Human Factors Engineering Process Area

Process Area Summary

Purpose
The purpose of Human Factors Engineering is to ensure that systems acquired are operationally safe, effective, and suitable from a perspective of human performance.

Major points addressed
The Human Factors Engineering process area involves a multidisciplinary effort to generate and compile information about human capabilities and limitations and apply that information to hardware, software, facilities, procedures, jobs, environments, training, staffing, and personnel management, to produce systems that are operationally safe, effective, and suitable. The human factors engineering process involves a systematic approach to the identification and resolution of issues related to human-system performance and human resources.

Human factors engineering is applied in the context of the total system concept in which the operator, maintainer, system, and operating environment are all integral components of the whole system.

Human factors engineering is initiated during mission analysis activities and fully integrated with the investment, development, and systems engineering efforts throughout the acquisition lifecycle.

Goals
1. Human factors engineering is addressed as an integral part of the system acquisition lifecycle. *(BP 24.01)*
2. Human factors information requirements and human-system performance needs are identified, analyzed, and documented. *(BP 24.02)*
3. Human-system performance is verified to have achieved system acquisition objectives for operational safety, suitability, and effectiveness. *(BP 24.03)*

Notes

When acquiring a system, experience has shown that acquisition programs tend to focus on the hardware and software and may ignore the impact on, and of, the people who operate and maintain the system. End users may have different aptitudes, abilities, cultural backgrounds, and training and may operate the system and respond to the system under various operating conditions, organizational structures, procedures, equipment configurations, and work scenarios. And, it is the composite of these elements (including the human response) that determines the performance, safety, and efficiency of the system.

Because there is a dynamic interaction among the major elements of a system (e.g., equipment/software design, environment, staffing and training, and procedures), investment and systems engineering trade-off decisions that consider human factors are required to assure that system operational performance objectives are met.

When human factors is applied at the onset of the acquisition lifecycle, it enhances the probability of meeting performance, safety, and productivity requirements; decreases lifecycle staffing and training costs; and becomes well-integrated into the program's strategy, planning, cost and schedule baselines, and technical trade-offs. Although HFE may be applied in different ways under different acquisition strategies, these benefits are applicable to commercial-off-the-shelf (COTS) and non-developmental items (NDI) as well as to developmental programs.

The term *user* refers to all people who use the system (i.e., including the personnel that operate equipment and those expected to maintain and support the system throughout its lifecycle).

Achieving the human-system performance objectives related to safety, suitability, and effectiveness can be considered to be synonymous with meeting usability goals, since high standards of usability must be realized in order for systems to meet high standards of safety, suitability, and effectiveness.

The term "Human Factors Engineering" is intended to include the full scope of human response and human-system performance concerns inclusive of such terms as human-computer interaction (HCI), man-machine interface (MMI), computer-human interface (CHI), Human-System Interface (HSI), and other similar terms.

Relationships between this PA and other PAs

Human factors engineering concepts are applied to the activities and products of other process areas. Human factors engineering also uses the practices, methods, and work products of the other process areas to satisfy human factors engineering process requirements. HFE provides guidance for carrying out other PAs especially when HFE is integral to the product or service acquired. These relationships should be emphasized in the process areas associated with: Needs (PA 01), Requirements (PA 02), Architecture (3), Alternatives (PA 04), Outsourcing (PA 05), Software Development and Maintenance (PA 06), Integration (PA 07), System Test and Evaluation (PA 08), Project Management (PA 11), Contract Management (PA 12), Risk Management (PA 13), and Coordination (PA 14).

Base Practices list

The following list contains the human factors engineering base practices that are essential elements of good systems acquisition:

BP 24.01 Integrate Human Factors Engineering in All Phases of Acquisition: Develop the strategy, approach, and procedures for the integration of human factors engineering in system acquisition and engineering activities.

BP 24.02 Conduct Analyses, Studies, or Research to Generate Human Performance Information: Conduct analyses, studies, or research to generate human performance information that mitigates the risks associated with human factors engineering acquisition issues.

BP 24.03 Ensure that Human-System Performance Objectives are Met: Produce evidence of the degree to which the total system meets performance objectives and can be operated and maintained by members of the target population in an operational environment.

BP 24.01 Integrate Human Factors Engineering in All Phases of Acquisition

Develop and carry out the strategy, approach, and procedures for the integration of human factors engineering in system acquisition and engineering activities.

Description
In conjunction with the system technical and operational requirements and acquisition/development strategy, define the concepts, mechanisms, responsibilities, and procedures for integrating human factors engineering in the acquisition. Establish the human factors engineering strategy and approach for applying human factors engineering to the system being acquired by focusing on the human performance produced when the system is operated and maintained in an operational environment by members of the intended target population. The approach to human factors engineering should include identifying and translating operational requirements into human engineering design, development, and implementation concepts and requirements, and identifying the human performance boundaries, risks, trade-offs, and opportunities of the systems engineering options and alternatives. These activities apply the results of research and other sources of human factors information related to design enhancements, safety features, automation impacts, human-system performance trade-offs, ease of use, and workload. To effectively integrate human resource and performance considerations for the system being acquired (as well as for other associated or neighboring systems), the human factors engineering effort is focused on:

- Improved human interfaces
- Effectiveness of human performance during system operation, maintenance, and support
- Demands upon personnel resources, skills, training, and costs

Typical Work Products

- Relevant demographics and performance parameters of the target audience
- Review of predecessor system assessments to identify human performance issues
- Initial risks, enhancements opportunities, and issues related to human-system performance
- Activities to be conducted in support of obtaining the required information about human performance
- Documented strategy for the application of human factors engineering to products and services
- User feedback mechanisms
- HFE strategy, approach, and prcedures
- Human factors engineering plans embedded in system engineering plans
- Inputs to key acquisition, solicitation, and system engineering documentation

Notes
Establishing the human factors engineering strategy and approach for a given system acquisition requires focusing on the tasks the end users will perform on the system and on the program activities that allow early identification and resolution of human performance issues. The origins of the human factors engineering integration approach occur early in the

acquisition lifecycle (as early as during mission analysis), and are refined during each subsequent acquisition phase, as required.

Where user teams or operator and maintainer representatives participate in providing the design and development team an operational viewpoint, human factors engineering conducts the appropriate user activities to ensure the data collected represents performance data and not just individual preferences.

The human factors engineering inputs to the acquisition documentation define: a) the human performance requirements, capabilities, thresholds, and criteria the system is to meet; b) any impact on the acquisition strategy to be taken; c) the performance and resource trade-offs to be encountered; d) and the specific tasks and activities that must be performed during system design, development, and implementation. Human factors engineering inputs are formulated to improve or resolve issues related to, at a minimum, the following essential elements for all users:

- Staffing (and organizational) constraints
- System operator and maintainer (user) skills
- Training performance, time available, and cost limitations for formal, informal, and on-the-job skill development
- Acceptable levels of human and system performance when operated and maintained by members of the target population

Identification of human resource and human performance considerations facilitates the development of system concepts for hardward and software, functional allocation, operations and training, and organizational structures. An iterative approach is advocated for assessing the trade-offs of various human performance and human resource alternatives with other system concepts (e.g., for requirements, design, and implementation). This practice applies equally to developmental and to non-developmental items (NDI) or commercial-off-the-shelf (COTS) acquisitions.

To reduce potential data redundancies, emphasis should be placed on coordination between the human factors engineering and integrated logistics support (ILS) for information requirements planning, data collection, and information sharing, especially in the areas of maintenance staffing, training, training support, and personnel skills.

Human factors engineering contributes to system engineering design and development decisions. Example activities in the human factors engineering are:

- Identify human factors engineering tasks and human performance unknowns or issues for resolution or mitigation
- Review system operation and maintenance concepts for human performance implications
- Develop a profile of the people (e.g. aptitudes, skills, anthropometric data, population distribution, capabilities, training history) who operate, maintain, and support the system
- Identify operator and maintainer tasks for explicit and implied human-system interfaces
- Devise a human factors engineering strategy

- Allocate human factors engineering tasks and activities for integration into the overall program plan
- Tailor and refine the human factors approach and requirements
- Document results and lessons learned for their application to other programs
- Prepare human performance portions of operations and maintenance mission profiles and mission scenarios
- Contribute to the preparation of human performance specifications for the system
- Perform functional analyses of flow block diagrams for human-system operations and define operational and support equipment and facilities requirements
- Study detailed functions, environment and technical design requirements to allocate tasks to personnel, equipment, software, or some combination to achieve system engineering goals
- Prepare and analyze operations and maintenance workload and task data to influence equipment and procedure design, and to determine personnel requirements
- Identify training implications of alternative designs
- Conduct trade studies of human response and performance with system design alternatives
- Embed human-system performance considerations in system specifications and translate the human performance design and integration activities to the contractor as clear, unambiguous requirements in a contractually binding way
- Prepare the human factors engineering portion of proposal evaluation criteria and the source selection plan
- Contribute human performance information and criteria to the source selection team process

BP 24.02 Conduct Analyses, Studies, or Research to Generate Human Performance Information

Conduct analyses, studies, or research to generate human response and human performance information that mitigates the risks associated with human factors engineering issues.

Description

A broad range of information gathering activities regarding the implications of human factors is conducted to support system acquisitions. These activities involve acquiring the information necessary to capitalize upon the understanding of the human capabilities and limitations that affect human-system performance. Human factors engineering research and analysis activities are employed to identify and resolve risks and to assess costs, benefits, performance levels, and trade-offs. Areas in which human factors analyses, studies, and research investigate include:

- Computer-human interface (CHI)
- Controls, displays, and alerts
- Procedures, incremental changes to systems, system upgrades, and system component integration
- Workforce productivity; accuracy levels, error rates and their consequences; workload; usability; and task performance
- Training for new automation operation and maintenance
- Equipment, workspace, and workplace design
- Manpower and staffing; unique skills, abilities, characteristics, and tools; communications and teamwork; job and organizational design
- Human performance aspects of safety, health, and environmental considerations

Typical Work Products

- Analysis, study, and research requirements and initiatives
- Research and study proposals, plans, and descriptions
- Technical reports and analyses providing research and study results
- Human performance and human factors engineering guidance, conventions, and technical direction for integration in system design and development alternatives
- User human performance data and information from post-fielding human factors engineering feedback mechanisms
- Human factors engineering functional, task, and operational performance analysis results (e.g. functional requirements for the user, minimum performance criteria) to support system design and engineering activities

Notes

Human factors engineering analyses, studies, and research conducted early in the program identify design considerations as well as human-system performance risks and unknowns that require greater exploration during later phases of the system acquisition.

These studies also assess the level of risk and related consequences to assist in estimating resource requirements for the follow-on analyses. Example activities include the following:

- Human-in-the-loop simulations
- Task and task sequence analyses (including cognitive task analyses)
- Use and usability studies
- Operation and maintenance timeline analyses for human-system reaction times
- Readability analyses
- System comparative studies (such as predecessor system early comparison analyses, ECA)
- Human performance trade-off analyses
- Skill decay and training performance studies
- Post fielding assessments of human performance
- User feedback surveys

BP 24.03 Ensure that Human-System Performance Objectives are Met

Produce evidence of the degree to which the total system meets performance objectives and can be operated and maintained by members of the target population in an operational environment.

Description

Human performance testing is performed to assist in the assessment of the operational effectiveness and suitability of the products to meet system requirements. Human factors engineering planning for test and evaluation (T&E) activities is initiated early in the acquisition lifecycle. Specific human factors engineering-related T&E tasks and activities are subsequently identified, and the conduct of the human factors engineering T&E is then integrated with the system T&E program. Post deployment assessments that include human performance parameters are conducted to assist in lifecycle planning, continuous improvement, or other programs.

Typical Work Products

- Human factors engineering test planning documentation for inclusion in the system test and evaluation planning
- Information required for resolution by human factors studies, analyses, or research
- Operator and maintainer task lists (especially critical tasks) to meet system performance goals
- Human performance measures of effectiveness and measures of performance
- Human performance data requirements and data collection plans
- Data collection methods, surveys, questionnaires, analyses, and evaluation schemes
- Human factors engineering reviews and demonstrations
- Resource requirements for human performance tests including equipment, software, data analysis skills, data collection personnel, computer time, personnel training requirements

Notes

Human factors engineering test and evaluation is conducted to:

- Ensure fulfillment of the applicable human performance requirements
- Demonstrate conformance of system, equipment, and facility design to human engineering design criteria
- Confirm compliance with system performance requirements where human performance is a system 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

Key principles for addressing human factors engineering requirements in system testing are:

- Coordinate human factors test planning early in the acquisition program
- Measure human performance of critical tasks during testing in terms of time, accuracy, and operational performance

- Emphasize the separation of measuring human performance from measuring system performance
- Leverage human factors data collection by integrating efforts with system performance data collection
- Make recommendations for human factors design and implementation changes and human performance improvements

Human engineering components of test and evaluation include:
- Performance measures of task or mission
- Critical tasks (including cognitive tasks)
- Representative samples of non-critical, scheduled and unscheduled maintenance tasks
- Personnel who are representative of the range of the intended user populations
- Proposed job aids, new equipment training programs, training equipment, and special support equipment
- Collection of task performance data in actual operational environments
- Identification of discrepancies between required and obtained task performance
- Criteria and thresholds for acceptable performance

Unfavorable outcomes occurring during test and evaluation are subjected to a human factors engineering review to differentiate between failures of the equipment alone, failures resulting from human-system incompatibilities and failures due to human error. Human-system incompatibilities and human errors occurring in the performance of critical tasks are analyzed to determine the reason for their occurrence and to propose corrective action(s).

Example activities include:
- Conduct Front-end Analyses to identify critical operational issues, resource limitations and constraints, critical tasks, and operator and maintainer performance levels as well as system performance thresholds that are to be incorporated into the testing program
- Develop human factors testing requirements using human performance measures of effectiveness and measures of performance for system operational effectiveness and operational suitability
- Contribute to system critiques during design and program reviews, technical demonstrations, and operational tests
- Conduct human performance testing to estimate or verify operational effectiveness and suitability and to provide information about human performance as an integral part of system performance
- Apply results of human performance testing to system development decisions