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Guidance on human factors engineering for system life cycle applications

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Международная Электротехническая Комиссия

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CONTENTS

FOREWORD ... 4
INTRODUCTION ... 5

1 Scope ... 6
2 Normative references ... 6
3 Terms and definitions ... 6
4 HF and its influence ... 7
4.1 Understanding the HF relationships ... 7
4.2 Human machine comparison ... 7
4.3 HF engineering process ... 8
4.4 HF in system life cycle ... 8
4.5 The importance of HF designs ... 9
4.6 HF design criteria ... 10
5 HF activities implementation ... 11
5.1 HF planning ... 11
5.2 HF requirements analysis in system definition ... 11
5.3 HF analysis in system design ... 12
5.4 Incorporating HF in system requirements ... 12
5.5 Integrating HF in systems engineering ... 12
5.6 Outsourcing projects and related HF issues ... 13
5.7 HF assessment in system operation/maintenance ... 14
6 HF methods ... 14
6.1 Classification of HF methods ... 14
6.2 Applications of HF methods ... 15

Annex A (informative) HF engineering process concerning task analyses for human-system interactions ... 17
A.1 HF engineering process for system application scenarios ... 17
A.2 HF engineering process for application environment ... 17
A.3 HF engineering process for requirements analysis ... 17
A.4 HF engineering process for functional analysis ... 17
A.5 HF engineering process for function allocation ... 18
A.6 HF engineering process for tasks design and analysis ... 18
A.7 HF engineering process for human interface ... 18
A.8 HF engineering process for requirements reviews ... 18
Annex B (Informative) Summary of HF design influence and impact on system dependability ... 19
B.1 Automation ... 19
B.2 Design for maintenance ... 19
B.3 Computer-human interface ... 20
B.4 Incorporation of displays, controls and alarm functions ... 20
B.5 Incorporation of input devices ... 21

B.6 Environment 21
B.7 Safety 21
B.8 Security 21
Annex C (Informative) Summary of methods for HF analysis, design and development and test and evaluation 22
C.1 HF analysis methods 22
C.2 HF methods for design and development 24
C.3 HF methods for test and evaluation 25
C.4 Summary of application areas for HF methods 26
Bibliography 27

Figure 1 – Human factors influence in the system life cycle process 9

Table C.1 – Summary of application areas for HF methods 26

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GUIDANCE ON HUMAN FACTORS ENGINEERING FOR SYSTEM LIFE CYCLE APPLICATIONS

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IEC-PAS 62508 has been processed by technical committee 56: Dependability.

The text of this PAS is based on the following document:	This PAS was approved for publication by the P-members of the committee concerned as indicated in the following document:
Draft PAS	**Report on voting**
56/1163/PAS	56/1184/RVN

Following publication of this PAS, which is a pre-standard publication, the technical committee or subcommittee concerned will transform it into an International Standard.

This PAS shall remain valid for an initial maximum period of three years starting from 2007-06. The validity may be extended for a single three-year period, following which it shall be revised to become another type of normative document or shall be withdrawn.

INTRODUCTION

This PAS provides technical information on human factors (HF) for engineering and implementation of systems. It fills the urgent need for an HF standard currently not available among the ISO or IEC standards.

HF is one of the key system elements that have significant influence on the system design to achieve dependability performance and service quality. This PAS provides guidance and criteria to facilitate the incorporation of HF requirements in system development and operation. It permits practical HF applications and design trade-offs with other key system hardware and software elements for cost-effective implementation. The technical contents of this PAS are based on human engineering standards and guidelines established by the FAA and NASA. Technical approaches and HF methods are adopted from industry best practices suitable for systems engineering applications.

The HF and human reliability knowledge base covers a broad scope of technical and scientific work. This PAS focuses on the engineering aspects for HF applications in the system life-cycle process. It does not address the human reliability issues involving the study of human anatomy, anthropometry, biomechanics, physiology, and psychology affecting system design and operation with human interactions.

GUIDANCE ON HUMAN FACTORS ENGINEERING FOR SYSTEM LIFE CYCLE APPLICATIONS

1 Scope

This PAS describes the process on human factors (HF) influencing system dependability design and provides HF methods and practices applicable to system life-cycle implementation to achieve dependability performance.

2 Normative references

The following referenced documents are applicable to this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60300-1, *Dependability management – Part 1: Dependability management systems*

IEC 60300-2, *Dependability management – Part 2: Guidelines for dependability management*

IEC 60300-3-15, *Dependability management – Part 3-15: Guidance to engineering of system dependability*[1]

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
human factors (HF)
knowledge on human abilities, limitations, and other human characteristics that are relevant to the design and application of products affecting human-system performance

3.2
human factors engineering
application of human factors knowledge to the design of tools, machines, systems, tasks, jobs, and environment for safe, comfortable, and effective human use

3.3
human reliability
study of human performance in terms of probability that a person will correctly perform some system-required activity during a given time period (if time is a limiting factor) without performing any extraneous activity that can degrade the system

NOTE The application of human reliability knowledge is often referred to as human reliability engineering, human engineering, or human system engineering. It is sometimes used interchangeably as human factors engineering and the scope of application may vary for each application.

3.4
ergonomics
study of scientific information concerning humans to the design of objects, systems and environment for human use incorporating elements from many subjects including human anatomy, physiology, and psychology in the design

NOTE Ergonomics is sometimes used interchangeably as human factors engineering. There are minor differences in approach.

[1] To be published.

4 HF and its influence

4.1 Understanding the HF relationships

The term “HF” is mainly used in North America. The term “ergonomics” is used in Europe and other parts of the world. HF involves working to make the environment function natural to human use. Ergonomics is matching the task and product to the human user. Ergonomics and HF engineering are often used interchangeably in the work environment. Both describe the interaction between the human user and the task demands, and the human-machine relationships. The difference between them is that ergonomics focuses on how the task affects the user, and HF engineering emphasizes the design to reduce the potential of human error in system operation. It is the HF engineering aspects influencing dependability performance that needs to be addressed in system dependability standards.

The relationship of HF to system is that humans are often deployed and used in system functions. The linkage of HF to dependability is that human functions affect the influencing characteristics of reliability, maintainability and maintenance support in system performance.

Human reliability is related to the field of HF engineering. It refers to the study of reliability of humans in various fields such as information processing, manufacturing, transportation, medicine and service operation. Human performance can be affected by many factors such as age, circadian rhythms, state of mind, physical health, attitude, emotions, propensity for certain common mistakes such as errors and cognitive biases.

The broader issues concerning the study of human reliability are directly linked to the possible adverse consequences of human errors or oversights, especially when the human is engaged in a crucial part of a complex system for safety, security or mission critical applications involving human machine and human system interactions. HF engineering utilizes the human reliability knowledge base for application in user-centric and error-tolerant designs by adapting appropriate technologies to enhance human-system operation.

4.2 Human machine comparison

The following presents an overview of human versus machine abilities for comparison. Although rapid advances in technologies have significantly increased the machine abilities, this overview presents a classical observation that remains valid in the HF field.

Humans surpass machines in

- ability to detect small amount of visual and acoustic energy;
- ability to perceive patterns of light or sound;
- ability to improvise and use flexible procedures;
- ability to store very large amounts of information for long periods and to recall relevant facts at the appropriate time;
- ability to reason inductively;
- ability to exercise judgement.

Machines surpass humans in

- ability to respond quickly to control signals and to apply great force smoothly and precisely;
- ability to perform repetitive and routine tasks;
- ability to store information briefly and then to erase it completely;
- ability to reason deductively, including computational ability;
- ability to handle highly complex operations;

- ability to do many different things at once.

The major differences between humans and machines are as follows.

- Machines can be modified, redesigned, and retrofit whereas humans cannot. Humans are born with innate, genetically determined differences that are shaped by the environment. Innate aptitudes or abilities are developed through education and training.
- Machines can be manufactured to be identical to provide exact output and duplicate precise operation. Humans are not identical and vary across all sensory, cognitive, physical and performance characteristics. Specific aspects of human performance can be made more equal through education and training.

4.3 HF engineering process

HF engineering involves the process of engineering the human into systems. The inclusion of humans in systems has the advantage of the human's intuitive reaction, flexibility to adapt to situations, and the capability of performing many functions and tasks. However, human has limitations in cognitive and physical capabilities for task performance. The inherent qualities in the human element as a system attribute can be exploited for design trade-offs with interacting hardware and software elements contributing in a holistic manner to enhance system performance. The aim is to maximize the overall system capabilities in performance operation.

Involvement of HF engineering at early design stages has extensive influence to maximizing the return on investments and optimizing the system capabilities in performance operation. The critical impact areas for HF engineering participation in system design and operation include

- early identification of critical system functions that are considered suitable and advantageous for human interaction by analysis of system operating scenario;
- user-oriented task designs for timing and operating task sequence through HF engineering activity in system decomposition and functional analysis for ease and expediency in human-machine operation;
- consideration of human capabilities and limitations when making function allocation decisions for cost-effective application and training needs;
- integrating the human requirements into the system design process for optimizing the system performance compatibility of human-machine interface and interoperability;
- the process of engineering human into systems includes task analyses of the systems engineering process and the HF engineering process. The relevant tasks, decisions, and information common between the two processes can be used as basis to identify areas of interactions between the human and the system.

Annex A provides additional information on the HF engineering process concerning task analyses for human system interactions.

4.4 HF in system life cycle

HF as a technical discipline is closely associated with systems engineering and system life-cycle process. The system life cycle concept adopted from IEC 60300-3-15 is shown in Figure 1 to identify the key HF influence in the system life cycle. The system life-cycle stages are briefly described as follows.

The concept/definition stage is to identify the market needs, define/identify the operational use environment/timeline, define preliminary system requirements and confirm feasible design solutions by producing technical specifications for the system design.

The design/development stage is to plan and execute selected engineering design solutions for realization of system functions.

Realization/implementation stage is to execute make-buy decisions for acquisition and deployment of subsystem elements.

The operation/maintenance stage is used to deploy the system for delivery of service and to support system operational capability by means of maintenance.

The enhancement stage is to improve system performance with added features to meet growing user demands on the system.

The retirement/decommissioning stage is to end the existence of the system entity.

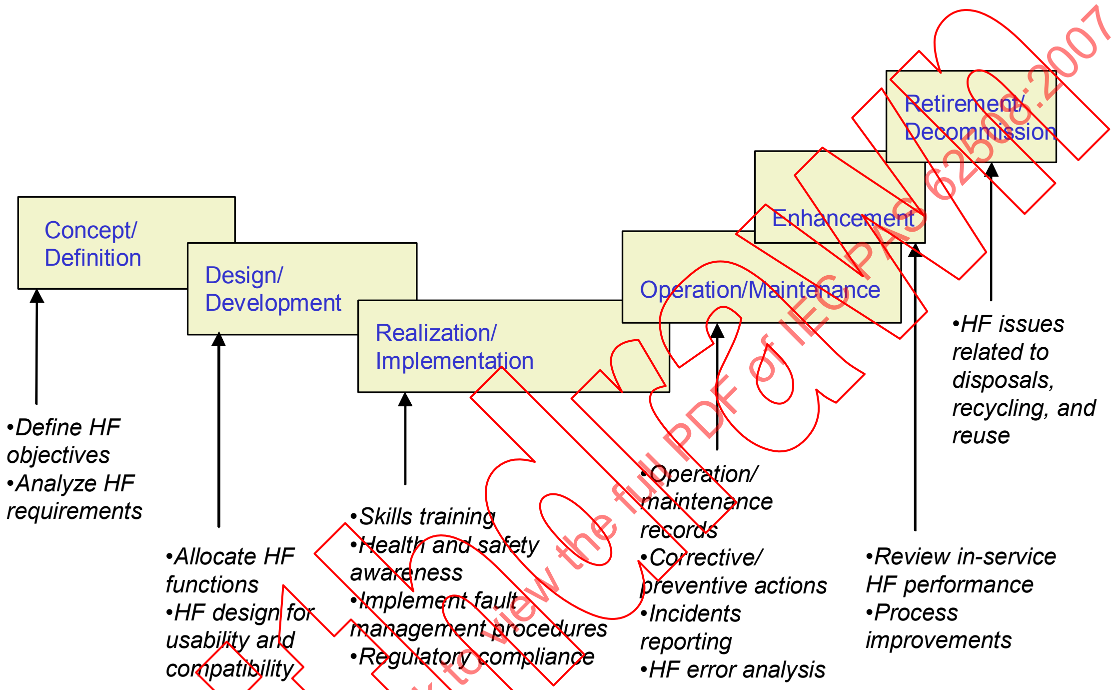

Figure 1 – Human factors influence in the system life-cycle process

4.5 The importance of HF designs

The HF activities complement the dependability projects and work programmes. Dependability is the ability of a system to perform as and when required to meet specific objectives. Dependability describes the availability performance of a system influenced by its performance characteristics of reliability, maintainability and maintenance support. The principles of dependability management are presented in IEC 60300-1. The applications of dependability management techniques are described in IEC 60300-2.

HF activities have significant impact on system dependability design and performance operation. The HF issues when identified and applied early in the system life-cycle design process would

- increase productivity, improve performance, and gain greater user satisfaction;
- reduce errors in design and operation;
- simplify system operation and maintenance procedures;
- reduce time in user support;
- reduce the need for special skills training;
- reduce risks of serious accidents;

- result in cost avoidance and optimize life-cycle costs.

4.6 HF design criteria

The premise for HF design and operation related to safety, security or mission critical application of complex systems is to avoid catastrophic impact and negative consequences. HF standardization facilitates system integration, enhances interoperability of system elements, and improves serviceability and overall dependability performance.

The HF design criteria are based on the following.

a) Fitness for use

- Make system durable, reliable and applicable for its intended use.
- Allocate functions appropriately.
- Test with users.

b) Simplicity

- Design for simplicity.
- Minimize training.
- Make functions obvious.

c) Consistency

- Make design consistent.
- Be consistent with user experience with real life objects and similar system.

d) Standardization

- Standardize hardware and software.
- Maintain identical interfaces for identical functions.
- Make controls, displays, markings, coding, labelling, and arrangement uniform.
- Make appearance distinctive.
- Standardize terminology, look, and feel.
- Make functionally similar equipment interchangeable.

e) Safety

- Incorporate safety factors.
- Provide fail-safe design.
- Make system error resistant and tolerant.
- Warning of potentially unsafe actions.
- Provide emergency procedures.

f) User-centred perspective

- Provide timely and informative feedback.
- Use familiar terms and images.
- Design within user abilities.
- Maximize human performance.
- Minimize training requirements.
- Facilitate transfer of skills.
- Accommodate physical diversity.

g) Maintenance support

- Provide logistic support where needed.

- Design for common tools.
- Make system easy to maintain and accessible.

Annex B summarizes the HF design influence and impact on system dependability.

5 HF activities implementation

5.1 HF planning

A HF plan is essential to establish a strategy for managing HF effort to support system development and operation. The objective is to address HF issues to improve total system performance and reduce developmental and life-cycle costs. This is achieved by optimizing human performance when the system is operated and maintained in the application environment. The planning approach should consider

- identifying the target system of interest and application environment;
- identifying legacy issues of existing system in enhancement projects;
- focusing on the tasks with human involvement in the system life cycle;
- early identification and resolution of human performance issues;
- assigning HF specialists responsible for activities coordination;
- determining the human capabilities and limitations for appropriate task designs;
- establishing a strategy for task implementation involving human interactions;
- project tailoring for system integration;
- incorporation of assurance provisions and review process.

An HF plan should be developed in early concept/definition stage of the system life cycle to maximize its effectiveness to influence system definition and framework development. The HF plan should be part of the system overall plan.

5.2 HF requirements analysis in system definition

HF requirements definition is needed for application scenario and mission analysis of the system of interest. This activity gathers essential information to develop system requirements, prepare cost-benefit and risk analyses, and develop plans, specifications, and statement of work. The HF requirements analysis provides the necessary information and relevant data to

- determine HF issues in system application and operating scenario;
- integrate HF principles into the system context;
- tailor the project to HF content in the system;
- establish HF plan and strategy.

The objective is to achieve a human-centred, error-resistant and tolerant system framework that is suitable and usable for effective system operation. HF requirements should address

- human-system interfaces influencing user performance efficiency and effectiveness;
- system architecture design affecting the human-system interactions;
- interoperability of system elements consisting of hardware, software and humans;
- system application environment impacting human resources and requirements.

The HF requirements analysis should be conducted in conjunction with the HF plan during the concept/definition stage of the system life cycle. This facilitates the tailoring process working to meet specific project needs in system definition. The project tailoring process is described in IEC 60300-2.

5.3 HF analysis in system design

HF analysis in system design is conducted during the design/development stage of the system life cycle. The objective is to ensure that

- human system capabilities and limitations are properly reflected in the system requirements;
- human system performance characteristics are providing relevant information to identify design options and alternatives;
- human system performance risks and cost impacts are appropriately addressed.

The HF analysis approach should consider

- human performance such as human capabilities and limitations, workload, function allocation, hardware and software design, decision aids, environmental constraints, and team versus individual performance;
- training needs such as duration of training, training effectiveness, skills retraining, training devices and facilities, and embedded training;
- staffing requirements such as staffing levels, team composition, and organizational structure;
- personnel selection such as minimum skill levels, special skills, competency and experience;
- health and safety issues such as hazardous materials and conditions, system and equipment design for safe operation, operational and procedural constraints, biomedical influences, protective equipment, and warnings and alarms requirements.

5.4 Incorporating HF in system requirements

The purpose of incorporating HF in system requirements is to

- provide HF inputs to development of system specifications;
- include HF requirements in quality assurance process;
- include HF requirements for outsourcing and subcontracting;
- establish HF procedures for system operation and maintenance.

For human performance influencing the system design and application, the system specifications and operation and maintenance procedures should consider

- staffing constraints;
- system operator and maintainer skills;
- training requirements;
- level of comprehension of the end users.

Incorporation of HF requirements in system specifications should be completed during the design/development stage of the system life cycle.

5.5 Integrating HF in systems engineering

The purpose of integrating HF in systems engineering is to

- develop or enhance human-system interface;
- achieve human performance design objective and effectiveness in system operation and maintenance support;
- establish system operating scenario;
- optimize utilization of personnel resources, skills, training, and costs;

- address resource allocation for automation and for task simplification;
- incorporate HF needs in system enhancement and retirement, equipment assembly and disassembly, and disposal of parts.

Integrating HF in systems engineering is done throughout the system life cycle, especially during the design/development, realization/implementation and operation/maintenance stages, where HF has the most influence on systems engineering tasks related to design enhancements, safety features, automation impacts, human-system performance trade-offs, ease of use, and workload.

Specific systems engineering activities related to HF include

- systems engineering planning and incorporation of HF requirements to identify critical issues for technical resolution;
- development of system design configuration based on functional analysis and function allocation contributed by human elements, and HF task design trade-offs with hardware and software system functions;
- task analysis to determine the information flow and processing requirements by operators, maintainers, and end users to accomplish the system performance objectives;
- test and evaluation of system functions involving human interactions to determine operational effectiveness and conformance to established HF requirements and system performance criteria.

5.6 Outsourcing projects and related HF issues

The HF requirements should be incorporated in system specifications and procurement documents. This is crucial for the system to achieve its objectives for coherent design and consistent performance involving proper function allocation and interactions of hardware, software and human elements in system design and operation. The outsourcing of subsystems development requiring human operation is common in today's complex system development and enhancement projects. Incorporation of commercial-off-the-shelf (COTS) products as system functions often has cost benefits. System support services are frequently used for contract maintenance. The success factors are dependent on the collaborative efforts of the acquirers and suppliers, the system integrators and service providers through application of supply-chain management and quality assurance processes. Since HF involves multi-disciplinary actions, technical experts are sometimes required to deal with resolution of critical HF issues related to outsourcing and procurement needs.

Outsourcing HF projects should consider

- human system interface requirements to achieve the level of human performance during system operation and maintenance;
- maximizing the economical demands on utilization of available human resources, skills, and training;
- staffing implications of the human resources required, job classification, skill levels, and experience needed for the projects;
- evaluation for design automation trade-off with human operation in terms of applicability, efficiency and cost implications;
- potential system safety and health hazards areas involving human-system interactions;
- quality assurance provisions for procurement contracts.

Outsourcing projects should be identified during concept/definition stage of the system life cycle. The procurement contracts should be well established at the completion of the design/development stage. This would permit time for subcontractor evaluation, multiple sourcing of preferred suppliers, and COTS product assessment for incorporation as system functions to facilitate the system integration process.

5.7 HF assessment in system operation/maintenance

HF assessment in system operation/maintenance is to ensure that HF considerations are adequately integrated into the system for effective performance operation. The assessment is conducted during the operation/maintenance stage of the system life cycle. The assessment is achieved by system testing and performance verification. This is to produce evidence of conformance to HF requirements in an application environment. The HF assessment process should

- measure human performance in critical tasks;
- determine efficiency and effectiveness of human intervention;
- maintain HF test records and assessment data as basis for evaluation and improvement.

Human performance testing of COTS products should take advantage of available information from the product manufacturers, records of warranty returns, previous commercial testing, and product use experience.

The HF assessment results should be analyzed to support recommendations in design changes where appropriate, provide rationale for human performance improvements, or implement training solutions. The HF information flow should include sharing with Integrated logistics support (ILS) programmes where applicable. ILS is a disciplined approach to integrate support considerations into design, to acquire the necessary initial support for the system, and to identify life-cycle support requirements. The HF programme provides the human resource and performance dimension for logistics support requirements and functions. Close coordination between the HF and ILS programs will reduce data redundancies and result in more effective use and sharing of information.

6 HF methods

6.1 Classification of HF methods

HF methods are classified as follows.

a) HF analysis methods

HF analysis methods are used to define system concepts, describe application/mission scenarios, determine functional requirements, and assign tasks for appropriate skills allocation. The various analyses provide a means for identifying HF-related goals, objectives, critical design issues, and further evaluation needs to meet system performance requirements involving human interactions.

b) HF methods for design and development

HF methods for design and development are used to incorporate all necessary HF design criteria into the human system interface design. The human system interface includes system hardware, software, procedures, work environments, and facilities associated with the system functions requiring human interactions. The process is to convert the results of the HF analysis activities into HF training and skill level design criteria for HF project development and implementation.

c) HF methods for test and evaluation

HF methods for test and evaluation are used to verify human system interface and procedures to ensure that the system can be operated, maintained, supported, and controlled in its intended operating environment by the users. These methods facilitate identification of critical HF issues in operation and maintenance for problem resolution and process improvement.

Annex C provides a summary of practical methods for HF analysis, evaluation and assessment.

6.2 Applications of HF methods

The HF methods for general analysis, evaluation and assessment applications are based on systems engineering techniques. They should be used in conjunction with other engineering methods and technical disciplines in system design and implementation. The HF methods listed in Annex C facilitate the accomplishments of one or more of the following tasks.

1) Application/mission effectiveness criteria.
2) Detailed design requirements.
3) Concepts formulation ideas.
4) Personnel requirements information.
5) Operational procedures development.
6) Training system development.
7) Maintenance system development.
8) System operational evaluation.
9) Additional HF analysis.

Other application areas related to implementation of HF activities include

a) HF planning
- project management;
- cost-benefits and risk analysis;
- decision-making process.

b) Human-system performance assessment
- situation assessment;
- function allocation;
- cognitive assessment.

c) modelling and simulation
- human performance modelling;
- information flow analysis and simulation;
- human-machine integrated design and analysis system.

d) human computer interaction
- human computer mock-up;
- diagnostic evaluation;
- cognitive walkthrough;
- usability inspection.

e) knowledge elicitation
- cognitive task analysis;
- interview, questionnaire, and observation.

f) physical ergonomics
- empirical models;
- standards.

g) safety
- accident investigation;
- human error;

- human reliability;
- risk assessment.

HF tools are mostly developed for specific applications. They often incorporate experienced database and custom design criteria in dedicated computerized systems. These HF tools are upgraded or changed to meet specific application needs which become difficult for generic application purposes. They are referenced in various literatures and not included in this PAS.

Annex A
(Informative)

HF engineering process concerning task analyses for human system interactions

A.1 HF engineering process for system application scenarios

System inputs	*HF engineering outputs*
• System scenarios • Mission profiles and timelines • Concept of system operations • Technology limitations • Regulatory constraints • Legacy issues	• Estimate of staffing requirements • Verification of workload and task assignments • Evaluation of skills and training requirements • Identification of potential problem areas related to operation and maintenance

A.2 HF engineering process for application environment

System inputs	*HF engineering outputs*
• Natural environmental conditions (weather, topology, time of day) • Induced environmental conditions (lighting, noise, vibration, induced heat)	• Effects of predicted natural environmental conditions • Design constraints reflecting the natural environmental conditions • Strategies to mitigate environmental impact on users

A.3 HF engineering process for requirements analysis

System inputs	*HF engineering outputs*
• Source requirements and application constraints • Human capabilities and limitations • System capabilities and limitations	• Users' knowledge, skills and abilities to perform tasks • Human performance requirements in terms of time for task completion and competency required • HF engineering design requirements to support operators and maintainers • Knowledge and experience database establishment

A.4 HF engineering process for functional analysis

System inputs	*HF engineering outputs*
• Mission analysis • Activity analysis • Requirements analysis	• Functional flow diagrams • Functional architecture • Critical functions identification • Decision actions • Design characteristics to support users

A.5 HF engineering process for function allocation

System inputs	*HF engineering outputs*
• Function allocation evaluation criteria • Functional analysis • Technology and design trade-off • Human roles in system operations	• Allocation of system functions to hardware, software, humans, or combinations • Staff training needs • Operational sequence • Procedural requirements • System and function models

A.6 HF engineering process for tasks design and analysis

System inputs	*HF engineering outputs*
• Allocation of system functions to hardware, software, humans or combinations • Technology and design trade-off • Alternate functions and design options • System physical architecture • System and function models	• Task list • Task interactions and sequence • Timeline analysis • Simulation and prototype models for task activities • Staffing and training needs • Task procedures requirements • Cognitive and physical workload predictions • Human-system performance predictions

A.7 HF engineering process for human interface

System inputs	*HF engineering outputs*
• Operational sequence • Information and decision requirements	• User interface concept • User interface designs • Team coordination tasks

A.8 HF engineering process for requirements reviews

System inputs	*HF engineering outputs*
• Simulations and prototypes results • User interface concepts and designs • Team concepts and designs • Concept of operations • Mission analysis • Operation scenarios • Human roles in system operations	• Usability evaluation • Human performance testing results • User interface feedback • Team feedback • Recommendations for improvement

Annex B
(Informative)

Summary of HF design influence and impact on system dependability

B.1 Automation

HF design	*Impact on system dependability*
• Provide automation information and operating status to system user • Incorporate simple to use features • Ensure safe operations within the user's capacity and capability • Alert user of automation failure or degradation, and potential unsafe modes of operation • Provide easy data access, error resistant and error tolerant features to prevent unauthorized or accidental access • Provide means for manual override	• Enhancing availability of system functions • Improved system performance due to automated functions • Enabling users to carry out the required tasks to avoid increased cognitive demands, extreme workload situations, interruption or distraction imposed on the user • Simplifying user training needs and requirements for system applications

B.2 Design for maintenance

HF design	*Impact on system dependability*
• Build in redundancy where practicable and cost-effective to reduce unscheduled maintenance. • Design for modularity, lowest replaceable unit and throwaway assembly. • Incorporate built-in-test capabilities, remote and self-diagnostic features. • Incorporate quick and easy access to all assembly units requiring maintenance for inspection, removal and replacement. • Minimize the numbers and types of tools and test equipment required for maintenance. • Incorporate self-healing and self-adjustment features where applicable and practical.	• Improved maintainability • Improved reliability. • Simplification of maintenance functions • Enhancing testability, diagnostics, and fault identification. • Reduced maintenance time and logistic support resource requirements.

B.3 Computer-human interface

HF design	*Impact on system dependability*
• Design user friendly interface to facilitate computer-human interactions • Effective screen design to provide minimal information density and directly usable form • User-selected graphic display • Dynamic information update features • Visual coding of critical information • User-selected interaction methods • User-initiated interrupts • Simple file management functions • User-specified transaction functions	• Improved system usability and serviceability

B.4 Incorporation of displays, controls and alarm functions

HF design	*Impact on system dependability*
• Make displays and controls visually legible, identifiable, and distinguishable under all conditions • Locate controls in a consistent manner in grouping and arrangement for easy access to the user • Design the control movement and direction in a consistent manner • Design the controls with sequential operations to follow a fixed pattern • Design the controls for maintenance and adjustment to be protected to avoid accidental activation • Design the coding for controls to differentiate among the controls with uniform application of the code throughout the system • Simplify coding entry and identify error for re-entering codes • Design alarm functions to be visible and auditable • Integrate the alarm function with the control to present responsible indication. • Design alarm functions to provide unambiguous and clear indication of the cause for the alert, and inform the user of the priority and nature of the problem • Incorporate alarm input validation to prevent false alarms • Provide voice communication systems where essential and applicable under alarm and emergency situation	• Improved maintainability • Improved testability • Improved system operation and maintenance tasks • Reduced false alarms • Simplifying user training needs

B.5 Incorporation of input devices

HF design	*Impact on system dependability*
• Design of keyboard entry and fixed-function keys • Design of pointing devices (mouse, joystick and trackball, light pen) • Design of non-pointing devices (touch interactive devices and touch panels, voice activated controls) • Inter-changeability among input devices	• Improved accessibility • Improved operability • Improved usability

B.6 Environment

HF design	*Impact on system dependability*
• Modular designs for lowest replaceable units • User control of workplace environment (ventilation, illumination, temperature, humidity, noise)	• Improved maintainability • Improved productivity in workplace

B.7 Safety

HF design	*Impact on system dependability*
• Workplace safety for accessibility and operation • Equipment-related safety for user operation • Hazard avoidance designs	• Improved productivity in a safe environment • Risk mitigation for degraded system performance

B.8 Security

HF design	*Impact on system dependability*
• System security and authorized access • Security safeguards and protective measures and controls • Physical security • Information security	• Improved system performance integrity • Risk reduction

Annex C
(Informative)

Summary of methods for HF analysis, design and development and test and evaluation

C.1 HF analysis methods

a) Application/mission analysis

Application/mission analysis is used to define the tasks required in system performance. The analysis provides information on the application scenario and the operating profile of the system tasks. An application scenario describes the sequence of actions and events associated with the execution of tasks in a mission. The operating profile represents the events or situations in end-use operation for the completion of the mission. The analysis establishes how the system performs in conceptual or actual operating environment.

b) Task description/analysis

Task description/analysis is a systematic process to record the perceptual, cognitive, and manual behaviour of the user (operator, maintainer) during human interactions with the system. The analysis shows the sequential and simultaneous manual and intellectual activities of the human user interacting with the system. The analysis provides information on the skills required in task performance, and identifies probable human errors and consequences.

c) Predetermined time standards

Predetermined time standards are internationally recognized time standards used for work measurement. They are employed to estimate performance times for tasks that can be decomposed into smaller units for which execution times can be determined or estimated. The assumption is based on standard performance of a trained average worker working at a normal pace. This method is used for time and motion studies, project scheduling and critical path analysis for task completion.

d) Cognitive task analysis

Cognitive task analysis describes the cognitive skills and abilities needed to perform a task proficiently. This method is used to analyze and understand task performance in complex real-world situations that involve change, uncertainty, and time pressure. Cognitive task analysis encompasses the knowledge elicitation method that identifies the skills used to perform a given task, and the knowledge representation method for structuring and depicting the cognitive information in a usable format for application.

e) Functional flow diagram

Functional flow diagram method is used for determining system requirements by delineating into system functions. It provides detailed outline of information flow of system functions consisting of hardware, software and human elements, and combinations. The information can be used for trade-off analysis, identification of critical functions and assessment of potential risk exposures. This method is also known as block diagram method.

f) Operational sequence diagram

Operational sequence diagram method is used for analysis of complex systems requiring many time-critical functions. The method is used for several operators and equipment to deal with information, decision and action. The diagram displays symbols indicating actions, inspections, data transmitted or received, data storage, or decisions to show the flow of information through the system in relation to both time and space of the workstations. The method presents a simple means for system simulation and display.