procedures |
|---|

2.4.1 GENERAL POLICIES

- Among other objectives, T&E programs shall be structured to:
 - Verify attainment of technical performance specifications and objectives¹
 - Verify that systems are operationally effective and suitable for intended use²
- Test planning, at a minimum, must address all system components (hardware, software and human interfaces) that are critical³ to the achievement and demonstration of contract technical performance specifications and minimum acceptable operational performance requirements specified in the ORD.

2.4.2 DEVELOPMENTAL TEST AND EVALUATION (DT&E) POLICIES

Among other objectives, DT&E programs shall:

- Identify potential operational and technological limitations of the alternative concepts and design options being pursued⁴;
- Support the identification of cost-performance trade-offs⁵;
- Support the identification and description of design risks⁶.

2.4.3 OPERATIONAL TEST AND EVALUATION (OT&E) POLICIES

OT&E programs shall be structured to:

- determine the operational effectiveness and suitability of a system⁷, using typical users⁸ to operate and maintain the system under conditions simulating combat stress⁹ and peacetime conditions;

- determine if the minimum acceptable operational performance requirements as specified in the ORD have been satisfied¹⁰.

2.4.4 PROCEDURES

- A TEMP will be prepared for all acquisition programs and will be used to generate detailed T&E plans.
- OT&E plans will include test objectives, measures of effectiveness, planned operational scenarios, threat simulation, resources, test limitations, and methods of data gathering, reduction, and analysis.

2.4.5 DISCUSSION OF DODI 5000.2 PART 8 REQUIREMENTS

1. Technical performance specifications and objectives can include SS/HH issues.
2. This would include HFE, SS, and HH concerns.
3. This does not imply "critical" as defined previously in the HFE sense, but critical as required for acceptable performance.
4. Limitations would include SS/HH hazards, and concept/design features negatively impacting MPT considerations or operability/affordability/maintainability/supportability, etc. All of these HSI issues should be investigated during DT&E and those objectives should be spelled out here.
5. Cost-performance tradeoffs could involve HFE design elements.
6. Design risks can include SS/HH risks and negative MPT impacts. These should be spelled out here.
7. Operational effectiveness will involve SS/HH issues, as well as effective and efficient man-machine interface considerations.
8. The use of typical users in operational testing is typically an HSI, and especially an HFE, concern.
9. Operation/maintenance/support under realistic use conditions is also typically an HSI, and especially an HFE, concern.
10. HSI input to the ORD will include the following. Their effective implementation must be evaluated during OT&E
 - Objectives and minimum acceptable requirements relating to operation, maintenance, training, and support of the system
 - Projected manpower, personnel, training, and safety limitations, considering existing systems, programs, or force structure being traded off to support the new or modified system

- Objectives and minimum acceptable requirements for manpower and training which may be incorporated, as appropriate, in the acquisition program baseline

2.5 MIL-H-46855B HUMAN ENGINEERING REQUIREMENTS FOR MILITARY SYSTEMS, EQUIPMENT AND FACILITIES

This document establishes and defines the requirements for applying HFE to the development and acquisition of military systems, equipment and facilities. These requirements are the basis for including HFE during proposal preparation, system analysis, task analysis, system design (including software design), equipment and facilities design, testing, and documentation and reporting. They include the work to be accomplished by the contractor or subcontractor in conducting a HFE effort integrated with the total system engineering and development effort.

The goals of imposing positive management control on HFE effort through MIL-H-46855B are as follows:

- System requirements are achieved by appropriate use of the human component
- Through proper design of equipment, software and environment, the personnel-equipment/software combination meets system performance goals
- Design features will not constitute a hazard to personnel
- Trade-off points between automated vs. manual operation have been chosen for peak system efficiency within appropriate cost limits
- HFE applications are technically adequate
- The equipment is designed to facilitate required maintenance
- Procedures for operating and maintaining equipment are efficient, reliable and safe
- Potential error-inducing equipment design features are minimized
- The layout of the facility and the arrangement of equipment affords efficient communication and use
- The contractors provide the necessary manpower and technical capability to accomplish the above objectives

Both general and detail requirements are propagated.

2.5.1 GENERAL REQUIREMENTS

- HFE shall be applied during development and acquisition of military systems, equipment and facilities to achieve the effective integration of personnel into the design of the system.

- The HFE effort shall develop or improve the crew-equipment/software

interface and achieve required effectiveness of human-performance during system operation/maintenance/control and make economical demands on personnel resources, skills, training and costs.

- HFE program planning will include the tasks to be performed, HFE milestones, level of effort, methods to be used, design concepts to be utilized, and the T&E program, in terms of integrated effort within the total project¹.

- Efforts performed to fulfill HFE requirements shall be coordinated with efforts performed in accordance with other contractual requirements, in order to avoid duplication of effort².

- HFE program effort will include, but not be limited to:

- Analysis --
 - Mission Analysis
 - Function Analysis
 - Function Allocation
 - Task Analysis
 - Design Effectiveness Studies
 - HFE High Risk Identification
- Design and Development --
 - Conversion of Analysis Data into Detail Design/Development Plans
 - Execution of Plans to Create Personnel-System Interface Which Will Operate Within Human Performance Capabilities, Meet System Functional Requirements, and Accomplish Mission Objectives
- Test and Evaluation --
 - Verify That Design of Equipment, Software, Facilities and Environment Meets HFE and Life Support Criteria
 - Verify That Design is Compatible With the Overall System Requirements

2.5.2 DETAIL REQUIREMENTS

Detail Requirements expand on the General Requirements:

2.5.2.1 Analysis.

2.5.2.1.1 Defining and Allocating System Functions. Functions that must be performed by the system to achieve its objective shall be analyzed and HFE principles and criteria employed to allocate function accomplishment to human, automatic, or combined operation/maintenance³.

- **Information Flow and Processing Analysis** -- determine basic information flow and processing required

- **Estimates of Potential Operator/Maintainer Processing Capabilities** -- identify plausible human roles in the system, estimate processing load, accuracy, rate, and time delay requirements
- **Allocation of Function** -- analysis and trade-off study to determine which system function should be machine-implemented or software controlled and which should be human operator/maintainer implemented, based on performance data, cost data, and known constraints³

2.5.2.1.2 Equipment Selection. HFE principles and criteria will be used, along with other design requirements, to identify and select particular equipment to be operated/maintained/controlled by personnel⁴.

2.5.2.1.3 Analysis of Tasks.

- **Gross Task Analysis** -- provide information for making design decisions, developing preliminary manning levels, and input to Logistics Support Analysis
- **Analysis of Critical Tasks** -- tasks which require critical human performance⁵, reflect possible unsafe practices or are subject to promising improvements in operating efficiency are analyzed in greater depth for all missions and phases, including degraded modes of operation
- **Workload Analysis** -- individual and crew workload analyses are performed and compared with performance criteria
- **Concurrence and Availability** -- task analyses will be modified as required to reflect the current design and will be available to the procuring activity

2.5.2.1.4 Preliminary System and Subsystem Design. Preliminary system and subsystem configuration and arrangement shall satisfy performance requirements and comply with applicable criteria in MIL-STD-1472D, *Human Engineering Design Criteria for Military Systems, Equipment and Facilities*, as well as other HFE criteria specified by contract⁶.

2.5.2.2 Human Engineering in Equipment Detail Design. HFE principles and criteria will be applied to system and subsystem designs represented by design criteria documents, performance specifications, and drawings and data.

2.5.2.2.1 Studies, Experiments and Laboratory Tests. As required to resolve HFE and life support problems specific to the system

- **Mockups and Models** -- full-scale three-dimensional mockups of equipment involving critical human performance will be constructed and employed to resolve access, workspace and related HFE problems and incorporating solutions into systems design
- **Dynamic Simulation** -- utilized as an HFE design tool when necessary for detail design of equipment requiring critical human performance

2.5.2.2.2 Equipment Detail Design Drawings. HFE principles and criteria will be reflected in detail design drawings, including

- panel layout drawings
- communication system drawings
- overall layout drawings
- control drawings
- drawings depicting equipment important to system operation and maintenance by human operators

2.5.2.2.3 Work Environment, Crew Stations and Facilities Design. Will be designed according to HFE principles and criteria of MIL-STD-1472D⁷ and other criteria specified by the contract, including at least:

- atmospheric conditions
- weather and climate aspects
- accelerative forces
- acoustic noise
- weightlessness
- disorientation minimization
- adequate space
- adequate physical/visual/auditory links
- safe/efficient walkways, stairways, platforms and inclines
- psychological stress minimization
- clothing and personal equipment effects
- equipment handling provisions
- chemical, biological, toxicological, radiological, electrical and electronic hazard protection
- illumination
- sustenance and storage requirements and refuse management
- crew safety protective restraints

2.5.2.2.4 HFE in Performance and Design Specification. Performance and design specifications will conform to HFE criteria of MIL-STD-1472D and other

HFE criteria specified by the contract.

2.5.2.2.5 Equipment Procedure Development. HFE principles and criteria will be applied to the development of procedures for operating, maintaining or otherwise using the system, based on human performance functions and tasks identified by HFE analyses⁸.

2.5.2.3 Human Engineering in Test and Evaluation. Establish and conduct a T&E program to:

- assure fulfillment of the applicable requirements of MIL-H-46855B
- demonstrate performance of system, equipment and facility design to HFE design criteria
- confirm compliance with performance requirements were personnel are a performance determinant
- secure quantitative measures of system performance which are a function of the human interaction with equipment
- determine whether undesirable design or procedural features have been introduced

2.5.2.3.1 Planning. Planning will include methods of testing (e.g., checklists, data sheets, test participant descriptors, questionnaires, operating procedures and test procedure), schedules, quantitative measures, test criteria and reporting processes⁹.

2.5.2.3.2 Implementation. HFE T&E will be implemented on approval by the procuring activity and will include:

- simulation of mission or work cycle
- tests in which human participation is critical
- representative sample of non-critical scheduled and unscheduled maintenance tasks
- proposed job aids, new equipment training programs, training equipment, and special support equipment
- test participants representative of the range of the intended military user of the system
- collection of task performance data in simulated or actual operational environments
- identification of discrepancies between required and obtained task performance
- criteria for acceptable performance of the test

2.5.2.3.3 Failure Analysis. All failures occurring during T&E will be subjected to an HFE review.

2.5.3 Discussion of MIL-H-46855B Requirements

1. Program planning is a management function within HFE. A data item description (DID) exists for a Human Engineering Program Plan (HEPP) (DI-HFAC-80740) and should be employed for the purposes of this requirement. Integration of HFE program planning within the total project is a function of HSI program management and would be described in the HSIP.

2. This requirement is also achieved through the integration of the HEPP into the HSIP.

3. This indicates that "left-over" or "economic" allocation methods are not sufficient. Some form of HFE procedures must be employed to ensure that allocations reflect "Fitts list" type principles and criteria.

4. This involves the application of "static" HFE guidance to the selection of equipment, without consideration of the dynamic role-of-man (his functions, tasks, instrumentation/control requirements, etc.) implications. These principles and criteria are essentially those found in MIL-STD-1472D.

5. A critical human performance is defined here as one which, if not accomplished in accordance with system requirements, will most likely have adverse effects on cost, system reliability, efficiency, effectiveness, or safety.

6. This extends to application of HFE principles and criteria, per MIL-STD-1472D to designed, as opposed to selected, equipment, systems, and subsystems.

7. MIL-STD-1472D contains safety and health guidance as well as HFE guidance. Many of these considerations overlap with SS/HH concerns which should be tracked separately.

8. This requirement is somewhat weak. A distinction should be made between an effective procedure and an efficient procedure. An effective procedure accomplishes the function; an efficient procedure accomplishes it in the most productive manner. Equipment procedure development should attempt to use HFE methods, principles and criteria to develop optimum procedures, both effective and efficient. In addition, some consideration should be given here to the differing implications of different types of procedures, i.e. normal operating procedures, emergency operating procedures, non-normal procedures (eg. maintenance), etc.

9. Distinctions should be made between the differing objectives of HFE DT&E and OT&E.

10. This discussion should indicate what HFE specific information should be included in the TEMP.

2.6 MIL-STD-882B SYSTEM SAFETY PROGRAM REQUIREMENTS

This Section presents information of MIL-STD-882B¹ as follows:

2.6.1 Purpose

2.6.2 System Safety Requirements

- 2.6.2.1 System Safety Program
- 2.6.2.2 System Safety Program Objectives
- 2.6.2.3 System Safety Design Requirements
- 2.6.2.4 System Safety Precedence
- 2.6.2.5 Risk Assessment
- 2.6.2.6 Action on Identified Hazards

2.6.3 System Safety Program Tasks

- 2.6.3.1 Program Management and Control
- 2.6.3.2 Design and Evaluation
- 2.6.3.3 Software System Safety

2.6.4 System Safety Program Requirements in the LCSMM

- 2.6.4.1 Mission Need Determination
- 2.6.4.2 Phase 0 -- Concept Exploration
- 2.6.4.3 Phase I -- Concept Demonstration and Validation
- 2.6.4.4 Phase II -- Engineering and Manufacturing Development
- 2.6.4.5 Phase III -- Production and Deployment
- 2.6.4.6 SSE Tasks in Program Phases

2.6.5 Discussion of MIL-STD-882B Requirements

2.6.1 PURPOSE

This standard provides uniform requirements for developing and implementing a system safety program of sufficient comprehensiveness to identify the hazards of a system and to impose design requirements and management controls to prevent mishaps by eliminating hazards or reducing the associated risk to a level acceptable to the managing activity².

The standard applies to DoD systems and facilities including test, maintenance and support, and training equipment. System safety tasks described in the standard are selectively applied to DoD contract-definitized procurements, requests for proposal (RFP), statements of work (SOW), and Government in-house developments requiring system safety programs for the development, production, and initial deployment of systems, facilities, and

equipment. (The word "contractor" used in the standard also includes Government activities developing military systems and equipment.)

2.6.2 SYSTEM SAFETY REQUIREMENTS

2.6.2.1 System Safety Program. The contractor will establish and maintain a system safety program to support efficient and effective achievement of overall objectives^{3,4}.

2.6.2.2 System Safety Program Objectives⁴. The system safety program shall define a systematic approach to ensure:

- safety, consistent with mission requirements, is designed into the system in a timely, cost-effective manner;
- hazards associated with each system are identified, evaluated, and eliminated, or the associated risk is reduced to a level acceptable to the managing activity throughout the entire life cycle of the system;
- historical safety data, including lessons learned from other systems, are considered and used;
- minimum risk is sought in accepting and using new designs, materials, and production and test techniques;
- actions taken to eliminate hazards or reduce risk to a level acceptable to the managing activity are documented⁵;
- retrofit actions required to improve safety are minimized through the timely inclusion of safety features during research and development and acquisition of the system;
- changes in design, configuration, or mission requirements are accomplished in a manner that maintains a risk level acceptable to the managing activity;
- consideration is given to safety, ease of disposal, and demilitarization of any hazardous materials associated with the system;
- significant safety data are documented as "lessons learned" and are submitted to data banks or as proposed changes to applicable design handbooks and specifications⁶.

2.6.2.3 System Safety Design Requirements. Specific system safety design requirements for a system will be specified after review of pertinent standards, specifications, regulations, design handbooks, and other sources of design

guidance for applicability to the design of the system under consideration⁷.

General system safety design requirements are:

- Eliminate identified hazards or reduce associated risk through design⁸.
- Isolate hazardous substances, components, and operations from other activities, areas, personnel, and incompatible materials.
- Locate equipment such that access during operations, servicing, maintenance, repair, or adjustment minimizes personnel exposure to hazards.
- Minimize risk resulting from excessive environmental conditions.
- Design to minimize risk created by human error in the operation and support of the system⁹.
- Consider alternate approaches to minimize risk from hazards that cannot be eliminated¹⁰.
- Protect the power sources, controls and critical components of redundant subsystems by physical separation or shielding.
- When alternative design approaches cannot eliminate the hazard, provide warning and caution notes in assembly, operations, maintenance, and repair instructions, and distinctive markings on hazardous components and materials, equipment, and facilities.
- Minimize the severity of personnel injury or damage to equipment in the event of a mishap.
- Design software controlled or monitored functions to minimize initiation of hazardous events or mishaps.
- Review design criteria for inadequate or overly restrictive requirements regarding safety.

2.6.2.4 System Safety Precedence¹¹. The order of precedence for satisfying system safety requirements and resolving identified hazards is:

- *Design to Eliminate Risk.* Design to eliminate or obviate the hazard from the beginning.
- *Design for Minimum Risk.* If an identified hazard cannot be eliminated, reduce the associated risk to an acceptable level through design selection.
- *Incorporate Safety Devices.* If a hazard cannot be eliminated or the associated risk reduced to an acceptable level through design, use fixed,

automatic, or other protective safety design features or devices to reduce risks to an acceptable level.

- *Provide Warning Devices.* When neither design nor safety devices can effectively eliminate identified hazards or adequately reduce associated risk, use devices to detect the condition and to produce an adequate warning signal to alert personnel of the hazard. Design warning signals and their application to minimize the probability of incorrect response to the signal and standardize within like types of systems.

- *Develop Procedures and Training.* Where it is impractical to eliminate hazards through design selection or adequately reduce the associated risk with safety and warning devices, use special safety procedures and training. However, without a specific waiver, no warning, caution, or other form of written advisory shall be used as the only risk reduction method for Category I or II hazards. Procedures may include the use of personal protective equipment. Precautionary notations shall be standardized. Tasks and activities judged critical by the managing activity may require certification of personnel proficiency.

2.6.2.5 Risk Assessment. Decisions regarding priority and resolution of identified hazards are based on an assessment of the risk associated with the hazard. Hazards are characterized in terms of severity and probability.

Hazard severity categories are defined to provide a qualitative measure of the worst credible mishap resulting from personnel error, environmental conditions, design inadequacies, procedural deficiencies, or system, subsystem or component failure or malfunction as follows:

<u>Description</u>	<u>Definition</u>
• Catastrophic	Death or system loss
• Critical	Severe injury, severe occupational illness, or major system damage
• Marginal	Minor injury, minor occupational illness, or minor system damage
• Negligible	Less than minor injury, occupational illness, or system damage

The probability that a hazard will be created during the planned life expectancy of the system can be described in potential occurrences per unit of time, events, population, items, or activity. Qualitative hazard probability ratings

are:

<u>Description</u>	<u>Individual Item</u>	<u>Fleet or Inventory</u>
Frequent Probable	Likely to Occur Frequently Will Occur Several Times in Life of an Item	Continuously Experienced Will Occur Frequently
Occasional	Likely to Occur Sometime in Life of an Item	Will Occur Several Times
Remote	Unlikely But Possible to Occur in Life of an Item	Unlikely But Can Reason- ably Expected to Occur
Improbable	So Unlikely It Can Be Assumed Occurrence May Not Be Experienced	Unlikely to Occur, But Possible

A hazard risk index (HRI) can be obtained from matrixing severity and probability ratings, as presented in an example from MIL-STD-882B, below:

	<u>Catastrophic</u>	<u>Critical</u>	<u>Marginal</u>	<u>Negligible</u>
Frequent	1	3	7	13
Probable	2	5	9	16
Occasional	4	6	11	18
Remote	8	10	14	19
Improbable	12	15	17	20
<u>Hazard Risk Index</u>	<u>Criteria</u>			
1 - 5	Unacceptable			
6 - 9	Undesirable (Managing Activity Decision Required)			
10 - 17	Acceptable with Review by Managing Activity			
18 - 20	Acceptable Without Review			

This is an example only, and actual HRI cross-products and criteria would be tailored for individual acquisition programs.

2.6.2.6 Action On Identified Hazards. Action will be taken to eliminate identified hazards or reduce the associated risk. Catastrophic and Critical hazards will be eliminated if their associated risk reduced to a level acceptable to the managing activity. If this is impossible or impractical, alternatives will be recommended to the managing activity.¹²

2.6.3 SYSTEM SAFETY PROGRAM TASKS

The bulk of MIL-STD-882B is a collection of system safety "tasks" which may be imposed on contractors or government activities in order to require and define the conduct a system safety engineering program. Task descriptions, contained in Section 5 of MIL-STD-882B, are to be tailored by the managing agency as required by governing regulations and as appropriate to particular systems or equipment program type, magnitude, and funding. The SSE tasks are divided into Program Management and Control (100-series), Design and Evaluation (200-series), and Software Safety (300-series).

2.6.3.1 Program Management and Control. The following constitute the MIL-STD-882B SSE Program Management and Control tasks:

<u>Task</u>	<u>Title</u>
100	System Safety Program
101	System Safety Program Plan
102	Integration/Management of Associate Contractors, Subcontractors, and Architect and Engineering Firms
103	System Safety Program Reviews
104	System Safety Group/ System Safety Working Group Support
105	Hazard Tracking and Risk Resolution
106	Test and Evaluation Safety
107	System Safety Progress Summary
108	Qualifications of Key Contractor System Safety Engineers/Managers

Task 100 must be imposed in order to require a SSE program. Paragraph 4.1 of MIL-STD-882B calls for the establishment and maintenance of an SSE program¹³.

The SSPP defined by **Task 101** is the basic tool used by the managing activity to assist in managing an effective SSE program. The SSPP identifies all safety program activities specified by the managing activity and shows how the safety program will provide input or preclude duplication of effort.

Task 102 provides the authority for management surveillance needed by the integrating or facilities acquisition contractor by assigning the various systems safety roles of associate contractors, subcontractors, integrators, and construction firms.

Special system safety reviews may be needed to fulfill requirements of munitions safety boards, first flight readiness reviews, or other safety certification

authorities. **Task 103** specifies these reviews in the Statement of Work.

Contractor support of a government SSG/SSWG is detailed in the contract through imposition of **Task 104**.

Task 105 defines requirements for documenting actions taken to eliminate hazards or reduce associated risk, as required in Objective 4.2.e.¹⁵

Task 106 provides needed contractor management activities to ensure that all test safety requirements are met prior to and during testing.

Task 107 requires a periodic written report on the status of SSE and management activities.¹⁶

Task 108 lists special qualifications for key systems safety engineers and managers which may be imposed on the contractor organization as required.¹⁷

2.6.3.2 Design and Evaluation¹⁸. The following constitute the MIL-STD-882B SSE Design and Evaluation tasks:

<u>Task</u>	<u>Title</u>
201	Preliminary Hazard List
202	Preliminary Hazard Analysis
203	Subsystem Hazard Analysis
204	System Hazard Analysis
205	Operating & Support Hazard Analysis
206	Occupational Health Hazard Analysis
207	Safety Verification
208	Training
209	Safety Assessment
210	Safety Compliance Assessment
211	Safety Review of ECPs and Waivers
212	--- Reserved ---
213	GFE/GFP System Safety Analysis

Task 201 requires a Preliminary Hazard Analysis (PHA), a listing of hazards that may require special safety design emphasis or hazardous areas where in-depth analyses need to be done.

Task 202 requires a Preliminary Hazard Analysis (PHA), the initial effort in hazard analysis during the system design phase, or the programming and requirements development phase for facilities acquisition.

Task 203 requires a Subsystem Hazard Analysis (SSHA), which looks at each subsystem or component and identifies hazards associated with operating or failure modes. It is especially intended to determine how operation or failure of components affects the overall safety of the system.

Task 204 requires a System Hazard Analysis (SHA), which examines how system operation and failure modes can affect the safety of the system and its subsystems. The SHA examines all subsystem interfaces.

Task 205 requires an Operating and Support Hazard Analysis (O&SHA), which identifies and evaluates the hazards associated with the environment, personnel, procedures, and equipment involved throughout the operation of a system/element.

Task 206 requires an Occupational Health Hazard Assessment (OHHA), which:

- identifies and determines quantities of potentially hazardous materials or physical agents involved with the system and its logistical support,
- analyzes how those materials or physical agents are used in the system and for its logistical support,
- estimates where and how personnel exposures may occur and the degree or frequency of exposure involved, and
- incorporates into the design of the system and its logistical support, cost effective controls to reduce exposures to acceptable levels.

Task 207 outlines how verification of safety requirements should be performed.¹⁹

Task 208 imposes required certification training for personnel involved in development, test, and operation of the system.

Task 209 imposes the requirement to develop a Safety Assessment Report (SAR).²⁰

Task 210 imposes the requirement to perform a Safety Compliance Assessment (SCA) to verify the safe design of the system and obtain a comprehensive evaluation of the safety risk being assumed prior to test or operation of the system. The SCA is typically reported as part of the SAR.

Task 211 imposes the requirement to assess ECPs and requests for deviations/waivers for any possible safety impacts to the system.

Task 212 is not currently assigned but is reserved for future use.

Task 213 is imposed to permit the contractor to integrate GFE/GFP items into the system design with full knowledge of the associated hazards and risk controls by requiring acquisition of existing analysis documentation.

2.6.3.3 Software System Safety.²¹ The following constitute the MIL-STD-882B Software System Safety tasks:

<u>Task</u>	<u>Title</u>
301	Software Hazards Safety Analysis
302	Top-Level Design Hazard Analysis
303	Detailed Design Hazard Analysis
304	Code-Level Software Hazard Analysis
305	Software Safety Testing
306	Software/User Interface Analysis
307	Software Change Hazard Analysis

Task 301 requires a Software Requirements Hazard Analysis (SRHA), which:

- establishes a software safety requirements tracking system within the configuration management system²²,
- performs a thorough review and analysis of software requirements aimed at identifying existing requirements and assuring an accurate flow down of those requirements into the Software Requirements Specification (SRS), and
- produces required and recommended actions to eliminate identified hazards (or reduce their associated risk to an acceptable level) and make preliminary testing requirements.

Task 302 requires a Top-Level Design Hazard Analysis (TDHA), which:

- relates hazards identified in the PHL, PHA, and SRHA to specific Computer Software Configuration Items (CSCIs),
- examines the software to determine the independence/dependence and interdependence among CSCIs, modules, tables, variables, etc.,
- Analyzes the top-level design for compliance with safety requirements.

Task 303 requires a Detailed Design Hazard Analysis (DDHA), which:

- relates hazards identified in the PHA, SRHA, and TDHA to specific low level computer software components, and identifies those components which control or affect the hazards;
- examines the software to determine the independence/dependence and interdependence among low level components, modules, tables, variables, etc.,
- analyzes the detailed design of components for compliance with the safety requirements;
- Develops requirements for inclusion in test plans, descriptions, and procedures.

Task 304 requires a Code-Level Software Hazard Analysis (CSHA), which examines the actual source and object code of software to verify the actual design implementation. Additionally the task requires a review of the software documentation being developed to ensure that the safety features and

requirements of the software are included.

Task 305, Software Safety Testing, establishes requirements for testing of the lower level units of software almost immediately after coding of the unit has been completed, and system level testing of the software after a successful TRR.

Task 306, Software/User Interface Analysis, establishes requirements for the user/operator interface to ensure that the system will be operated in a safe manner.²³ Procedures²⁴ must be developed that will:

- provide for the detection of the onset of hazardous conditions in order to prevent the hazard from occurring;
- control the hazard so it occurs only in specific instances and on specific command from the operator;
- provide a warning to the operator that a potentially hazardous situation is about to occur or is occurring;
- ensure that the system will survive if a hazard occurs;
- provide damage control and recovery procedures should a hazard occur, or if prevention and control procedures fail;
- provide survival and recovery procedures from critical hazard conditions;
- provide the capability to safely abort or cancel an event, process, or program;
- provide a warning to alert of system or software malfunction or failure, and ensure that the operator is made aware of all such failures existing at one time;
- ensure that the display of hazard data is unambiguous and provides the operator all necessary data to make safety critical decisions.

Task 307 requires the conduct of Software Change Hazard Analysis , which is the examining and analysis of changes, modifications, and patches to specifications, requirements, equipment, software design, and source and object code for safety impact.

2.6.4 SYSTEM SAFETY PROGRAM REQUIREMENTS IN THE LCSMM

MIL-STD-882B was developed and revised prior to the 1990 revision of DODD 5000.1 and DODI 5000.2. The following discussions attempt to express the requirements of MIL-STD-882B in terms of the current LCSMM.

2.6.4.1 Mission Need Determination. The SSE effort should support the justification of the materiel need by identifying safety deficiencies in existing or projected capability and by identifying opportunities for system safety to improve mission capability or reduce life cycle costs.²⁵

2.6.4.2 Phase 0 -- Concept Exploration. Evaluate the alternative system concepts under consideration for development and establish the system safety program, consistent with the identified mission need and life cycle requirements. Specific tasks will include:²⁶

- Prepare a System Safety Program Plan (SSPP);
- Perform a Preliminary Hazard Analysis (PHA) to identify hazards associated with each alternative;
- Review safe and successful design of predecessor or similar systems for consideration in alternative concepts;
- Define the SSE requirements based on past experience with similar systems;
- Evaluate all considered materials, design features, maintenance, servicing, operational concepts, and environments which will affect safety throughout the life cycle;
- Highlight special areas of safety considerations, such as system limitations, risks, and man-rating requirements;
- Identify safety requirements that may require a waiver during the system life cycle;
- Identify safety design analysis, test, demonstration and validation requirements.
- Document the system safety analyses, results, and recommendations for each promising alternative system concept;
- Prepare a summary report of the results of the SSE tasks conducted during the phase to support the decision-making process;
- Tailor the SSE program for subsequent phases and include detailed requirements in the appropriate contractual documents.

2.6.4.3 Phase I -- Concept Demonstration and Validation. SSE tasks during this phase will be tailored for programs ranging from extensive study and analyses through hardware development to prototype testing, demonstration and validation. Specific tasks will include:

- Prepare or update the SSPP;
- Establish SSE requirements for system design and criteria for verifying that these requirements have been met;
- Participate in tradeoff studies to reflect the impact on system safety

requirements and risk;

- Recommend system design changes based on these studies to ensure optimum safety consistent with performance and system requirements;
- Perform or update the PHA to evaluate the configuration to be tested.
- Prepare a System Hazard Analysis (SHA) report of the test configuration considering the planned test environment and methods;
- Perform detailed hazard analyses (SHA or Subsystem Hazard Analysis (SSHA)) of the design to assess the risk involved in test operation of the system hardware and software;
- Recommend redesign or other corrective action based on evaluation of the results of safety tests, failure analyses, and mishap investigations;
- Perform Operating and Support Hazard Analyses (O&SHA) of each test, and review all test plans and procedures. Make sure hazards identified by analyses and tests are eliminated or the associated risk minimized;
- Identify critical parts and assemblies, production techniques, assembly procedures, facilities, testing and inspection requirements which may affect safety and ensure²⁷:
 - Adequate safety provisions are included in the planning and layout of the production line;
 - Adequate safety provisions are included in inspections, tests, procedures, and checklists for quality control of the equipment being manufactured;
 - Production and manufacturing control data contain required warnings, cautions, and special safety procedures;
 - Testing and evaluation are preformed on early production hardware to detect and correct safety deficiencies;
 - Minimum risk is involved in accepting and using new design, materials, and production and test techniques;
- Establish analysis, inspection and test requirements for GFE or other contractor-furnished equipment to verify prior to use that applicable SSE requirements are satisfied;
- Review logistic support publications for adequate safety considerations, and ensure the inclusion of applicable DOT, EPA, and OSHA requirements;

- Ensure SSE requirements are incorporated into the system specification/design document;
- Prepare summary report of the results of SSE tasks conducted to support the decision-making process;
- Continue to tailor the SSE program.

2.6.4.4 Phase II -- Engineering and Manufacturing Development. SSE tasks will include:

- Prepare or update the SSPP;
- Review preliminary engineering designs to ensure safety design requirements are incorporated and hazards identified are eliminated or reduced to an acceptable level;
- Review appropriate engineering documentation to ensure safety considerations have been incorporated;
- Identify, evaluate, and provide safety considerations for tradeoff studies;
- Perform or update the SSHA, SHA and O&SHA and safety studies concurrent with the design/test effort to identify design and/or operating and support hazards. Recommend any required design changes and control procedures;
- Perform an O&SHA for each test, and review all test plans and procedures;
- Participate in technical design and program reviews and presents of the SHA, SSHA, and/or O&SHA;
- Recommend redesign or other corrective actions based on identification and evaluation of the effects of storage, shelf-life, failure analyses and mishap investigations;
- Review logistic support publications for adequate safety considerations and ensure the inclusion of applicable DOT, EPA and OSHA requirements;
- Verify the adequacy of safety and warning devices, life support equipment, and personal protective equipment;
- Identify the need for safety training and provide safety inputs to training courses;
- Provide system safety surveillance and support of test unit production

and of plan for production and employment. Identify critical parts and assemblies, production techniques, assembly procedures, facilities, testing and inspection requirements which may affect safety and ensure:

- Adequate safety provisions are included in the planning and layout of the production line;
- Adequate safety provisions are included in inspections, tests, procedures, and checklists for quality control of the equipment being manufactured;
- Production and manufacturing control data contain required warnings, cautions, and special safety procedures;
- Testing and evaluation are performed on early production hardware to detect and correct safety deficiencies;
- Minimum risk is involved in accepting and using new design, materials, and production and test techniques;
- Ensure that procedures developed for system test, maintenance, operation, and servicing provide for safe disposal of expendable hazardous materiel;
 - Update SSE requirements in system specification/design documents;
 - Prepare a summary report of the results of the SSE tasks to support the decision making process;
 - Tailor SSE program requirements for the Production and Deployment Phase.

2.6.4.5 Phase III -- Production and Deployment.

- Prepare or update the SSPP
- Identify critical parts and assemblies, production techniques, assembly procedures, facilities, testing and inspection requirements which may affect safety and ensure:
 - Adequate safety provisions are included in the planning and layout of the production line;
 - Adequate safety provisions are included in inspections, tests, procedures, and checklists for quality control of the equipment being manufactured;
 - Production and manufacturing control data contain required warnings, cautions, and special safety procedures;

- Testing and evaluation are performed on early production hardware to detect and correct safety deficiencies;
- Minimum risk is involved in accepting and using new design, materials, and production and test techniques;
- Verify that test and evaluation is performed on early production hardware to detect and correct safety deficiencies;
 - Perform O&SHA for each test, and review all test plans and procedures. Ensure that hazards identified by test and analysis are eliminated or associated risk reduced to an acceptable level;
 - Review technical data for warnings, cautions and special procedures identified as required in the O&SHA for safe operation, maintenance, servicing, storage, packaging, handling, and transportation;
 - Perform O&SHA of deployment operation, and review all deployment plans and procedures. Ensure that hazards identified by analysis are eliminated or associated risk reduced to an acceptable level;
 - Review procedures and monitor results of periodic field inspections to ensure acceptable levels of safety are maintained. Identify major or critical characteristics of safety significant items that deteriorate with age, environmental conditions, or other factors;
 - Perform or update hazard analyses to identify new hazards that may result from design changes. Ensure that safety implications of the changes are considered in all configuration control plans;
 - Evaluate results of failure analyses and mishap investigations. Recommend corrective actions;
 - Monitor the system throughout the life cycle to determine the adequacy of the design and operating/maintenance/emergency procedures;
 - Conduct a safety review of proposed new operating and maintenance procedures, or changes, to ensure the procedures, warnings, and cautions are adequate and inherent safety is not degraded;
 - Document hazardous conditions and system deficiencies for development of follow-on requirements for modified or new systems;
 - Update safety documentation to reflect safety "lessons learned";
 - Evaluate the adequacy of safety and warning devices, life support equipment, and personal protective equipment.

2.6.4.6 SSE Tasks in Program Phases.

MIL-STD-882B provides an application matrix providing guidance on task selection to establish an acceptable and cost effective SSE program. This matrix can be used to initially identify those tasks which typically are included in an effective SSE program for a particular acquisition phase. The matrix is optional guidance only and not to be construed as covering all procurement situations.

Task	Title	Phase			
		0	I	II	III
100	System Safety Program	G	G	G	G
101	System Safety Program Plan	G	G	G	G
102	Integration/Management of Associate Contractors, Subcontractors, and AE Firms	S	S	S	S
103	System Safety Program Reviews	S	S	S	S
104	SSG/SSWG Support	G	G	G	G
105	Hazard Tracking & Risk Resolution	S	G	G	G
106	Test and Evaluation Safety	G	G	G	G
107	System Safety Progress Summary	G	G	G	G
108	Qualifications of Key SSE Personnel	S	S	S	S
201	Preliminary Hazard List	G	S	S	NA
202	Preliminary Hazard Analysis	G	G	G	GC
203	Subsystem Hazard Analysis	NA	G	G	GC
204	System Hazard Analysis	NA	G	G	GC
205	Operating & Support Hazard Analysis	S	G	G	GC
206	Occupational Health Hazard Assessment	G	G	G	GC
207	Safety Verification	S	G	G	S
208	Training	NA	S	S	S
209	Safety Assessment	S	S	S	S
210	Safety Compliance Assessment	S	S	S	S
211	Safety Review of ECPs & Waivers	NA	G	G	G
212	--- Reserved ---	--	--	--	--
213	GFE/GFP System Safety Analysis	S	G	G	G
301	Software Requirements Hazard Analysis	S	G	G	GC
302	Top-Level Design Hazard Analysis	S	G	G	GC
303	Detailed Design Hazard Analysis	S	G	G	GC
304	Code-Level Software Hazard Analysis	S	G	G	GC
305	Software Safety Testing	S	G	G	GC
306	Software User Interface Analysis	S	G	G	GC
307	Software Change Hazard Analysis	S	G	G	GC
S -- Selectively Applicable		G -- Generally Applicable			
NA -- Not Applicable		GC -- Generally Applicable to Design Changes Only			

2.6.5 DISCUSSION OF MIL-STD-882B REQUIREMENTS

1. MIL-STD-882B is the most comprehensive of the DoD-level, HSI-related regulatory and standards documents.

2. The establishment and conduct of a system safety program is required in a number of places within MIL-STD-882B.

The identification of hazards is the first step in system safety control; MIL-STD-882B details a number of analyses to be employed in the identification of hazards and their subsequent analysis and classification.

The preferred method for mitigating hazards is their elimination through design solutions. The SS program must interact with the design team to impose design requirements aimed at eliminating specific hazards.

Failing a design solution, the SS program must ensure the imposition of management controls (training, procedures, warnings and cautions, protective equipment, etc.), to achieve control of the hazard or the reduction of associated risk to an acceptable level.

3. This requirement effectively compels the imposition of Task 100 on all system development efforts.

4. This list summarizes the requirements of MIL-STD-882D Section 4, which are discussed more fully in Section 2.6.2 of this report.

5. This requirement effectively compels the imposition of Task 105 on all system development efforts.

6. This requirement effectively compels the imposition of Task 209 on all system development efforts.

7. The simple imposition of general safety standards, requirements, and design criteria is not sufficient. The developer (i.e., the military department) is required to analyze the system to identify the need for specific safety requirements and to impose those on it's development as well.

8. The interaction between SS/HH and HFE is essentially the way in which identified hazards are eliminated or risk reduced. SS/HH identifies the hazards, HFE provides the solution.

9. Standard, normal HFE design efforts have this as a goal. Those efforts must be coordinated.

10. These are trade-off efforts. Both design-based mitigation and management controls are proposed by HFE and analyzed in trade-studies.

11. This section (Paragraph 4.4 of MIL-STD-882B) explicitly states the manner in which SS/HH efforts will be directed. "The order of precedence for satisfying system safety requirements and resolving identified hazards shall be..." This is what drives all SS/HH efforts and prioritizes HFE solution seeking.

12. This is arguably the weakest part of MIL-STD-882B. Catastrophic and Critical hazards are specifically designated for action, but it is unclear as to how these efforts are to be approached.

13. Since a SS program is required for all acquisitions in Section 4.1 of MIL-STD-882B, this task should be imposed in all contract SOWs.

14. A SS Program Plan (SSPP) describes in detail tasks and activities of SS management and SS engineering required to identify, evaluate, and eliminate hazards, or reduce the associated risk to an acceptable level, throughout the system life cycle. It would be somewhat ineffective and illogical to require a SS program without requiring a SSPP to define and layout the program. There is, however, no explicit or implicit requirement within MIL-STD-882B for the imposition of Task 101.

15. Since Paragraph 4.2.e of MIL-STD-882B required documentation of SS/HH actions taken, Task 105 should be imposed in all contract SOWs.

16. This task should also require the imposition of Task 105. The hazard log required in Task 105 would form the basis for the periodic reports required in Task 107.

17. Additional levels of qualification would be helpful for tailoring purposes. The requirement of registration as a professional safety engineer or certification by the Board of Certified Safety Professionals in system safety can eliminate many qualified SS personnel, especially from an HFE background, from acting as principal SS engineer/manager. Differing programs, considering size, complexity, etc, may not need this level of certification.

18. These tasks really detail what will be the effort that constitutes the SS program. Unfortunately, while individual tasks describe what will be included in various analyses, specific methodologies for conducting the analyses are not described or referenced. This is a general weakness in MIL-STD-882B.

19. Task 207 should contain specific links to T&E requirements and

efforts, especially required inputs to the TEMP.

20. Section 4.2 requirements to document SS/HH actions and provide "lessons learned" effectively require the imposition of Task 209 on all system acquisitions.

21. This entire section was added to MIL-STD-882B through Notice 1 modification. Software safety is a relatively new field and as such is highly specialized, requiring a combination of expertise in safety and software/hardware design

Tasks 301 through 304 are increasingly more detailed analyses of the software, and are increasingly more difficult and costly.

22. This imposes the establishment of a "requirements" tracking system, which is different from the "hazard" tracking system required by Task 105. The Task 105 Hazard Tracking System is peculiar to the SS organization and is not contained within the configuration management system.

23. Software/user interface design is primarily and essentially an HFE task and must be closely coordinated between SS and HFE personnel.

24. Procedure development is also an HFE activity. Both aspects of Task 306, interface and procedure design, should have a heavy HFE involvement and not be left solely to the software personnel.

25. This conflicts with statements in DODD 5000.2 Part 6 Section I, which apparently indicate that lessons learned should not be addressed prior to Phase I. Again, a SS/HH deficiency in an existing system can itself be a mission need element which must be expressed in the MNS.

26. Not all of these activities would necessarily be imposed contractually via an SOW, though some of them may be; e.g, SSPP through Task 101, PHA through Task 202. The same is true for activities in subsequent phases. See section 2.6.4.6 of this report.

27. This effort goes beyond system-specific design and involved production capabilities and activities. This is another example of HSI concerns extending beyond simple design considerations.

2.7 DODD 1322.18 MILITARY TRAINING

DODI 5000.2 Part 7 Section 5 Paragraph 3.e.(4) directs that training materials and devices will be integrated into the total system¹ using the procedures prescribed in DODD 1322.18, *Military Training*, including the development of a total system training plan by Milestone II². The total system training plan will include a description of the total training system and address the training and/or operational system development schedule.

This section describes the purpose, policy, and procedures established by DODD 1322.18

2.7.1 PURPOSE

"This Directive establishes DoD policy, provides procedures, and assigns responsibilities for the training of military personnel and military units under the authority of reference (a)."

2.7.2 POLICY

"It is DoD policy to provide military training programs for the total force that effectively support required levels of force readiness³ and that use resources efficiently."

2.7.3 PROCEDURES

2.7.3.1 General.

2.7.3.1.1 Training as a System. Collective training, individual training (including institutional and on-the-job training (OJT)), and unit training shall be considered interdependent parts of an overall training system⁴. When decisions are made concerning one type of training, the effects on other types of training shall be considered.

2.7.3.1.2 Allocation of Resources for Training. Assigned wartime missions, employment and deployment schedules, and related requirements for training⁵ will be considered when allocating resources for individual and unit

* Title 10, *United States Code*, Sections 133 and 141.

training.

2.7.3.1.3 Planning Training for New Systems. The planning of training support for new weapon and equipment systems will be an integral part of the materiel acquisition process, per DODI 5000.2.⁶

2.7.3.1.4 Innovation in Training Technology. The development of innovative uses of training technology to make military training programs more effective and efficient will be supported by vigorous research programs.

2.7.3.1.5 Application of Simulation. Simulators will be developed, procured, distributed and used when they are capable of effectively and economically supplementing training on the actual equipment⁷, especially when they can provide training that might be limited by safety considerations or constraints on training space, time, or other resources⁸. Improving the quality of training and the state of readiness are primary considerations, potential savings in operating and support costs are secondary considerations.⁷

2.7.3.1.6 Application of Technology to Reserve Component Training. Technology will be emphasized in developing solutions to the unique training problems of the Reserves, related to geographical location and to limited time and training facilities.

2.7.3.2 Individual Training.

2.7.3.2.1 Training Requirements and Utilization. Training is based on the required skills and knowledges needed for specific military jobs, or on requirements for broader military skills, such as leadership.⁹

- The number of personnel trained is based on:¹⁰
 - the number of job positions in the approved force structure,
 - the projected inventory of qualified members, and
 - projected gains and losses in each skill and skill level.
- Assignment policies for each job skill are aimed at fully utilizing qualified members with relevant previous training, in order to avoid unnecessary training.
- Computations of aviator requirements, the utilization of inventories of qualified members, and the determination of aviator training rates are especially closely managed, due to the high cost of training.

2.7.3.2.2 Procedures for Structuring Training Programs. Individual training programs are designed, conducted and evaluated based on a systematic

set of procedures¹¹, including:

- Identification of training requirements for tasks to be performed on the job¹² and the knowledge and skills required to perform those tasks;
- Determination of the proper allocation of training tasks between institutional training and OJT in operational units;
- Selection of the most cost-effective methods of instruction and identification of training equipment and other media requirements;¹³
- Investigation of methods of tailoring training to the more restricted time available to the Reserve and development of curricula to meet those needs;
- Development of programs of instruction, including exportable instructional packages, to support OJT in units;
- Development of methods based on performance objectives for evaluating student progress and success;¹⁴
- Development of procedures, including feedback from operational units, for evaluating training programs to provide a basis for revisions and to verify that the programs meet training requirements at an acceptable cost.¹⁵

2.7.3.2.3 Other Related Considerations.

- Institutional training courses will be no longer than required to fulfill course objectives. Teaching methods which satisfy course objectives and compress time in training status will be employed when cost effective.
- Criterion for graduation from school coursed will be the satisfactory performance of identified learning tasks.¹⁶
- When dividing responsibility for teaching tasks between schools and operational units, the ability of the units to conduct effective OJT will be considered.¹⁷
- Computer-based instruction will be considered when front-end analysis determines that its use is effective and efficient.¹⁸

2.7.3.2.4 Training of New Military Personnel. New personnel will be given fundamental instruction for transitioning to the military environment, and in occupational specialties through institutional training courses or OJT. Such

institutional training normally is limited to the skills required in the initial period of service.

2.7.3.2.5 Training of Noncommissioned Officers. Each service will maintain military training programs, including institutional courses and OJT, which provide for the continued development of NCOs as leaders and skilled technicians.

2.7.3.2.6 Training of Officers. A structure of training programs for officers is maintained to provide a foundation for progressively more demanding leadership, managerial, and technical responsibilities and subsequent professional military education.

2.7.3.2.7 Inter-Service Training Cooperation. The services will jointly determine effective and affordable solutions to common training problems.

2.7.3.2.8 DoD Schools. A single DoD school will be considered when skills with a high degree of commonality are required in more than one service.

2.7.3.2.9 Capability for Mobilization Expansion. The services will periodically review requirements for trained manpower under mobilization conditions and their capacities in facilities, equipment and training staff to meet those requirements. Verified deficiencies will be considered for phased correction.¹⁹

2.7.3.3 Collective Training.

2.7.3.3.1 Requirements for Collective Training. Unit proficiency required to accomplish wartime missions will be achieved through collective training.

2.7.3.3.2 Realism. Collective training will be conducted under conditions and rates of activity closely approximating those that the units will encounter in combat²⁰, subject to such constraints as safety requirements²¹ and limits of space for training.

- Simulation and other technologies will be used to enhance realism when constraints limit the use of realistic training conditions.²¹
- Collective training will include, as feasible:
 - electronic warfare activity,
 - nuclear, biological and chemical defense activity,
 - the periodic use of opposing forces trained in the tactics of potential adversaries.
- All collective training exercises will emphasize realistic

performance of the functions of individual personnel in the exercising units.

- Support units will be integrated into exercises for realistic training in their wartime supporting roles.

2.7.3.3.3 Joint and Combined Exercises.

- When units from two or more services may operate together in wartime, they will periodically conduct joint exercises to maintain a high standard of coordination and joint control.
- Combined exercises with allied forces will be conducted for establishing and maintaining a capability to cooperate effectively in wartime.

2.7.3.3.4 Shared Use of Training Facilities. To ensure effective and efficient utilization of training facilities:

- The services will coordinate the shared use of ranges, maneuver areas, devices, and other training resources.
- Ranges, maneuver areas, and other facilities and devices maintained primarily for research, development, test, evaluation or other non-training functions, but with training potential, will be made available as applicable for shared training use.

2.7.3.3.5 Operational Activity and Training. Participation in operational missions will be used to meet the collective training requirements of the units involved.

2.7.3.3.6 Reserve Component Collective Training. Reserve components will be integrated into applicable exercises with the active forces.

2.7.3.3.7 Evaluation. All collective training and exercises are evaluated against established standards of military proficiency for identifying and correcting deficiencies.

2.7.4 DISCUSSION OF DODD 1322.18 REQUIREMENTS

1. Training, therefore, is a part of the *total system*. The system is not simply the hardware, it is the totality of hardware, software, personnel, procedures, training, maintenance, support, etc. DODD 1322.18, though promulgated in January of 1987, is very much in sync with the objectives and procedures of the HSI initiative.

2. The completion of a total system training plan by Milestone II is appropriate, permitting the development of training systems/material based on the established concept and development baseline, and providing all of Phase II for the generation of the required systems/material.

3. This makes the HSI-related connection between Training and Manpower, i.e., there must be sufficient training resources available to support the required manpower levels.

4. The concept of "Training as a System" is a logical extension of applied general systems theory and accepted systems engineering practice. Recognizing the effects of decisions regarding one type of training on another type of training, eg. the effects on unit training of decisions regarding institutional training, avoids unintended (often negative) impacts on training time requirements, costs, effectiveness, etc.

5. Training is not done for the sake of training, it is planned and executed based on the requirements of assigned wartime missions.

6. This requirement is based on 1987 acquisition policy. However, the intent and effect remain intact, i.e. training is not an add-on considered after the development of the system -- it is an integral part of the development and acquisition of the system.

7. The use of simulators should not be technology driven, i.e. the use of simulation because it is technically feasible. Simulation should be used when it effectively and efficiently adds to training effectiveness.

8. This implies and involves trade-off considerations between safety and training, training device designs and training procedures, training and trainer personnel/manpower requirements, etc. It is essentially an HSI function.

9. Again, training is not done for the sake of training. In a systems approach, training is based on the missions the personnel must carry out, either specific to MOS or general military skills.

10. Again, this is an HSI function of integration of Manpower, Personnel and Training.

11. This set of procedures implements the "Training as a System" approach.

12. Training requirements are based on the mission (i.e. job).

13. Training technology selection is based on effectiveness and efficiency,

not novelty or availability.

14. Student performance evaluation is based on the mission/job requirements identified in the first procedural step, not on some arbitrary training-related criteria.

15. The training system itself must be subjected to evaluation procedures, to ensure that it is effectively transmitting the required skills, knowledges and aptitudes required to carryout the mission/job requirements established in the first procedural step.

16. These, again, are the skills, knowledges and aptitudes required to carryout the mission/job requirements established in the first procedural step.

17. This reflects the both the "Training as a System" and HSI approaches. Overburdening operational units with OJT requirements will adversely impact the larger system for the sub-optimization of the training system.

18. The use of computer-based instruction will not be technology driven.

19. This is an acknowledgement of the HSI Training/Manpower inter-relationship, i.e. will there be sufficient training capability to meet manpower requirements during mobilization.

20. Realism in training is essentially an HFE/Training HSI consideration.

21. This is a Training/System Safety HSI consideration.

2.8 ASD (FM&P)* MEMO, 28 MAY91, HUMAN SYSTEM INTEGRATION PLAN IMPLEMENTATION PROCEDURES

2.8.1 PURPOSE

This memo guides the formulation of implementation procedures concerning the HSIP required by DODI 5000.2 Part 7 Section B. Specific requirements to support the ASD (FM&P) submission of HSI assessments to the Defense Acquisition Board are established.

2.8.2 GENERAL REQUIREMENTS

The memo requires that, at a minimum, each HSIP satisfy program documentation requirements for each of the six HSI elements specified in DODI 5000.2 Part 7 Section B Paragraph 3a(3).¹

The Program Manager/Program Executive Officer (or user representative prior to the appointment of a PM), will develop the HSIP after Concept Studies Approval², and document the management and resolution of HSI issues during the acquisition process.³ Human system goals and objectives, constraints, trade-offs, risks, and cost drivers documented in the plan will serve as the basis for HSI reporting requirements in other acquisition program documentation.⁴

ACAT ID plans will be furnished, upon request, to the HSI Division of ASD (FM&P).

2.8.3 SPECIFIC REQUIREMENTS

Plan formats (and the scope and formality for ACAT IC, II, III, and IV programs) will be left to the discretion of component program offices to support their individual responsibilities for HSI assessment.⁵

2.8.3.1 Milestone I -- Concept Demonstration Approval. By MS I, the HSIP will address:

- HSI high-drivers and lessons learned from predecessor or comparable systems;
- Whether any HSI parameters documented in the ORD were included in the Acquisition Program Baseline;

* Assistant Secretary of Defense for Force Management and Personnel

- Whether any human system exit criteria have been established;
- Identification of probable target audience for system operators and maintainers;⁶
- Impacts on HSI resources of design alternatives being considered;⁷
- How HSI cost, schedule, and design risk areas will be identified and managed;⁸
- How HSI will be included within early operational assessment of the most promising design approaches during Demonstration and Validation Phase;⁹
- Tools, analyses, data bases, and methodologies that are to be employed by the government or by industry to address HSI during Demonstration and Validation Phase;⁷
- How HSI considerations will be incorporated in the Acquisition Strategy.⁸

2.8.3.2 Milestone II -- Development Approval. By MS II, the HSIP will address:

- HSI trade-offs made during Demonstration and Validation;¹⁰
- How the results of HSI analytic efforts were used to enhance the design concept;¹⁰
- Results of early developmental testing and/or operational assessment as they pertain to HSI;
- Risk management plans affecting human systems;
- Whether adequate resources and manpower to support the program have been, or are committed to be programmed, and are affordable over program life;¹¹
- Human system performance criteria to be included in operation test and evaluation during Engineering and Manufacturing Development Phase and whether models, test beds, and simulations are to be used;
- How source selection criteria will assess the degree to which the proposed system reduces the cost of ownership and can be used effectively in its intended operational environment, considering such items as safety, human factors, manpower, and training requirements.¹²

2.8.3.3 Milestone III -- Production Approval. By MS III, the HSIP will address:

- How operational test and evaluation conducted during Engineering and Manufacturing Development Phase demonstrated that the system is operationally effective and suitable under realistic combat conditions;
- Whether adequate resources and manpower to support production, deployment, and support have been programmed;¹¹
- How scheduled maintainability demonstrations will be conducted in operational scenarios using personnel with representative skill levels.

2.8.3.4 Milestone IV -- Major Modification Approval. By MS IV, the HSIP will address:

- Further opportunities to reduce the cost of ownership;
- Efforts to ensure that residual health hazards and safety problems will be corrected as identified;
- Execution of deployment and support plans to include transition from contractor to organize support (if applicable).

2.8.4 DISCUSSION OF ASD (FM&P) MEMO, 28 MAY91 REQUIREMENTS

1. The six elements are the 6 HSI domains (HFE, SS, HH, MPT). The requirements of DODI 5000.2 Part 7 Section B Paragraph 3.a.(3) are listed in Section 2.1.3.1.3 of this report.

2. HSI activities should commence during Mission Needs Determination, i.e. prior to Concept Studies Approval (Milestone 0). The requirement to develop the HSIP after Milestone 0 should not be interpreted as implying that pre-MS 0 HSI activities are not essential or are to be avoided.

3. The requirement to document the management and resolution of HSI issues during the acquisition process makes the HSIP a "living document" and establishes the requirement for an "audit trail", "program history", or similar section in the HSIP.

4. HSI goals, objectives, constraints, trade-offs, risks and cost drivers must originate in the HSIP if they are to be referenced and serve as the basis for reporting requirements in other acquisition program documentation. This makes the identification and characterization of such elements within the HSIP a

critical and on-going effort for the HSI program.

5. The military department HSI program documentation should include approved HSIP formats.

6. It is unclear whether this requires the *description*, as opposed to the simple *identification*, of the intended target audiences. The requirement should be for a description, i.e., the development of a formal TAD.

7. These constitute the HSI technical program.

8. These represent the HSI management program.

9. This represents the HSI T&E program.

10. These constitute a description of HSI impacts on the system design entering Milestone II.

11. This essentially moves HSI activities beyond the development effort; the HSIP must indicate that resources and manpower external to the development effort are available, committed, and affordable.

12. This implements the HSI-relevant element of DODI 5000.2 Part 10 Section B, *Selection of Contractual Sources*, as described in Table 2.