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Guidance on human aspects of dependability

Lignes directrices relatives aux facteurs humains dans la sûreté de fonctionnement

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IEC Secretariat
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

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Guidance on human aspects of dependability

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IEC 62508 has been prepared by IEC Technical Committee 56: Dependability. It is an International Standard.

This second edition cancels and replaces the first edition published in 2010. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) The emphasis on user-centred design in the previous edition was reduced in favour of a greater emphasis on human dependability in an existing operational environment.
b) The emphasis on human error and error-rate determination methods was reduced in favour of a greater emphasis on means of providing organizational support for the workforce in their execution of required tasks.
c) Where appropriate, discussions of human factors in an operational environment were aligned with current theory, terminology and practice.

The text of this International Standard is based on the following documents:

Draft	Report on voting
56/2074/FDIS	56/2096A/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

INTRODUCTION

This document is intended as a basic guide for managers, engineers and other professionals. It concerns good practice for improving dependability of humans in an operational environment, as well as optimizing the interactions between humans and equipment, software, and organizational systems. Modern workplaces often involve the integration of humans with complex technologies and production systems. This document is intended to assist management to:

- understand the basis for human dependability, including designing equipment and systems to minimize human error rather than overly relying on the workforce to act correctly,
- assess the risks related to human performance in an operational environment, and
- implement changes in an operational environment in order to improve the effectiveness of personnel in relation to the technology and systems with which they interact.

One objective in implementing the guidelines in this document is to facilitate the optimization of interactions between humans and equipment, software, facilities, services and organizational systems. A second objective is to reduce the potential for failures to occur that can adversely affect production, equipment maintenance, safety or the well-being of the workforce. Towards this end, guidance on applicable methods and metrics are included for assessing the risks associated with human dependability.

This document is not intended as a handbook or theoretical guide to the fields of human factors or human-systems interactions. These are available elsewhere, and some useful references are listed in the bibliography. Rather, it is intended as a tool for managers and engineers who are tasked with designing, assessing or controlling the human and technical elements of their area of responsibility.

Rather than being a review of human "undependability", the aim is to describe the elements of operational systems that positively contribute to human performance. This document provides an awareness of the relative importance of these elements to dependability, and the tools for assessing how well they are functioning in the organization, and how they can be enhanced.

In accordance with other dependability standards (cf. IEC 60300-1), the term ‘human reliability’ will refer to qualitative and, when appropriate, quantitative measures of human performance. The term "human dependability" will be applied more broadly to the ability of humans to conduct a task or job as-required and when-required, with an outcome that satisfies agreed stakeholder expectations. The concepts of "maintainability" and "supportability" will still apply, but in the broader context of the organizational factors required for maintaining and supporting human performance.

Although knowledge of the field of human factors in the workplace and principles of human-centred design would be useful, this document will help managers, engineers and other professionals to identify the areas of their responsibility that would benefit from improvement in terms of human dependability, and to put in place interventions designed to optimize human performance.

This document primarily addresses complex technical systems, but some parts are also applicable to manufacturing of mass-produced industrial and consumer products. Principles for the design of the human-machine interface (usability) are described, and further information can be found in technical literature and in relevant product standards.

1 Scope

This document provides guidance on current knowledge and practice concerning dependability in an operational environment, in terms of the humans, teams and organizations involved in conducting the work. It is part of a suite of IEC standards that are intended to address the dependability of both the technical and human elements of equipment and organizations.

This document describes the human elements of a typical operational system, and the importance of those elements to overall dependability. It also describes the means of assessing how well these elements are functioning, and general concepts on how the reliability of humans can be improved. These elements typically include the individual workers, the groups or teams into which they are organized, the interfaces between humans and technical systems, and the overall organization.

The following guidance is applicable to any industry that depends on human-systems interactions involving the technology, software, or systems of work required to support the production and safety objectives of an organization. This document primarily addresses complex technical systems, but some parts are also applicable to the manufacturing of industrial and consumer products. Principles for design of the human-machine interface (usability) are described, and further information can be found in the technical literature and in relevant product standards. Although this document does not specifically cover worker health or safety, the application of this document can raise related issues, particularly in process safety, which is closely associated with system reliability.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of 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 60050-192:2015, *International Electrotechnical Vocabulary (IEV) – Part 192: Dependability,* available at www.electropedia.org

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-192 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

3.1.1
dependability
ability to perform as and when required

Note 1 to entry: A dependable item or service is one where there is justified confidence that it operates as desired and satisfies agreed stakeholder expectations.

Note 2 to entry: In most cases, the term "dependability" is used as an umbrella term to express its core attributes of reliability, maintainability, and supportability and the attribute of availability derived therefrom. In some cases, attributes such as resilience, recoverability, durability, integrity, safety, security, trustworthiness are also included in or overlap with dependability.

Note 3 to entry: In order to express the ability to perform, requirements are specified in terms of the functions to be performed, when the performance is to be achieved, and the life profile conditions, as specified by customers, users, or stakeholders.

Note 4 to entry: The attributes of dependability can be expressed qualitatively or quantitatively.

Note 5 to entry: It is also a common practice to use the term "dependability" in the context of a subject of study or discipline.

[SOURCE: IEC 60050-192:2015, 192-01-22, modified – The domain <of an item> has been deleted and the Notes to entry have been replaced with new Notes to entry.]

3.1.2
ergonomics
human factors
HF
scientific discipline concerned with the understanding of interactions among human and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance

[SOURCE: ISO 6385:2016, 2.3]

3.1.3
human error resistance
ability of a system to minimize the probability of human error occurring

3.1.4
human aspects
abilities, limitations, and other human characteristics that are relevant to the design, operation or maintenance of systems and their components, affecting overall system performance

3.1.5
human-centred design
approach to systems design and development that aims to make interactive systems more usable by focusing on the use of the system, applying human factors, ergonomics and usability knowledge and techniques

Note 1 to entry: Usable systems provide a number of benefits including improved productivity, enhanced user well-being, avoidance of stress, increased accessibility, and reduced risk of harm.

Note 2 to entry: This standard uses the term "human-oriented design" to refer to the need to take account of humans in system design but retains the term "human-centred design" used in ISO standards to refer to the specific principles and activities.

Note 3 to entry: The term "human-centred design" is used rather than "user-centred design" in order to emphasize that this document addresses a number of stakeholders, not just those typically considered as users. However, in practice, these terms are often used synonymously.

[SOURCE: ISO 9241-210:2019, 3.7, modified – Note 2 to entry has been added, and Notes 1 and 3 to entry have been renumbered.]

3.1.6
human error
discrepancy between the human action taken or omitted, and that intended or required

[SOURCE: IEC 60050-192:2015, 192-03-14, modified – the example has been omitted.]

3.1.7
human error probability
probability that an operator will fail in an assigned task

Note 1 to entry: This can be based on the ratio of the average number of errors within a certain task in relation to the overall number of error possibilities for this type of task.

Note 2 to entry: Human error probability is expressed as a distribution, where the distribution is determined in accordance with the human variations and situational variations under which the task is to be conducted.

3.1.8
human failure
occurrence of a deviation from the human action that is necessary for achieving an objective, regardless of the reason for that deviation

Note 1 to entry: For any particular system or situation, the range of human failures is the combination of human errors and violations that lead to system failures or hazardous outcomes, or both.

3.1.9
human-oriented design
user-centric approach to design by adapting technologies to meet human performance requirements, account for human limitations, achieve mental comfort and enhance overall system performance

3.1.10
human reliability
ability of human beings to complete a task under given conditions within a defined period of time and within the acceptance limits

3.1.10.1
human dependability
ability of humans to conduct a task or job as required and when required, with an outcome that satisfies agreed stakeholder expectations

3.1.11
human reliability analysis
human reliability assessment
systematic process to evaluate human reliability

Note 1 to entry: Evaluation methods can be qualitative alone or can be expanded to provide quantitative results.

3.1.12
machine
non-human component of a system that assists humans to achieve the organization's output

Note 1 to entry: Machine includes hardware and software used to perform physical, computational, decisional and creative tasks.

3.1.13
mistake
deficiency or failure in the judgemental or inferential process involved in the selection of an objective or in specification of the means to achieve it, irrespective of whether or not the actions run according to plan

3.1.14
performance shaping factors
characteristics of the task, workplace or organizational environment that influence the outcome of human activities

3.1.15
requirement
statement which translates or expresses a need and its associated constraints and conditions

Note 1 to entry: Requirements exist at different levels in the system structure.

Note 2 to entry: A requirement is an expression of one or more particular needs in a very specific, precise and unambiguous manner.

Note 3 to entry: A requirement always relates to a system, software or service, or other item of interest.

Note 4 to entry: A requirement is a statement where evidence or assurance of compliance can be provided.

[SOURCE: ISO/IEC/IEEE 29148:2018, 3.1.19, modified – Note 4 to entry has been added.]

3.1.16
situational awareness
human perception of the elements in the environment within a specified or implied volume of time and space, the comprehension of their meaning and the projection of their status in the near future

3.1.17
socio-technical system
set of interrelated or interacting technical, human and organizational elements which produce an output generally based on inputs and tasks

EXAMPLES A system producing IT, a factory production line, an office processing paperwork or a mine extracting minerals.

Note 1 to entry: In the context of dependability, a system will have:

– a defined purpose expressed in terms of intended functions,

– stated conditions of operation or use, and

– defined boundaries.

Note 2 to entry: The structure of a system can be hierarchical.

Note 3 to entry: For some systems, such as information technology products, data is an important part of the system.

3.1.18
task
defined activity that is assigned to a person or machine in order to achieve a specific goal

Note 1 to entry: These activities can be physical, perceptual or cognitive.

Note 2 to entry: While goals are independent of the means used to achieve them, tasks describe particular means of achieving goals.

3.1.19
violation
deliberate, but not necessarily malicious, deviation from practices deemed necessary

3.1.20
workplace
permanent, temporary, physical, or virtual location where tasks are accomplished

EXAMPLE A component of a socio-technical system.

3.2 Abbreviated terms

ASEP	accident sequence evaluation programme
ATHEANA	a technique for human error analysis
CAD	computer-aided design
CAHR	connectionism assessment of human reliability
CARA	controller action reliability assessment
CPC	common performance condition
CREAM	cognitive reliability and error analysis method
EFC	error-forcing context
ESAT	Experten-System zur Aufgaben-Taxonomie (expert system for task taxonomy)
FMEA	failure modes and effects analysis
FMECA	failure modes effects and criticality analysis
HEART	human error assessment and reduction technique
HEP	human error probability
HF	human factors
HRA	Human Reliability Analysis
HR	human resources
HSI	human-system interactions
ILS	integrated logistics support
IT	information technology
MERMOS	méthode d'évaluation de la réalisation des missions opérateur pour la sûreté (method for evaluating the accomplishment of an operator's safety tasks)
ORE	operator reliability experiments
PSF	performance shaping factor
RR	reliability rating
SHERPA	systematic human error reduction and prediction approach
SLI	success likelihood index
SLIM	success likelihood index methodology
SPAR-H	standardized plant analysis risk-human reliability analysis
THERP	technique for human error rate prediction

4 Dependability elements of a socio-technical system

4.1 Overview

Human actions can have a strong influence on the dependability of the whole system and the quality of the output. Therefore, important benefits accrue from consideration of human aspects, among which are preventing failures, improving system performance, promoting safe systems of work, increasing reliability and enhancing cost effectiveness. A system that requires human interaction involves human(s), machine(s) and the organizational and physical environment in which they operate. The dependability of the system and the efficiency and effectiveness with which the output or tasks of the system are achieved depend on each component of the system individually and the interactions between them (Figure 1).

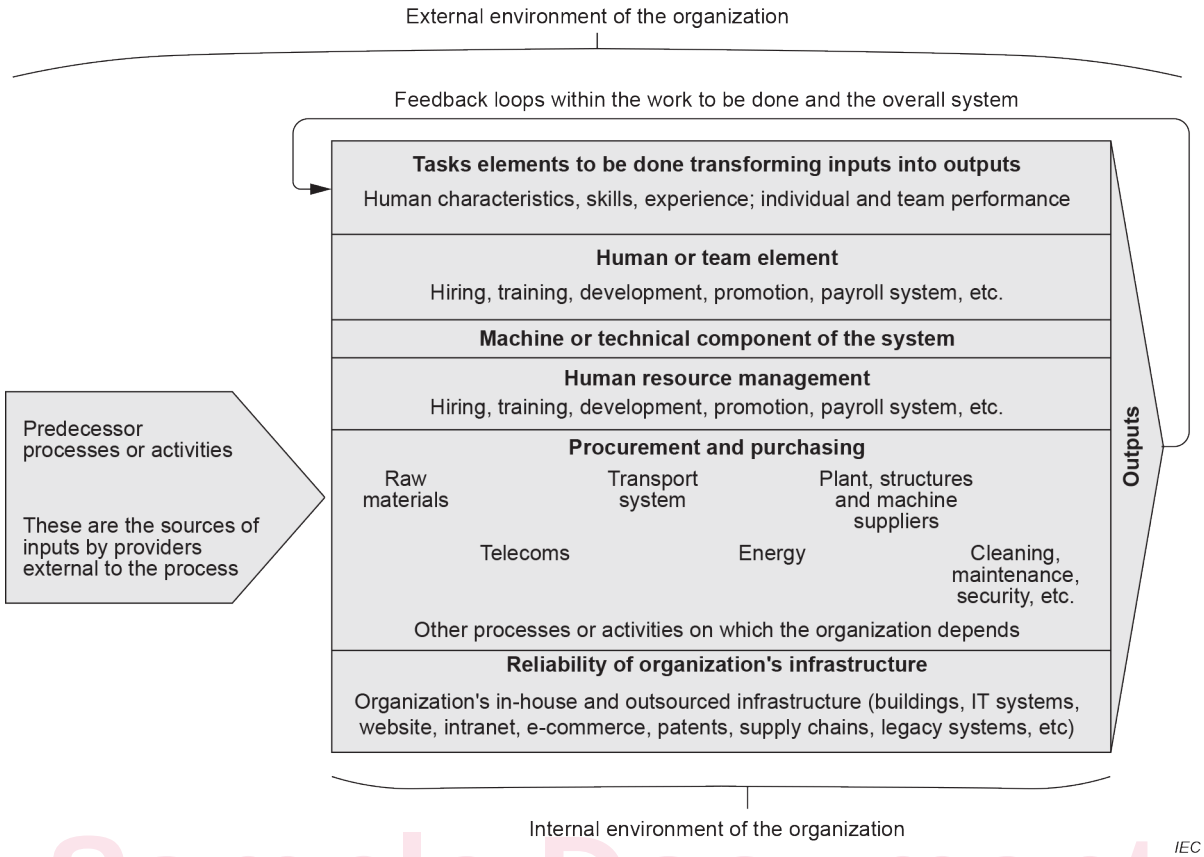

Figure 1 – Components and interaction of a socio-technical system

The elements shown in Figure 1 are as follows.

- Task element: what the work system is expected to achieve (4.2).
- Human or team element: person or people who perform the task (4.3).
- Machine: technical component of the system designed to support achievement of the work system tasks by interacting with the human element (4.4).
- Team and organizational element: structure of the social and organizational operating environment, and systems for organizing the human element (4.5).
- Physical and cultural environment: factors in the operational environment that can influence the humans and organization (4.5.3).
- Output: that which the system achieves with the required level of effectiveness, efficiency and satisfaction.
- Feedback: information exchanged between elements of the system to indicate successful or unsuccessful achievement of the output (4.6).
- In addition, all the elements of the system are influenced by performance shaping factors (PSFs) (5.2.2).

Dependability is usually characterized in terms of reliability, maintainability, supportability, and availability. In some cases, attributes such as resilience, recoverability, durability, and integrity, are also included in dependability. Dependability is critical at all life-cycle stages. Dependability also affects other attributes such as safety and environmental protection, where the inability to perform a required function can result in safety-related or environmentally damaging consequences. Dependability should therefore be actively managed throughout the system life cycle. Clause 7 describes the details of human dependability at each life-cycle stage.

NOTE The dependability objective can be different from the safety objective at each life-cycle stage because dependability is defined as "ability to perform as and when required" and safety is "freedom from unacceptable risk". Although this document does not directly refer to safety nor environmental issues, much of the guidance in this document can also be applied to them.

4.2 Task element

Achieving the goals of a socio-technical system can require the satisfactory completion of many tasks. The objective of the socio-technical system is to complete these tasks with a desired effectiveness and output quality, within an efficient timeframe, in accordance with defined processes and procedures (including safe methods of work).

Tasks within an operational environment vary depending on the work system. Tasks can be value-adding or non-value adding; both can affect dependability. Examples of different types of tasks include:

- design of the system (not covered by this document);
- construction tasks e.g. assembling, connecting, testing and commissioning;
- operational tasks e.g. sampling, monitoring, changing configurations, adjustment of parameters, removing impediments;
- maintenance tasks e.g. inspection, fault-finding, cleaning, repair or replacement, calibration, lubrication, updating;
- travelling and movement within the system;
- transferring information e.g. communication, reporting, handovers and briefings;
- supervision e.g. planning, issuing directions to personnel, monitoring and correcting;
- training, instruction and assessment e.g. determining skills required, determining skills level, assigning to appropriate training courses and materials.

The allocation of tasks between humans and technology (such as machines and software) should be based on performance criteria, such as performance demands (e.g. work constraints, speed of response, frequency of action, need for judgement and decision-making) and relative capabilities of humans versus technology (see 5.4.2 for allocation of tasks to humans versus machines). The dependability of humans involved in executing tasks can be affected by factors such as difficulty or complexity, and how routine or unusual the task is, as well as support factors, such as the clarity of procedures, resources and time available, and the quality of planning and training.

Design of tasks and jobs within an operational environment should manage the risks associated with that work, pre-empt potential workarounds, and minimize the potential for excessively high or low workload (either physical or cognitive workload).

Tasks can be described by objectives, resource allocation, and operational procedures. To improve understanding, a complex task is usually decomposed into sub-tasks in hierarchical or chronological order. The accomplishment of each task can be measured through the use of key performance indicators. Maximizing or minimizing these indicators, as appropriate, while managing other task requirements and constraints, will assist in achieving the organization’s objectives.

Resource allocation describes the natural, machine, and human resources that contribute to successfully executing the task. Operating procedures include standard operating procedures that describe how to complete the task in normal operating conditions, as well as emergency operating procedures that describe how to recover from incidents and accidents or minimize further damage and risk.