NOT MEASUREMENT SENSITIVE

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DEPARTMENT OF DEFENSE STANDARD PRACTICE

HUMAN ENGINEERING REQUIREMENTS FOR MILITARY SYSTEMS, EQUIPMENT, AND FACILITIES

AMSC 9204 AREA HFAC

FOREWORD

1. This Military Standard has been approved for use by all Departments and Agencies of the Department of Defense.

2. MIL-STD-46855 is the primary tasking document used by the services to specify human engineering efforts during system acquisition. It supports the human factors engineering discipline independently or as a part of Human System Integration initiatives. MIL-STD-46855 is also written to accommodate a wide range of products, including small equipment items as well as major systems. This standard intentionally provides reasonable latitude for performing organizations to apply technical and program judgment and innovation consistent with specific procurements.

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

4. As a result of striving to accommodate all service HSI initiatives, all acquisition phases, and a wide range of products, while avoiding overly restrictive requirements, this Standard furnishes somewhat general tasking provisions for analysis, design, test, and related requirements. A collateral result is a lack of detail. While MIL-STD-46855 defines the tasking and planning for a human engineering program, specific design criteria for the other domains is governed by each domain's documents.

5. Comments, suggestions, or questions on this document should be addressed to Army Research Development and Engineering Command Aviation and Missile Research and Engineering Center, ATTN: RDMR-SET, 5400 Fowler Road Redstone Arsenal, AL 35895-5000 or emailed to streview@amrdec.army.mil. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at https://assist.daps.dla.mil.

CONTENTS

1. SCOPE

1.1 Scope. This standard establishes and defines the requirements for applying human engineering to the design, development, and acquisition of military systems, equipment, and facilities. These requirements include the work to be accomplished in conducting a human engineering effort integrated with the total system engineering and development effort. These requirements are the basis for including human engineering in proposals; system, equipment, software and associated user interfaces, and facility analysis, design and test; and documentation and reporting.

1.2 Applicability. This standard applies to the acquisition of military systems, equipment, and facilities. It is intended that these requirements be tailored to address the needs of each individual program or program phase.

1.3 Application guidance. In accordance with Department of Defense principles, directives and regulations governing the application and tailoring of specifications and standards to achieve cost effective acquisition and lifecycle ownership of defense materiel, this standard should be tailored to specific programs and the milestone phase of the program within the overall lifecycle. This tailoring should selectively apply methods, tables, sections, individual paragraphs, or sentences, or a combination thereof, to be placed on contract in order to impose essential human engineering requirements, consistent with avoiding unnecessary program costs. Criteria for the procuring activity's selection of this standard for contract use, and, when invoked, the partial and incremental application of the requirements provisions, are contained in Appendix A.

1.4 Section 508 compliance. Section 508 of the Rehabilitation Act of 1973 requires that when Federal agencies develop, procure, maintain, or use electronic and information technology, Federal employees with disabilities have access to and use of information and data that is comparable to the access by Federal employees who are not individuals with disabilities. Acquisition programs will need to determine whether the requirements of Section 508 are applicable.

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3, 4, and/or 5 of this standard. This section does not include documents cited in other sections of this standard or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in sections 3, 4, and/or 5 of this standard, whether or not they are listed.

2.2 Government documents

2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

STANDARDS

DEPARTMENT OF DEFENSE

MIL-STD-1472 - Human Engineering

HANDBOOKS

DEPARTMENT OF DEFENSE

MIL-HDBK-1908 - Definitions of Human Factors Terms

(Copies of these documents are available online at https://assist.daps.dla.mil/quicksearch/ or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

2.2.2 Other Government documents, drawings, and publications. Not applicable.

2.3. Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

HUMAN FACTORS AND ERGONOMICS SOCIETY (HFES)

ANSI/HFES 100 - Human Factors Engineering of Computer Workstations

ANSI/HFES 200 - Human Factors Engineering of Software User Interfaces

(Copies of these documents can be ordered at http://www.hfes.org or from the Human Factors and Ergonomics Society, PO Box 1369, Santa Monica, CA 90406-1369.)

2.4 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. DEFINITIONS

Unless otherwise specified, terms are defined in accordance with MIL-HDBK-1908.

NOTE: MIL-HDBK-1908 defines human engineering as "The application of knowledge about human capabilities and limitations to system or equipment design and development to achieve efficient, effective, and safe system performance at minimum cost and manpower, skill, and training demands. Human engineering assures that the system or equipment design, required human tasks, and work environment are compatible with the sensory, perceptual, mental, and physical attributes of the personnel who will operate, maintain, control, and support it." Department of Defense policy documents mention "human factors engineering" but do not define the term. For the purposes of this standard, the terms "human engineering" and "human factors engineering" should be considered to be equivalent.

4. GENERAL REQUIREMENTS

4.1 Scope and nature of work. Human engineering shall be applied during analysis, design, development, acquisition, test, and evaluation of military systems, equipment and facilities to effectively integrate humans into the design of the system. A human engineering effort shall be conducted to provide safe and effective human interfaces to support system performance requirements. This shall be accomplished through:

a. Developing or improving all human interfaces of the system so the design is consistent with relevant human engineering standards;

b. Achieving required effectiveness of human performance during system operation, maintenance, control, and support (human effectiveness requirements are often implicit in reliability and maintainability requirements);

c. Coordinating analyses and information with overall systems engineering and human-systems integration (HSI) efforts and with other HSI domains;

d. Evaluating system design alternatives and system design issues, including cost-benefit implications, addressed in trade-off studies and white papers to ensure that human factors are appropriately prioritized and addressed, and that recommended alternatives achieve human factors requirements; and

e. Balancing personnel resources, skills, training, and costs.

The human engineering effort shall include, but not limited to, active participation in the following three major interrelated areas of system development: 1) analysis, 2) design and development, and 3) test and evaluation.

4.1.1 Analysis. The functions that must be performed by the system in achieving its objectives shall be identified and described. These functions shall be analyzed to determine their best allocation to personnel, hardware, software, or combinations thereof. All functions that require any element of human interaction shall be further dissected to define the specific tasks that must be performed to accomplish the functions. Each task shall be analyzed to determine the human performance parameters; the criticality of the task in accomplishing the objective; the system, equipment, and software and associated user interfaces; and the environmental conditions under which the tasks are conducted. All analyses of tasks shall utilize a consistent task taxonomy, including that used in training analyses. Task requirements shall be quantified where possible, and shall be expressed in a form that permits effectiveness studies of the human-system interfaces in relation to the total system operation. Gaps between human performance requirements and target user audience capabilities and approach for mitigation shall be identified. Human engineering risk areas shall be identified as part of the analysis. Analyses shall remain current with the design effort.

4.1.2 Design and development. Human engineering shall be applied to the design and development of the system hardware, software and associated user interfaces, procedures, work environments, and facilities associated with the system functions requiring personnel interaction,

as part of the larger system engineering and HSI effort. This human engineering effort shall convert the requirements, system, and task analysis data into a detailed design so as to create a human-system interface that will operate within human performance capabilities, meet system functional requirements, and accomplish system objectives. The human engineering design of a system shall also take into account any requirements to interoperate with other systems and personnel. The human engineering program shall be executed by a qualified human engineering practitioner(s), working as an integrated member of the system engineering team. As appropriate, the responsible human engineering practitioner should have sign off authority for those portions of the program's design and development that have a human interface. Experience has shown that an isolated or "standalone" human engineering program that is not integrated with the larger system engineering efforts and with activities in other HSI domains cannot be effective. Therefore, only an integrated human engineering program shall be permitted.

4.1.3 Test and evaluation. Human engineering test and evaluation shall be conducted to support design decisions, verify, and validate that military systems, equipment, and facilities meet human engineering criteria, can be operated and maintained in their intended operational environment, within the intended users' performance capabilities, and are compatible with the overall system requirements.

4.2 Early application of human engineering in system acquisition. Human engineering activities are required throughout the system acquisition process, occurring at each point where the user (operators, maintainers, and support personnel) interacts with the system. Department of Defense acquisition policy emphasizes the importance of optimizing total system performance and minimizing the cost of ownership. The total system includes not just the hardware and software and associated user interfaces, but also the personnel who operate, maintain, and support the system; the training and training devices; job aids; and the operational and support infrastructure. Human engineering assists in fully integrating the human into the total system. Human-system performance impacts associated with proposed designs shall be identified in order to reduce technical risks and lifecycle costs (e.g., research, engineering, design, and operations over the economic life of the system). Since operational costs are often greater than acquisition costs, lifecycle costs shall be assessed early in the program. Early program decisions shall consider operator and maintainer capabilities and limitations to avoid expensive training, staffing, or redesigns. The human engineering practitioner shall identify and assess opportunities to reduce lifecycle costs through acquisition or design changes, and shall identify acquisition and design changes that are likely to adversely impact lifecycle costs.

4.3 Human engineering program planning. Human engineering activities shall be described in a document such as a Human Engineering Program Plan (HEPP) (see 6.3). The document shall be prepared in accordance with the requirements of this standard, the system specification and the statement of work, and shall include the tasks to be performed, human engineering milestones, level of effort, methods to be used, design concepts to be used, and the test and evaluation program. The human engineering effort shall be part of an integrated effort within the total project, and shall include a description of human engineering participation in system (hardware, software, and associated user interfaces) design and collaboration with other program disciplines, including but not limited to, all domains of Human Systems Integration.

4.4 Risk management. Risk management procedures shall be planned and implemented for the entire lifecycle of the system. Human performance and human engineering design criteria issues that involve potential technical, cost, or schedule risks shall be identified, analyzed, and prioritized early to coordinate with program management and establish requirements for eliminating or reducing the associated risks to acceptable levels. Such provisions shall be implemented and monitored during the human engineering program. Human engineering shall participate in defining criteria for system acceptance to achieve operational suitability. Risk management shall:

a. Identify potential cost, schedule, design, safety, and performance risks that result from design aspects of human system integration;

b. Quantify such risks and their impacts on cost, schedule, and performance;

c. Evaluate and define sensitivity of risks interrelated with human engineering design;

d. Identify alternative solutions to human engineering problems and define the associated risks of each alternative;

e. Document the identified risks, their impact, and the mitigation action(s) taken;

f. Take actions to avoid, minimize, control, or accept each human engineering risk; and

g. Ensure that human performance risks are included in the program's risk management process.

4.5 Reviews.

4.5.1 System reviews. Human engineering program and technical status shall be reviewed at program, technical, design, and system reviews, which include, but are not limited to:

a. Concept and requirements definition
b. Analysis of alternatives
c. System requirements review
d. Technical readiness review
e. Preliminary design review
f. Critical design review
g. System design reviews
h. System safety reviews
i. Engineering change proposal reviews
j. Post-implementation reviews

4.5.2 Subsystem and other reviews. Human engineering program and technical status shall be reviewed in subsystem reviews, including, where applicable, software and associated user interfaces specification, test readiness, and functional reviews (e.g., support, training, systems engineering, test, and manufacturing). Human engineering shall also participate in other

technical activities that further human engineering efforts, as well as any system reviews that provide an opportunity to gain insight on human performance.

4.6 Program cognizance and coordination. The human engineering program shall be integrated into the total system program and management. The efforts performed to apply the human engineering principles and practices specified herein shall be coordinated with, but shall not duplicate, efforts performed to fulfill other contractual program tasks. The human engineering program shall be coordinated with RAM (reliability, availability, and maintainability), system safety, survivability and vulnerability, facilities engineering, integrated logistic support, and other human factors functions including bio-medical, life support, personnel and training, and shall be integrated into the total system program. The human engineering portion of any analysis, design or test and evaluation program shall be conducted under the direct cognizance of a qualified human engineering practitioner(s) assigned such responsibility by the contractor.

4.7 Data.

4.7.1 Traceability. Contractor documentation shall provide in a timely manner traceability from initially identifying human engineering requirements during analysis and/or system engineering, through implementing such requirements during design and development, to verifying that these requirements have been met during test and evaluation of approved design, software and associated user interfaces, and procedures.

4.7.2 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, shall be maintained and made available to the procuring activity for meetings, reviews, audits, demonstrations, test and evaluation, and related functions.

4.8 Subcontractors and suppliers. The prime contractor shall be responsible for total system conformance of tasks and products from subcontractors and suppliers to relevant human engineering requirements herein. The prime contractor shall ensure all relevant human engineering requirements, standards, and criteria are flowed to subcontractors and/or suppliers as part of their subcontractor management process.

4.9 Nonduplication. The efforts performed to fulfill the human engineering requirements specified herein shall be coordinated with, but not duplicate, efforts performed pursuant to other contractual requirements. Necessary extensions or transformations of the results of other efforts for use in the human engineering program will not be considered duplication. Instances of duplication or conflict shall be brought to the attention of the Contracting Officer.

5. DETAILED REQUIREMENTS

Building upon the three major interrelated areas of system development outlined in 4.1 (analysis, design and development, and test and evaluation), this section provides greater detail regarding the various tasks and activities to be conducted as part of the human engineering program.

5.1 Human engineering in analysis. This section specifies the various analyses to be conducted to analyze the mission and its implied requirements, ensure the proper allocation of system functions, and ensure that the tasks assigned to the human (operator, maintainer, or support personnel) are within human capabilities and limitations. These analyses shall be conducted as early as possible and may be updated at any point in the acquisition lifecycle.

5.1.1 Analyze human and system performance requirements. Determine human and system performance requirements for system operation, maintenance, and support functions based on an analysis of the functions that must be performed by the system in achieving its objective(s) within specified operational environments, identification of the system requirements that depend on human and system performance, and human engineering principles.

5.1.1.1 Conduct an information flow and processing analysis. Analyses shall be performed to determine the necessary information flow and processing to accomplish the system objectives. These analyses shall include decisions and operations without assuming any specific hardware or software implementation or predetermined level of human involvement.

5.1.1.2 Describe operator and maintainer capabilities. Plausible human roles in the system (e.g., operator, maintainer, programmer, decision maker, communicator, monitor) shall be identified and defined. The capabilities and associated quantities of the operators and maintainers shall be coordinated with the manpower, personnel, and training communities to ensure that they will be available in the time frame that the system is to be fielded. Estimates of capabilities in terms of productivity, workload, accuracy, rate, and time delay shall be prepared for each operator or maintainer information function. Comparable estimates of equipment capabilities shall also be made. These estimates shall be used initially in determining the allocation of functions and shall later be refined for use in defining operator and maintainer information requirements and control, display, and communication requirements. In addition, estimates shall be made of how implementing or not implementing human engineering design recommendations is likely to affect these capabilities. Results from studies in accordance with 5.2.2 may be used as supportive inputs for these estimates.

5.1.1.3 Determine the allocation of functions. Analysis and trade-off studies shall be conducted using known constraints and projected operator and maintainer performance and cost data to determine which system functions shall be hardware-implemented, software-controlled, or performed by the human operator or maintainer. Function allocation and automation decisions that are inherent to a previously deployed system, subsystem, or equipment selected for the system being acquired shall be analyzed to ensure that they are consistent with function allocation decisions for the rest of the system, and with operator and maintainer capabilities and limitations. Allocation of functions shall consider the mission performance risks of incorrectly allocating a

function to software and associated user interfaces, hardware, or human operator. Designs shall provide adequate decision support to minimize situations where human decisions are made under conditions of uncertainty, time stress, or workload stress. The conduct of a human error analysis may provide useful information when considering the allocation of functions. The possibility of enhancing human or equipment capabilities through personnel selection and training as well as through equipment and procedure design shall be considered. The costs of personnel selection and training shall be considered in trade-off studies and cost-benefit analyses.

5.1.2 Conduct an analysis of tasks and workload. Human engineering principles and criteria shall be applied to analyses of tasks and workload, including cognitive task analysis if required. These analyses shall also be available for developing preliminary manning levels; equipment procedures; and skill, training, and communication requirements; and as integrated logistic support inputs, as applicable. All analyses of tasks shall utilize the task taxonomy expressed in MIL-HDBK-1908, or appropriately tailored to ensure consistency between human engineering, manpower, and training analyses.

5.1.2.1 Conduct an analysis of tasks. An analysis of tasks shall be conducted and shall provide a basis for making design conceptual decisions. For example, before hardware fabrication, task analyses shall be considered in determining whether system performance and maintenance requirements can be met by the combination of anticipated equipment, software and associated user interfaces, and personnel, and in ensuring that human performance requirements do not exceed human capabilities. Time requirements for tasks shall be evaluated for task duration versus time availability, task sequencing, and task simultaneity. Task requirements shall be evaluated, as applicable, for criticality, accuracy, precision, completeness, and the effects of task feedback and error tolerance/error recovery on performance. These analyses shall also consider effects of sustained and continuous operations on human performance. Tasks identified during human engineering analyses that require performance of critical tasks, reflect possible unsafe practices, or show the potential for improvements in operating efficiency shall be further analyzed.

5.1.2.2 Conduct an analysis of critical tasks. Further analysis of critical tasks shall identify the:

a. Information required by operator or maintainer, including cues for task initiation;
b. Information available to the operator or maintainer;
c. Information processing and decision evaluation process;
d. Possible decisions that could be reached;
e. All possible actions that might be taken depending on the decision reached;
f. Body movements required by all actions that might be taken;
g. Workspace envelope required by all actions that might be taken;
h. Workspace available;
i. Location and condition of the work environment;
j. Frequency and tolerances of all actions that might be taken;
k. Time available for completion of the task;

l. Feedback informing operator or maintainer of the adequacy of actions taken or the failure to take an action;

m. Tools and equipment required, and their timely availability;

n. Number of personnel required, their skills, and aptitude requirements;

o. Probability and severity of human error;

p. Potential for error recovery;

q. Job aids, training, or references required, and their timely availability;

r. Communications required, including type of communication;

s. Hazards involved;

t. Personnel interaction where more than one person is involved;

u. Performance limits of personnel;

v. Operational limits of hardware and software and associated user interfaces; and

w. Concurrent tasks and the associated potential workload and attention management issues.

The analysis shall be performed for all affected operational missions and phases including degraded modes of operation. Each critical task shall be analyzed to a level sufficient to identify operator and maintainer problem areas that can adversely affect mission accomplishment, and to evaluate proposed corrective action(s).

5.1.2.3 Conduct a workload analysis. Operator and maintainer (individual and team) workload analyses shall be performed and compared with performance criteria. To avoid overloading or underloading, the degree to which demands of any task or group of tasks tax the attention, capacities, and capabilities of system personnel (individually and as a team) and thus affect performance shall be evaluated. Sensory, cognitive, and physiological limitations shall be considered, as applicable. The workload analyses shall define operational sequences and task times. Preliminary workload estimates shall correlate required actions with team tasks for each task component (visual, auditory, motor, and cognitive) specified in terms of time, workload, mental effort, and psychological stress. A workload estimate for each individual shall be defined in a fashion permitting individual and team workload to be related to operational procedures.

5.1.2.4 Identify corrective action. Human-system interface design incompatibilities shall be corrected by changing the design or restructuring the tasks to ensure that degraded human performance does not result in degraded system performance.

5.1.2.5 Prepare timely updates. Analyses of tasks shall be modified as required to remain current with the design and development effort and shall be available to the procuring activity.

5.1.3 Select equipment. Human engineering principles and criteria shall be applied along with all other design requirements to identify and select the particular equipment to be operated, maintained, or controlled by personnel. The selection of equipment shall be based on the results of the functional, task, and workload analyses. Equipment selection shall be iteratively updated as the supporting analyses are updated. The selected design configuration shall reflect human

engineering inputs, based on supporting data, to satisfy the functional and technical design requirements and to ensure that the equipment will meet the applicable criteria contained in MIL-STD-1472, as well as other human engineering criteria specified by the contract. The use of commercial-off-the-shelf, government-off-the-shelf, legacy, or reuse products shall meet the human engineering requirements herein.

5.2 Human engineering in design and development. During design and development, the human engineering inputs and results from human engineering analyses shall be converted into detail engineering design features. Design of the equipment shall satisfy human-system performance requirements and meet the applicable criteria of MIL-STD-1472 and other human engineering criteria specified by the contract. The design criteria in the ISO 9241-series and ANSI/HFES 100 should be used as applicable. Human engineering requirements for testing the system or equipment shall be considered during design, and shall include such factors as verifying proper operation, defining need for maintenance, and specifying facilities and test personnel, including test subjects. Human engineering provisions shall be evaluated for adequacy during design reviews. Human engineering practitioners assigned human engineering responsibilities by the contractor shall maintain currency with the design and participate in design reviews and engineering change proposal reviews of end items that involve the human-system interface.

5.2.1 Participate in preliminary system and subsystem design. Human engineering principles and criteria shall be applied to system and subsystem designs and shall be reflected in design criteria documents, specifications, functional flow diagrams, system and subsystem schematics and block diagrams, interface control drawings, overall layout drawings and related applicable drawings provided in compliance with contract data requirements. Human engineering evaluations of preliminary designs shall include consideration of design solutions for human performance, manpower, and training issues from predecessor or comparison systems. The preliminary system and subsystem configuration and arrangements shall satisfy human-system performance requirements and comply with applicable criteria of MIL-STD-1472 as well as other human engineering criteria specified by the contract.

5.2.2 Conduct experiments, demonstrations, tests, and studies. The contractor shall conduct experiments, demonstrations, tests (including dynamic simulation and software and associated user interfaces prototyping), and studies to identify and resolve human engineering and life support problems specific to the system. Experiments, demonstrations, tests, and studies shall be performed with representative users in the actual (or realistically simulated) user environment to validate design goals as well as human and system performance. These experiments, demonstrations, tests, and studies shall be accomplished as early as possible and reiterated as the design matures so that their results may be incorporated in the equipment design and, if necessary, used to revise initial function allocations. Any significant human engineering or life support problem, deemed resolvable only by major experiment, demonstration, test, or study effort, shall be brought to the attention of the procuring activity and shall include the estimated effect on system performance if the problem is not resolved. To avoid duplication of effort, the applicability and utility of existing human engineering and other relevant databases (e.g., general literature, research reports, studies) shall be determined before initiating major efforts.

5.2.3 Models and mockups.

5.2.3.1 Generate computer models. As required, three-dimensional computer models, rapid prototyping, and computer-aided design/computer-aided manufacturing (CAD/CAM) techniques shall support the development of the design of systems, subsystems, equipment, components, or facilities for which human performance will be a determinant of operational performance and maintenance effectiveness. Additionally, when appropriate, the use of rapid prototyping of user interface designs, the use of task network and workload models to evaluate procedures, and other forms of modeling and simulation shall be considered. Computer models shall be able to provide relevant anthropometric information (such as a suitable range of body sizes, clothing, and postures for evaluating proposed designs and design changes in terms of compatibility with whole-body fit and access; finger, hand, arm, foot, leg, and other access and reach; visual field; and strength). Computer models shall not be used for compliance testing of human performance and human engineering design. When used for predictive purposes, such models shall produce accurate and empirically repeatable, valid outputs. Computer models, simulations, rapid prototyping outputs, and CAD/CAM designs shall be available during technical meetings and design reviews.

5.2.3.2 Fabricate three-dimensional mockups. Prior to the fabrication of system prototypes, full-scale three-dimensional mockups of equipment involving critical human performance shall be constructed. The mockups shall be constructed sufficiently early to ensure that results of human engineering evaluations can influence design. The mockups shall be no more elaborate or expensive than is essential to represent those aspects of the human-system interface to be evaluated. These mockups shall provide a basis for resolving operational and maintenance access, workspace, and related human engineering problems, and for incorporating solutions into system design. In those design areas that involve critical human performance and for which human performance measurements are necessary, development of functional mockups shall be accomplished. The mockups shall be available for inspection as determined by the procuring activity. Disposition of mockups, after they have served the purposes of the contract, shall be as directed by the procuring activity.

5.2.3.3 Use scale models. Scale models may be used to supplement three-dimensional computer models, rapid prototyping, CAD/CAM, or mockup techniques, but shall not be substituted for mockups unless such substitution provides equivalent, valid, repeatable, and accurate information in a cost-effective and timely manner.

5.2.3.4 Use dynamic mockups. Dynamic mockups (full-scale physical models which simulate functions), shall be used when static, three-dimensional mockups are inadequate for assessing human performance in the design of complex systems. These mockups shall be used to:

a. Evaluate operator and maintainer procedures and user-system interfaces, and identify any potentially unsafe procedures or unacceptable workload demands;

b. Evaluate interaction between individual operators and/or maintainers;

c. Evaluate the non-mechanical aspects of a design, such as communications, information requirements, and display formats;

d. Emulate user-system interaction to derive estimates of performance for alternate design configurations and cost-effectiveness evaluations of variable manpower, personnel, and training parameters;

e. Evaluate biomedical and environmental considerations; and

f. Validate that the proposed design is suitable for operational use.

While the dynamic mockup equipment is intended as a design tool, consideration should be given to transitioning its technology to subsequent training simulators.

5.2.4 Review engineering drawings. The design, as reflected by such drawings, shall comply with applicable human engineering design criteria such as that found in MIL-STD-1472. Human engineering practitioners assigned human engineering responsibility by the contractor shall review layouts and drawings for all designs with potential impact on human performance or the human-system interface, and shall identify for corrective action those designs that may induce human error or be unsafe. Human engineering design attributes shall be reflected in the engineering drawings and CAD representations to ensure that the final product can be used and maintained effectively, efficiently, reliably, and safely by the target user audience.

5.2.5 Participate in work environment and facilities design. Human engineering principles and criteria shall be applied to detail design of work environments, crew stations, and facilities to be used by system personnel. Drawings, specifications, and other documentation of work environment, crew stations, and facilities shall reflect compliance with human engineering requirements and compliance with applicable human engineering design criteria such as MIL-STD-1472. The design of work environments, crew stations, and facilities which affect human performance under normal, degraded, and emergency conditions shall incorporate at least the following, where applicable:

a. Adequate physical, visual, and auditory interfaces between personnel and their equipment and with other personnel, including provision for proper eye position in relation to display surfaces, controls, and external visual areas.

b. Provisions for addressing the effects of atmospheric conditions, such as temperature, humidity, and air flow.

c. Provisions for the ranges of acceleration forces, positive and negative, including linear, angular, and radial.

d. Provisions for minimizing the effects of weather and climate, such as rain, hail, snow, ice, and mud, as well as desert and arctic conditions.

e. Protection from physical and performance effects of acoustic noise (steady state and impulse), vibration, and impact forces.

f. Provisions for human performance during weightlessness.

g. Provisions for minimizing disorientation.

h. Adequate space for personnel, their movement, and their equipment, including job aids.

i. Safe and efficient walkways, stairways, platforms, and inclines.

j. Provisions for minimizing physiological and psychological stresses.

k. Provisions for minimizing fatigue.

l. Allowance for the effects of clothing and personal protective equipment, such as gloves, masks, and cold weather clothing.

m. Equipment-handling provisions, including remote handling provisions and tools when materiel and environment require them.

n. Provisions for equipment installations that are safe and non-error inducing.

o. Protection from chemical, biological, toxicological, radiological, thermal, mechanical, electrical, electromagnetic, and directed energy hazards.

p. Adequate illumination commensurate with anticipated visual tasks.

q. Sustenance and storage equipment (i.e., oxygen, food, and water) and provisions for refuse management.

r. Crew safety protective restraints (shoulder, lap, and leg restraints systems, inertia reels, and similar items) in relation to operational objectives and control and display utilization.

s. Adequate space, clearance, and layout for normal ingress and egress and emergency escape from workstations and facilities.

5.2.6 Participate in procedure development. Based upon the functions and tasks identified by human engineering analyses (5.1 herein), the contractor shall apply human engineering principles and criteria to the development of procedures for operating, maintaining, supporting, or otherwise using the system equipment throughout its intended lifecycle. Human engineering shall be applied to procedure development to ensure 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 integrated logistics support where required; and to provide inputs to the development of operation, maintenance, training, and technical publications. The development of procedures shall minimize training demands, and consider the possible individual, organizational, and culturally diverse nature of the operational, maintenance, and support population. Procedures developed for system operations that involve multiple user groups shall consider the human performance factors of individual user groups as well as interactions among the various user groups. To the degree practical, the use of models, simulations, and prototypes shall be used to support development of procedures.

5.2.7 Participate in software and associated user interface development. The contractor shall apply human engineering principles to software and associated user interface architecture and design in those systems where software and associated user interfaces determine part of the human interface. Human-computer interface design guidance and standards such as ANSI/HFES 200 and graphical user interface design guides such as Windows, MOTIF, and JAVA should be used and specified on contract as applicable. Human engineering shall participate in the development of the look, feel, and content of controls and displays, including multifunction displays, to assure that the human-computer interface supports efficient data input and retrieval, access to required information, and execution of decisions and commands. Human engineering participation shall seek opportunities to benefit from commonality as well as reduction in training requirements. Automated system functions that require human monitoring or

intervention shall be considered part of the human-system interface. Multifunction controls and displays that vary in function depending on system software and associated user interfaces shall also be considered part of the human-system interface. The contractor shall use a style guide in the development of software and associated user interfaces to define the general principles and specific rules that guide the design and consistency of individual components. To the degree practical, the use of models, simulations, and prototypes shall be used to support software and associated user interface development and user interface designs.

5.2.8 Review manuals and technical documentation. Human engineering shall be applied to the development of operational, maintenance, and training manuals and documentation (electronic or hard-copy) to ensure thoroughness, technical accuracy, suitable format of information presentation, appropriate reading level, technical sophistication required, clarity, and quality of illustrations. Human engineering input shall be provided for the selection of the level of interaction to be supported in interactive electronic technical manuals (IETMs).

5.3 Human engineering in test and evaluation. The contractor shall establish and conduct a test and evaluation program to:

a. Verify that the system can be operated, maintained, and supported by the designated staffing with the expected personnel attributes in the intended operational environments;

b. Secure quantitative measures of system performance that are a function of the human interaction with equipment or software and associated user interfaces;

c. Confirm compliance with system performance requirements where personnel performance is a system performance determinant;

d. Demonstrate conformance of system, equipment, and facility design to human engineering design criteria;

e. Determine whether undesirable design or procedural features have been introduced; and

f. Verify and validate proposed training, training devices, and job aids provide adequate training and access to reference information.

Maximum use shall be made of the data collected from experiments, demonstrations, and studies (see 5.2.2). Both qualitative and quantitative data can be used to support human engineering efforts in the test and evaluation process. The fact that individual tests and evaluations may occur at various stages in system, subsystem, equipment, or facility development shall not preclude final human engineering verification of the complete system. Operator and maintainer normal, emergency, and degraded mode tasks shall be performed during the final system test.

5.3.1 Conduct test and evaluation planning. Human engineering testing using operational hardware, software and associated user interfaces shall be incorporated into the system test and evaluation program and shall be integrated into engineering design and development tests, contractor demonstrations, flight tests, acceptance tests and other development tests. Compliance with human engineering requirements shall be tested as early as possible. Human engineering findings from design reviews, mockup inspections, demonstrations and other early engineering tests shall be used in planning and conducting later tests. Human engineering test planning shall

be directed toward verifying that the system can be operated, maintained, supported, and controlled by user personnel in its intended operational environment including emergency and degraded modes. Human engineering test planning should also consider data needed from, or to be provided by, operational test and evaluation. Test planning shall include the data to be collected, the method(s) by which the data will be analyzed, and how the analysis will be used to support the overall findings of the testing. Test planning shall includes 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.

5.3.2 Implement planned test and evaluation. The human engineering test and evaluation plan shall be implemented upon approval by the procuring activity. Test documentation (e.g., checklists, data sheets, test participant descriptors, questionnaires, operating procedures, and test procedures) shall be available at the test site. Human engineering portions of all tests shall include the following:

a. Performance of mission or work, or a simulation thereof if actual performance is not feasible;

b. Critical tasks;

c. A representative sample of non-critical scheduled and unscheduled maintenance tasks that do not duplicate the tasks selected for a maintainability demonstration;

d. Proposed job aids, new equipment training programs, training equipment, and special support equipment;

e. Use of personnel who are representative of the range of the intended user populations in terms of aptitudes, skills, capabilities, experience, size, and strength; wearing suitable clothing and equipment appropriate to the tasks (use of personnel from the intended user population is preferred);

f. Collection of task performance data in actual operational environments, or in simulated environments if collection in the actual operating environment is not feasible;

g. Identification of discrepancies between required and obtained task performance; and

h. Criteria for acceptable performance or rejection of the test.

5.3.3 Conduct failure and error analysis. All failures occurring during test and evaluation shall be subjected to a human engineering review to differentiate among failures of equipment alone, failures resulting from human-system incompatibilities, and failures due to human error. Human errors occurring in the performance of critical tasks shall be analyzed to determine the reason for their occurrence. The contractor shall identify those design characteristics or procedures which may contribute substantially to human error and shall propose corrective action.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. This standard is intended for use to specify human engineering tasking requirements for military systems, equipment, and facilities, cited contractually in statements of work. It may be invoked in its entirety or selectively as prescribed by the procuring activity. The primary use of this standard for procurement does not necessarily preclude its utilization for in-house efforts, where desired. Compliance with this standard will provide the procuring activity with assurance of positive management control of the human engineering effort required in the design, development, and acquisition of military systems, equipment, and facilities. Specifically, it is intended to ensure that:

a. system requirements are achieved by consideration of the capabilities and limitations of the human component;

b. through proper design of equipment, software and associated user interfaces, and environment, the personnel-equipment-software combination meets system performance goals;

c. design features will not constitute an undue hazard to personnel;

d. trade-off points between automated versus manual operation have been chosen for peak system effectiveness within appropriate cost limits;

e. the application of human engineering principles to system design is 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; and

i. the layout of the facility and the arrangement of equipment affords efficient communication and use.

6.2 Acquisition requirements. Acquisition documents should specify the title, number, and date of this standard.

6.3 Associated Data Item Descriptions (DIDs). The following DIDs may be of benefit in obtaining data to support the human engineering effort. When it is necessary to obtain the data, the applicable DIDs must be listed on the Contract Data Requirements List (DD Form 1423). Not all DIDs will be applicable to every acquisition. The application of these DIDs should be evaluated on a program-by-program basis.

DI-HFAC-80742	Human Engineering Simulation Concept
DI-HFAC-80743	Human Engineering Test Plan
DI-HFAC-80744	Human Engineering Test Report
DI-HFAC-80745	Human Engineering System Analysis Report

DI-HFAC-80746	Human Engineering Design Approach Document – Operator
DI-HFAC-80747	Human Engineering Design Approach Document – Maintainer
DI-HFAC-81399	Critical Task Analysis Report
DI-HFAC-81742	Human Engineering Program Plan

The above DIDs were current as of the date of this standard. The Acquisition Streamlining and Standardization Information System (ASSIST) database should be researched at http://assist.daps.dla.mil to ensure that only current and approved DIDs are cited on the DD Form 1423.

6.4 Tailoring guidance for contractual application. See Appendix A.

6.5 Subject term (key word) listing.

Analysis
Design and development
Dynamic simulation
Equipment procedures
Mockups, dynamic
Mockups, three-dimensional
Models, computer
Models, scale
Simulators, engineering
Task analysis
Task taxonomy
Test and evaluation
Work environment
Workload analysis

6.6 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extent of the changes.

APPENDIX A

SELECTION AND TAILORING OF MIL-STD-46855

A.1 SCOPE. This appendix provides criteria for the procuring activity's selection of the standard for contract use and, when used, the partial and incremental application of the requirements provisions.

A.2 APPLICABLE DOCUMENTS.

HANDBOOKS

DEPARTMENT OF DEFENSE

MIL-HDBK-505 - Definitions of Item Levels, Item Exchangeability, Models, and Related Items

A.3 SELECTION OF MIL-STD-46855

A.3.1 General. Selection of MIL-STD-46855 for application to contracts for military systems, equipment, and facilities is dependent upon the nature of the system (hardware and/or software and associated user interfaces) in terms of operational, maintenance, and support functions; the degree to which human interface is involved with the system; and the acquisition phase involved. Selection of MIL-STD-46855 is generally independent of system complexity, branch of military service involved, equipment duty cycles and, within practical limits, contract type, cost, duration, and size of production lots.

A.3.2 Selection for use. A decision must first be made whether to use MIL-STD-46855, prescribe it as a guide, or invoke it as a mandatory contract provision. Selection for use should consider the following provisions.

A.3.2.1 Nature of the materiel. Selection of MIL-STD-46855 for a specific contract is dependent upon the nature of the end-item, materiel, or system in terms of its ability to perform operational, maintenance, and support functions. Generally, the standard:

a. should not be considered for use in contracts for parts, subassemblies, or units as defined in MIL-HDBK-505, but

b. should be considered for use in contracts for sets, subsystems, and systems, as defined in MIL-HDBK-505, and for facilities.

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 diverse uses to which they will be applied or knowledge of the human performance requirements implicit in such uses. Accordingly, it is not generally reasonable to invoke MIL-STD-46855 for parts, subassemblies, assemblies or units.

A.3.2.2 Extent of human interface involved. Selection of MIL-STD-46855 for application to a specific contract is sensitive to the extent of human involvement or interface for operation, maintenance, support, control, transport, and/or shelter. Generally, the standard should not be considered for use in contracts for materiel where human involvement or interface is not anticipated or is obviously insignificant.

A.3.2.3 Nature of stated system performance requirements. If, for a specific request for proposal (RFP) or similar procurement action, MIL-STD-46855 has survived the tests of A.3.2.1 and A.3.2.2, its selection or non-selection should be based on stated system performance requirements. If the RFP, specification, or other requirement document states system performance requirements or goals, such as time and error, for which human performance can reasonably be considered as a determinant or contributor, MIL-STD-46855 should be employed. On the other hand, if such system performance requirements to which human performance contributes are not stipulated, the standard should be considered for use as a guide.

A.3.2.4 Selection review. At this point, use of the standard as a requirement, citation as a guide, or non-selection as being not applicable shall have been tentatively determined. If the procuring activity's human engineering practitioners have not already been involved in this decision-making process, they must be consulted at this point to ensure that the standard is not erroneously involved or waived. Should results of this review disclose that the standard should not be used or should be applied only as a general guide, the process is complete; however, if results of this review conclude that the standard should be invoked, the tailoring process or section A.4 must be pursued.

A.4 TAILORING OF MIL-STD-46855

A.4.1 General. The primary purpose of a human engineering program, and therefore MIL-STD-46855, is to influence the design of the system, equipment, and facility. Every human engineering task must focus on influencing design and test, consistent with the nature of the procurement and the acquisition phase involved.

A.4.2 Tailoring. Unless otherwise specified, contractors shall use the appropriate tailored version of MIL-STD-46855 as a baseline in the preparation of proposal responses and human engineering program planning. This does not preclude the contractor from proposing further tailoring.

APPENDIX A

A.4.3 Contractual applicability.

A.4.3.1 Evolutionary development. MIL-STD-46855 shall be applied across the full lifecycle of an evolutionary development effort. At each evolutionary phase or contract, the application of MIL-STD-46855 and associated human engineering design criteria, and any tailoring previously made, shall be updated as required. For evolutionary development of older or existing systems, equipment, software and associated user interfaces, and facilities, this standard will generally apply only to new designs and procedures involving human interfaces and old designs, procedures, and interfaces which may be impacted thereby. Old systems undergoing improvement through evolutionary means will generally not have the standard applied to components retained and unaffected by such evolutionary development techniques. Old systems undergoing improvement should have this standard applied if there is any change in how the equipment is used. It is important to understand that there may be exceptions to this general rule; therefore, evaluation by the human engineering practitioner is extremely advisable.

A.4.3.2 Product improvement. Recognizing that product improvement actions may occur during more than one acquisition phase and that product improvements can involve concept exploration and definition, demonstration and validation, engineering and manufacturing development tasks or a combination of these, the procuring activity should tailor the human engineering program to the specific performance objectives of the product improvement program.

A.4.3.3 Production and deployment or operations and support phases. Design changes affecting human performance during the production and deployment or operations and support phases can, like product improvement actions, involve conceptual concept exploration and definition, demonstration and validation, or engineering development human engineering tasks; therefore, the procuring activity should tailor the human engineering program to the specific performance objectives of the design changes. Particular attention should be directed toward failure analysis, quality assurance, drawing review, and software and associated user interface considerations.

A.4.3.4 Nondevelopmental item (NDI) . Where an NDI is being acquired, applicable provisions of MIL-STD-46855 may be used to guide government in-house efforts (see 6.1). Paragraph 5.1 should be considered to ensure the availability of adequate information on operator and maintainer capabilities or to conduct a task analysis to provide documentation and context for how the item will be used. Paragraph 5.2 should be considered to ensure that MIL-STD-1472 will be a part of the selection criteria for determining the suitability of the item. Paragraph 5.3 should be considered, as applicable, to verify human performance supports total system performance. In addition, the nature of the NDI program will influence tailored, in-house use of this standard. Where an item requires minor modification to meet the requirements of the procuring activity, and where the modification is driven by human performance or will result in significant human performance effects, applicable analysis tasks of 5.1, 5.2, and their subparagraphs may be used for identifying and implementing the modification.

APPENDIX A

A.4.4 Human engineering review. Procuring activities are responsible for assuring that the application of this Standard to specific contracts has been subjected to human engineering review to ensure consistency of the tailored requirements with human performance requirements pursuant to the nature of the objectives of the contract.

CONCLUDING MATERIAL

Custodians:
Army – MI
Navy – AS
Air Force – 11

Preparing activity:
Army – MI

Review activities:
Army – AR, AT, AV, CR4, EA, GL, MD, MR, TE, TM
Navy – EC, MC, OS, PE, SH, TD
Air Force – 13, 19

(Project HFAC-2009-001)

NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using the ASSIST Online database at https://assist.daps.dla.mil.