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HUMAN FACTORS FOR DESIGNERS OF EQUIPMENT

PART 13: HUMAN COMPUTER INTERACTION

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Revision Note

Historical Record

This Defence Standard has its origins in "Human Factors for Designers of Naval Equipment" (a naval handbook in two volumes) published in 1971.

Arrangement of Defence Standard 00-25

Human Factors for Designers of Equipment
Part 1 - Introduction
Part 2 - Body Size
Part 3 - Body Strength and Stamina
Part 4 - Workplace Design
Part 5 - Stresses and Hazards
Part 6 - Vision and Lighting
Part 7 - Visual Displays
Part 8 - Auditory Information
Part 9 - Voice Communication
Part 10 - Controls
Part 11 - Design for Maintainability
Part 12 - Systems
Part 13 - Human Computer Interaction
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HUMAN FACTORS FOR DESIGNERS OF EQUIPMENT

PART 13: HUMAN COMPUTER INTERACTION

PREFACE

i This Part of the Defence Standard is concerned with the Human Factors aspects associated with the analysis, design and development of human-computer interfaces, and the associated human-computer interaction.

ii This Part of the Defence Standard is published under the authority of the Human Factors Subcommittee of the Defence Engineering and Equipment Standardization Committee (DEESC).

iii This Standard has been agreed by the authorities concerned with its use and is intended to be used whenever relevant in all future designs, contracts, orders etc and whenever practicable by amendment to those already in existence. If any difficulty arises which prevents application of the Defence Standard, the Directorate of Standardization shall be informed so that a remedy may be sought.

iv Any enquiries regarding this Standard in relation to an invitation to tender or a contract in which it is incorporated are to be addressed to the responsible technical or supervising authority named in the invitation to tender or contract.

v This Standard has been devised for the use of the Crown and its contractors in the execution of contracts for the Crown. The Crown hereby excludes all liability (other than liability for death or personal injury) whatsoever and howsoever arising (including, but without limitation, negligence on the Part of the Crown its servants or agents) for any loss or damage however caused where the Standard is used for any other purpose.

vi This Part of the Defence Standard is being issued as an INTERIM Standard. It shall be applied to obtain information and experience of its application. This will then permit the submission of observations and comments from users, using D Stan Form 42 enclosed.

A review of this INTERIM Standard should be carried out within 12 months of publication. Based on the comments received the author and/or committee responsible for the preparation of the Defence Standard shall judge whether the INTERIM Standard can be converted to a normal Standard or decide on what other action should be taken.

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0 Introduction

This Part identifies a minimum set of activities which are considered to be mandatory in the development of any defence equipment in which HCI is a significant factor. This Part also provides general guidance on the principal technical issues involved in HCI development.

The document is split into five major sections with two annexes. The sections are:

Section 1 Introduction

Section 2 Identifies a minimum set of mandatory activities and describes HCI activities normally expected to form part of an HCI development process

Section 3 Defines the requirements relating to the design of the interface

Section 4 Defines the requirements relating to interactive devices

Section 5 Details the requirements for quality and compliance

Annex A Definition of Terms

Annex B References

The objective of setting out procedures and requirements in this Part is to ensure through a structured approach, the successful analysis, design and development of the HCI aspects of a system. These activities will provide a means of arriving at a reasonable and acceptable balance between the reduction of the risk and the cost of the work required.

This Part describes the systematic application of risk assessment to Human Factor issues involved in the analysis, design and development of human computer interfaces. The formal identification of HCI Operability Risks is central to this process and is the principal means for establishing the extent of HCI specific work required in a system development, it also identifies HCI issues influencing the effective use of a system and summarizes the work required to provide confidence that these issues are adequately addressed in a system development.

This Part also discusses HCI factors which can influence task performance and overall system effectiveness. It provides quantitative technical data where available and identifies considerations which should be addressed during a development and is principally concerned with providing technical guidance on design issues rather than on the process of HCI development. However, a minimum set of activities normally required to develop effective HCIs are described. A mandatory requirement for the Design Authority to conduct an HCI Operability Risk Assessment for each phase of a project is also described and can be applied to the procurement of commercial-off-the-shelf (COTS) equipment. Where COTS are intended to be used for principally office-based tasks, equipment should comply with BS 7179, or ISO 9241.

Where an equipment procurement programme relates specifically to combat system equipment for naval systems, compliance with BR 8710 (Chapter 14) is also required, unless otherwise specified in contractual documents. The guidance given within this document is intended to be independent from any specific development method and from any hardware or software environment. The content is intended to be sufficiently general to allow projects and design authorities to apply the Standard without prejudice to particular design solutions.

1 Scope

This Part of the Defence Standard specifies requirements for the Human Computer Interaction (HCI) aspects of system development.

Operational and non operational use information contained herein refers to any computer-based equipment procured by the MOD which is intended for operational use. For the purpose of this Part of the Standard, 'Computer-based equipment' is defined as computer technology which provides an interface between human users and related equipment or data. Such equipment may provide the user with access to information about the status of equipment, the environment, or other operational data. It also applies to equipment providing users with facilities to monitor or dynamically interact with equipment or data.

2 WARNING

This Defence Standard embodies procedures, techniques, practices and tools which when followed or used correctly will reduce, but not necessarily eliminate the probability that the use of equipment may be injurious to health if adequate precautions are not taken. It refers only to technical suitability and in no way absolves either the designer, the producer, the supplier or the user from statutory and all other legal obligations relating to health and safety at any stage of the manufacture or use.

Particular attention is drawn to the following hazard(s), although the list is not necessarily exhaustive and the inclusion of such a list does not absolve the supplier or user from the obligations referred to in this warning.

(a) Upper limb pains and discomfort.

(b) Eye and eyesight effects.

(c) Fatigue and stress.

(d) Epilepsy.

(e) Facial dermatitis.

(f) Electro magnetic radiation.

(g) Implications of user error.

2.1 Health and Safety. The details contained within this Standard do not replace or take precedence over the "Health and Safety at Work Act etc (1974)". The requirements of this Standard and of the Health and Safety Regulations are to be seen as complementary.

2.2 Purpose. The purpose of this Part is to influence the operational effectiveness of manned systems in a positive way by ensuring that the design of Human Computer Interfaces support effective Human Computer Interaction.

This can be referred to as the HCI Design Quality aspects of the system.

This Part is intended to reduce the risk of computer-based systems being put into service in which the performance of capability of the system's users results in the system failing to satisfy operability requirements. Operability requirements addressed include the overall standards of system effectiveness, the levels of user training, support and effort required to achieve those standards, and considerations of system availability, reliability and user acceptance.

2.3 Usage. This Part is intended to be cited on all projects in which operational computer-based equipment is being procured, where the interaction between the system and the human users impacts the operational effectiveness of the equipment. It describes requirements for a minimum set of documents to be developed and maintained throughout a procurement, to provide control of HCI development issues.

HCI "Considerations" which are relevant to a procurement are identified and described. This Part identifies issues which typically need to be addressed in HCI development. Users of the Standard are expected to identify those issues which are relevant to the specific development, then apply appropriate consideration of those issues. Compliance with this Part depends on demonstrating:

(a) that the design issues relevant to a particular development have been identified;

(b) that appropriate consideration has been given to the issues and

(c) providing evidence that the results of the consideration are documented and reflected in the HCI Design.

2.4 Audience. This Part is intended to be used by those both within MOD and Industry who have involvement in HCI development. The principal target audience are those people directly involved in equipment development, including MOD(PE) project personnel and their supporting technical advisors, user representatives within the armed forces, and those involved in the design and development of defence equipment within industry.

3 Related Documents

3.1 The documents and publications referred to in this Part of the Standard, are listed at annex B.

3.2 Related documents can be obtained from:

DOCUMENT	SOURCE
Consumer Protection Act 1987 Health and Safety at Work Act 1974	PO BOX 276 LONDON SW8 5DT
British Standards/ISO	British Standards Institution 389 Chiswick High Road LONDON W4 4AL
STANAGs	NMST Room 202 Archway Block South Old Admiralty Building Spring Gardens LONDON SW1A 2BE
Defence Standards, Def Stans	Directorate of Standardization Stan 1 Kentigern House 65 Brown Street GLASGOW G2 8EX
BRs	Central Services Establishment CSE 1c Llangennech DYFED SAS14 8YP
SSCPs	MOD Library Room 2 Block E Foxhill BATH BA1 5AB
Mil Standards Mil Specs	Technical Indexes RAPIDOC Willoughby Road Bracknell BERKSHIRE RG12 4DW

3.3 Reference in this Part of the Standard to any related document means in any invitation to tender or contract the edition and all amendments current at the date of such tender or contract unless a specific edition is indicated.

4 Definitions

For this Part of the Defence Standard the definitions listed at annex A apply.

Section Two. Design Process

5 Management of an HCI Development

5.1 Design Authority responsibilities. The Design Authority is responsible for planning and undertaking all activities necessary to ensure that the design of the Human-Computer Interface does not represent a risk to the operational performance, availability or reliability of the overall manned system. This includes the responsibility for ensuring that all considerations relevant to the design and production of the HCI cited in this Part have been adequately addressed.

5.2 Identification of HCI Related Operability Risk

5.2.1 The Design Authority shall carry out an assessment to identify the risks to the system's overall operational objectives which might arise through the design of the HCI. The level of detail in the risk identification shall:

(a) be commensurate with the size, complexity and novelty of the system being procured;

(b) be appropriate to the complexity of the HCI;

(c) be commensurate with the range of users expected to use the system, including maintainers, training personnel and other relevant stakeholders;

(d) be commensurate with the complexity of the tasks and the demands expected to be imposed on the user.

5.2.2 A separate risk identification shall be conducted for each stage of a project life cycle, and a report shall be issued prior to commencement of the relevant stage. It may often be appropriate for the assessment to be included as part of the contractor's response to an invitation to tender.

5.2.3 The method by which the risk identification is carried out shall be determined by the Design Authority but it shall, as a minimum, satisfy the following requirements:

5.2.3.1 The results of the identification shall be documented.

5.2.3.2 Critical HCI risks which come within the responsibility of the Design Authority for the project shall be identified, together with the supporting rationale. Critical HCI requirements are those issues affecting the design of the HCI which, if they are not achieved, may result in one or more of the system objectives not being met. If the risk identification concludes that there are no critical HCI requirements within the responsibility of the Design Authority, this shall be documented, with supporting evidence.

5.2.3.3 For each critical HCI risk, the risk identification report shall include:

(a) a statement of the nature of the risk and the operational objectives which may be affected (ie operability, maintainability, training, health and safety etc);

5.2.3.3 (Contd)

(b) an estimate of the most extreme magnitude of the risk quantified in an appropriate manner (such as "time to perform critical operations could be 100% longer than the time expected to be available") also

(c) a statement of the priority which should be given to the risk, both relative to other HCI and Human Factors issues, and relative to other system considerations.

5.2.3.4 System and HCI Design decisions which will impact on each HCI risk shall be identified, together with a description of the information needed to support appropriate decisions. Activities necessary to adequately address the risk during the subsequent life-cycle stage shall also be identified.

5.2.4 Scope of Risk Identification. Developing a system which meets its operational objectives can only be assured by integrating HCI analysis and design with the overall system analysis and design process. During the risk analysis, the full scope of HCI requirements shall be addressed.

5.2.5 The top level system requirements (such as the need to reduce manpower, or the requirements to use commercial "off the shelf" packages) shall be identified. The HCI Risk Identification shall explicitly address, but not be limited to, the following issues:

(a) Overall system effectiveness.

(b) Initial and on-going training.

(c) Consequences of delayed implementation.

(d) Post implementation maintenance.

(e) Post implementation support.

(f) Pre-acceptance design changes.

(g) Post implementation design changes.

(h) Health and safety.

5.2.6 The identification shall address both the cost, and the operability impact of HCI issues. The assessment shall be judged in accordance with the following Table A.

NOTE: In Table A the "Likelihood" column refers to the likelihood of the design of the HCI leading to failure to meet operational requirements.

5.2.6 (Contd)

Table A

HCI Related Operability Risk Assessment

Likelihood	Possible Consequences			
	Catastrophic	Critical	Marginal	Negligible
Very high	Level 4			
High		Level 3		
Moderate			Level 2	
Low				
Very Low				Level 1

5.3 The HCI Design Rationale. Where the results of the HCI Operational Risk Assessment indicate that aspects of the design of the HCI represents a significant risk to system objectives, an HCI Design Rationale document shall be prepared and maintained during each stage of a procurement. The document shall include a record of the considerations given and conclusions drawn, including design decisions. The document will provide traceability of decisions made during the design process that affect the HCI. Traceability in general must be viewed in managerial as well as technical terms.

5.4 User representation. Where a project involves HCI analysis, design or evaluation activities, the HCI development team shall be provided with adequate access to user representatives. User representatives are individuals having appropriate and recent user experience and training for them to be able to represent the interests of the target user population. Special consideration shall be given to the methods and mechanisms for communication between representative users and those involved in HCI development. User representatives need to have an appropriate level of authority and to understand that authority.

NOTE: Many design problems arise from poor communication between the design team and the target users.

5.5 Safety considerations. Where a hazard analysis programme or a safety risk assessment (see Def Stan 00-56) is required in the development of the equipment, the HCI program shall identify the relationship and interface between the two programs.

6 Essential HCI Development Activities

6.1 General. The development activities necessary to ensure that HCIs developed for operational military equipment will be effective, depend on a range of factors associated with each development. These include the nature, complexity and novelty of the equipment, requirements for inter-operability with other equipment, and the extent to which the operational effectiveness of the equipment depends on the equipments' users. Equipment development projects will often involve activities such as HCI requirement analysis, conceptual design and rapid prototyping, user trials and operator

6.1 (Contd)

workload analysis. (Part 12 of this Standard describes the Human Factors activities often conducted in system development.)

6.1.1 HCI development activities should lead to the production of a set of documents controlling and defining the HCI development process. The following documents, or their equivalents shall be produced:

(a) an HCI Risk Identification Report;

(b) an HCI Development Plan;

(c) an HCI Requirements Specification;

(d) an HCI Design Rationale and Specification;

(e) a User Evaluation Report;

6.1.2 An HCI Acceptance Questionnaire shall be drafted by the contractor and approved by the appropriate authority. It shall document all the assessment/acceptance activities including demonstrations, prototypes and development rigs for both informal and controlled trials. The trials may use experts and/or representative personnel from the user or maintainer population. The results of the assessments derived from the use of the questionnaire shall cover the functionally, equipment operability and the performance of the users during agreed scenarios. It may also cover the interoperability between equipments used in close proximity or in relationship to one another.

6.1.3 The format of these reports will normally be agreed between the Design Authority and the MOD(PE) Project Manager. The resultant document set shall however, allow traceability from requirements to design. Where a project mandates a specific approach to Human Factors (such as those mandated under MANPRINT or SSCP1O, 11 or 12), the resultant programme of work shall ensure that their output covers the content of the above reports.

6.1.4 The extent of the work undertaken to produce these documents at the different stages of the system life cycle shall be appropriate to the scope of that stage. The figure below identifies a typical relationship between the extent of this work and the overall design life cycle.

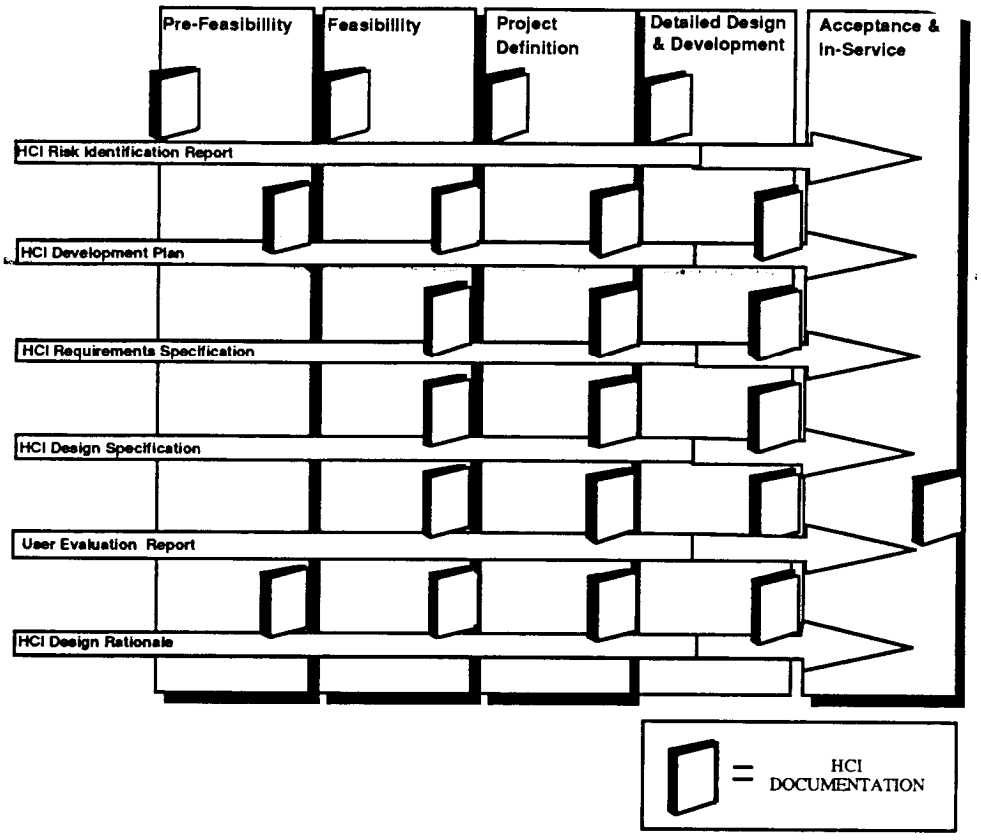

Fig 1: Relationship Between Required HCI Documentation and System Development Life Cycle Stages

6.2 HCI Risk Identification report. The HCI Risk Identification report shall contain the information contained in clause **5.2.3.** The Design Authority shall generate this information by whatever methods are deemed appropriate. Techniques such as Stakeholder Analysis, Task Analysis and Workload Assessment may often be appropriate in identifying HCI Risks.

6.3 HCI development plan. Where the results of the HCI Risk Identification indicates that HCI issues require formal consideration during a project stage, the overall program plan for the stage shall include details of the HCI activities to be performed. The plan shall identify the activities, relationships and extent of activities required to address the identified risks. The activities for the development of HCI aspects of the system shall be undertaken in a systematic and structured way.

6.3.1 HCI prototyping The HCI development plan shall explicitly describe the use of HCI prototyping. HCI prototyping shall be carried out at all phases of the design and development process. HCI prototypes should not be confused with Alpha and Beta code releases. They should also not be confused with demonstrators or simulators. HCI prototypes should be considered as development environments performing three essential roles in producing successful HCIs.

(a) Clarifying HCI requirements via the identification of the HCI problems.

6.3.1 (Contd)

(b) Development design solutions and reviewing them with user and customer representatives.

(c) Supporting both informal user evaluations and formal user trials (which may form part of overall system acceptance).

6.3.1.1 The purpose, nature and complexity of an HCI prototyping activity will depend on the specific objectives of the development phase and the extent to which HCI issues are critical to operational objectives. The following list identifies typical uses of HCI prototyping at each stage of a development life-cycle:

(a) Within the pre-feasibility and feasibility phases, the prime objective of HCI prototyping should be to facilitate the elicitation and specification of high level HCI and operability requirements. Consideration should also be given to investigating basic HCI design concepts.

(b) The prime objective during the project definition phase should be to clarify and support the preparation of detailed HCI requirements specifications. During this stage, consideration should also be given to using the facility as the basis for conducting informal user trials and design validation activities.

(c) Within full development and initial production phases, HCI prototyping shall be used to support the development, demonstration and specification of detailed HCI design solutions. The environment should also be used to support further formal and informal user trials. Where the prototyping environment and the implementation of the system HCI on the prototype is sufficiently representative of the production system, consideration should be given to the possibility of conducting formal acceptance trials in the environment.

(d) Where in-service equipment is being upgraded, consideration shall be given to the use of prototyping to prove the operational performance criteria will be met before the in-service date.

6.3.2 Task analysis. Task analysis will normally be required in any Human Factors development process. Where an analysis is carried out in support of HCI development, consideration shall be given to ensuring the analysis method is appropriate to support HCI development. Results of the consideration shall be documented in the HCI Design Rationale. The task analysis shall address both operational users and system maintainers and shall, as a minimum, identify:

(a) The set of all user and maintainer tasks especially those expected to require interaction with the Human Computer Interface and their relationships to user goals and objectives.

(b) Performance requirements for each HCI related role and task.

(c) The sets of 'objects', and the related data and behaviour which need to be reflected in the HCI to support user tasks.

(d) Information required from the system to support each task.

6.3.2 (Contd)

(e) Critical tasks and decisions which depend on interaction with the system.

(f) The expected allocation of function at an HCI device level between the user and the system.

(9) Assumptions made about the system design envisaged.

NOTE: The HF task analysis may have implications for the ILS Maintainer Task Analysis and vice versa.

6.3.2.1 The analysis shall consider the impact of facilities provided by or required from the system to support sharing of information within and between operational units.

Further information on Task Analysis is contained in Part 12 of this Defence Standard (00-25) and in STANAG 3994. Kirwan and Ainsworth (1992), provide a recent summary of a range of Task Analysis techniques together with case studies illustrating their application. Diaper (1989) contains details on Task Analysis techniques particularly relevant to HCI development.

6.4 HCI Requirements Specification. The HCI Requirements Specification identifies the total set of HCI requirements for the system, and specifies the basis by which acceptance of operability aspects of the HCI design will be achieved. The document shall cover both functional and non-functional requirements, and shall be expressed in a manner which, as far as possible, is independent from any particular design solution.

6.4.1 The level of detail contained in the HCI Requirements Specification will vary depending on the life cycle stage in which it is produced. The document shall, however, contain the following information:

(a) A description of the essential characteristics of the target user population (including operational and maintenance personnel) detailing how they affect the design of the HCI.

(b) Details of key tasks to be performed by the target users, including the conditions in which the standards are to be achieved and the user’s capabilities.

(c) A statement of the guiding principles to be used in developing the HCI.

(d) A specification of the information and control facilities to be provided at the HCI, including the data capacities and standards of system performance to be achieved.

(e) A specification of the non-functional requirements, including, as appropriate, the standards of HCI performance to be achieved and the maximum amount of training to be given.

Activities which may often be appropriate to generate the information required in the HCI Requirements Specification include Stakeholder Analysis, Task and Workload Analysis and HCI Prototyping.

6.5 HCI Design Specification. Shall contain a description of each of the display elements and interactive controls to a level of detail such that the appearance and behaviour of the HCI is unambiguously defined. In some cases, a configured HCI prototype is an acceptable format for an HCI Design Specification but it should be noted that it cannot necessarily replace a design Specification.

6.5.1 The information required to complete the HCI Design Specification will often be generated through HCI Prototyping together with the use of suitable devices for specifying design details. The Design Specification shall include a list of terms, parameters, abbreviations and acronyms displayed in the interface.

6.6 HCI Evaluation Report. Shall document all activities conducted to validate that the HCI Design satisfies the requirements or evaluate usability aspects of the design. The document will, for example, contain details of formal and informal user evaluations, results of workload prediction or other activities conducted to predict user performance, or the results of HCI Audits.

6.6.1 HCI Evaluations. Evaluations of the HCI shall be carried out at all phases of system development. These evaluations shall be used both to assist in deciding between alternative design options, and to support validation that the HCI Design satisfies the system's operability requirements. Design decisions based on the results of HCI evaluations shall be recorded within the HCI Design Rationale document.

6.7 HCI Design Rationale. The HCI Design Rationale shall provide a source of traceability of decisions affecting the design of the HCI throughout a system development. The document shall be maintained by the Design Authority during each stage of a procurement. The document shall contain, as a minimum:

(a) A summary of the principal HCI Risks which have been identified both for the overall project and for the current stage.

(b) A statement of system design issues which may impact the HCI Design.

(c) A summary of activities undertaken to address each of the risks.

(d) A description of design issues and options which have been addressed.

(e) A summary of HCI evaluation activities conducted.

(f) A summary of design decisions made, based on the results of HCI evaluations.

(g) A statement of outstanding issues to be addressed in future project stages.

Section Three. Interaction

7 Introduction

7.1 General. Appropriate consideration of the means by which users interact with computer-based systems is essential in ensuring the efficiency and effectiveness of an HCI development. Considerations to be addressed cover:

(a) Principles of interaction.

(b) Presentation of information.

(c) Logical interaction.

(d) Physical interaction.

(e) Supporting facilities.

Where the Operability HCI Risk Assessment identifies critical HCI issues involved in an equipment development project, the Design Authority for each stage shall demonstrate that appropriate consideration has been given to each of these areas during the analysis and specification of HCI requirements, development of HCI design solutions and introduction into service. Details of the consideration in each of these areas shall be included in the HCI Design Rationale document.

7.1.2 Desirable characteristics. Systems shall display the following desirable characteristics:

(a) Suitability for the task. An HCI is suitable for a task when it supports the user in the effective and efficient completion of the task.

(b) Self descriptiveness. An interface is self descriptive when each dialogue step is immediately comprehensible through feedback from the system, or is explained to the user on request.

(c) Controllability. An interface is controllable when the user is able to initiate and control the direction and pace of the interaction until the point at which user goals have been met.

(d) Conformity with user expectations An interface conforms to user expectations when it is consistent and compatible with the user characteristics such as task knowledge, education, experience, and to commonly accepted conventions.

(e) Error tolerance. An interface is error tolerant if, despite evident errors in input, the intended result may be achieved with either no or minimal corrective action by the user.

(f) Suitability for learning. An interface is suitable for learning when it supports and guides the user in learning to use the system.

7.2 Principles of interaction

7.2.1 General. It is essential that the principles underlying effective human-computer interaction are understood and applied consistently.

7.2.1 (Contd)

Principles provide a unifying framework within which design decisions leading to a coherent HCI design can be made. The principles discussed in this section are intended to be generic to a wide range of systems.

NOTE: Principles are intended as high level design guidance. They are not intended to be followed blindly or to be taken to their logical extremes. It will often be necessary to make trade-offs between the importance of applying a principle consistently against other functional and non-functional system requirements.

7.2.2 During each stage of a procurement, the Design Authority shall demonstrate, through the HCI Design Rationale document, that consideration has been given to the Principles of Interaction. During the feasibility stage, a set of 'Guiding Principles' for the design of the HCI shall be prepared based on those principles identified in this section. The Guiding Principles shall be further refined and elaborated in later stages of the project, prior to detailed HCI design work being carried out. Where a principle applies to a procurement, examples of its application should be provided. Where a principle does not apply, an explanation should be provided.

7.2.3 Design for the users and their tasks. The ways in which information is presented on an HCI and the style of interactive dialogue shall be based on knowledge both of task requirements and of relevant characteristics of the target user population. The HCI shall be suitable for the range of abilities of the user population.

7.2.3.1 Task characteristics. Task characteristics which shall be considered include:

(a) The degree of criticality of user tasks.

(b) Standards of performance and reliability required.

(c) Relationships between different items of information and between information and control facilities.

(d) The extent of physical or mental demands which may be imposed on users while operating the equipment.

(e) Relationships between HCI tasks and non-HCI tasks or tasks supported with other computer-based equipment.

(f) The conditions under which tasks are expected to be performed, including the physical environment and task duration.

(g) Special clothing or equipment.

7.2.3.2 User characteristics. User characteristics which shall be considered include:

(a) Visual capabilities (including visual screening of the user population).

(b) Degree of task and system-specific expertise.

7.2.3.2 (Contd)

(c) Extent and regularity of system usage.

(d) Experience with similar equipment.

(e) Stereotypes and expectations which the user population can be expected to hold.

7.2.4 Understand the user's conceptual model. The design of an HCI shall be based on an explicit representation of what users' interaction with the system is expected to be like. This is known as the 'HCI Design Model'. All users of equipment develop their own mental understanding of the way the equipment works. This is done during training, familiarization and use of the equipment, and draws on each user's experience, expectations and understanding of how the equipment actually works. This is often called the "Users Conceptual Model".

Similarly, system designers develop their own concepts and mental representations of what they expect the user's interaction with the system to be like. These representations are rarely made explicit and may be very different both between different designers, and between a designer and a user. In large systems, where many individuals involved in the design process have an impact on the HCI, each designer can develop a different mental model of the user's interaction with their part of the system. Operability problems typically arise when the designer(s) model(s) of the users interaction are inconsistent, and differ from those which users develop or are taught.

7.2.4.1 The HCI Design Model shall be recorded in an appropriate format and shall be documented in the HCI Design Rationale. The Design Authority is responsible for ensuring that all individuals who impact on the HCI design are aware of and understand the HCI Design Model.

7.2.4.2 The HCI Design Model shall be expressed in a manner which directly lends itself to use as a training aid. If the Model cannot be easily explained and understood by representative users, it is likely either to be too complex or expressed using language and concepts with which users are unfamiliar. In either case it will not satisfy the requirement for use as a training aid.

7.2.4.3 During the HCI design process, the system shall be designed such that the appearance and behaviour of the HCI reinforces the user's conceptual model. This should be achieved for example by:

(a) making the result of interactions visible prior to commitment and

(b) developing the user's model as an integral part of the training programme design.

7.2.5 Use the user's language. Words, symbols, colours and concepts shall be based on terms with which users are familiar. Standard English shall be used, and where necessary, technical terms or concepts which users can be expected to understand from training shall be adopted. Users should not be expected to learn computing terminology. Where necessary, description or reference to operations within the HCI should be based on words or expressions which describe the operation in simple everyday terms.

7.2.6 Simplicity. In both physical and conceptual terms, the physical movements and actions involved in using an interface should be as simple as possible. The principle of simplicity refers to the level of experience and knowledge which a user requires in order to use an interface, as well as the complexity of physical actions necessary. The way in which information is displayed, including the complexity of language, and any specialist terminology used, should be easily understood by the target user population. This also involves ensuring that the concepts used in the HCI relate easily to user experience and expectations.

7.2.6.1 An HCI should be based on simple operations which can be combined in meaningful ways to produce more complex interactions. Complex keying sequences (eg control and Shift and Key) should not be necessary to perform operations. They may be used as alternatives, or to provide rapid access to experienced users. Direct interaction, where the user manipulates a pointing device (such as a tracker ball or light pen) to input instructions to the system is one of the simplest forms of interaction, drawing on simple perpetual-motor operations.

In WIMPS(**W**indows, **I**cons, **M**ice, **P**ull-down menus and **S**election) style interfaces the principal concepts underlying most interaction involves one or more combinations of four basic concepts:

(a) "select this" (eg point and click to select an object);

(b) "open this" (eg double click on a selected object);

(c) "put this there" (eg select an object and drag it to a new position;

(d) "do this to that" (eg identify an operation - "this" - and apply it to a selected item - "that").

7.2.7 Transparency. Transparency is concerned with ensuring that the HCI does not interpose user and task. The design of the HCI should allow users to concentrate on achieving their immediate tasks, and should not require the user to concentrate on the details of interacting with the system.

7.2.8 Predictability. Having learned the underlying principles behind an HCI and the basic operations used to manipulate the system, users should be able to predict what to do to achieve a desired effect, and, in general, how the HCI will respond to a user action. Predictability is supported when the other principles, particularly consistency and simplicity are met, and when the user can relate to the system in terms of experience or training.

7.2.8.1 Consistence. Consistency supports the principle of predictability and covers all elements of an HCI. It addresses the layout of screens, use of information coding, the dynamic behaviour of display elements, use of terminology and the sequence of dialogue steps necessary to perform operations. Consistency requires that items which look the same behave in a consistent manner.

7.2.8.2 Follow reality. The way in which the HCI represents the world, the relationships between objects within the HCI, and the way in which objects within the HCI behave, should be based on the properties of objects in the real world. To interact with the system, the user should be able to use existing knowledge and experience of the real world. This should make

7.2.8.2 (Contd)

it easier for the user to predict commands, or to interpret the state of the interface. (For example, if one object is placed in front of another, the one behind is obscured. In order to see the one behind, it must be brought to the front). However, real world analogies should not be pushed to logical extremes. (For example, if an object in the interface is being "moved", and is then accidentally "dropped", it does not need to "bounce" or "roll" before coming to a stop!)

7.2.8.3 Avoid a causality. The behaviour of the system should be wholly deterministic. Users should be able to clearly identify whether changes in the system have been caused by the user's actions, by changes in the state of the system, or by changes in the world, or external equipment connected to the system.

7.2.9 Let the user control the system. In most cases, the user should initiate and control the sequence and pace of interaction with the system. Allowing the system to initiate and control user interaction can be frustrating, and can lead to dissatisfaction and stress. It can also impact on the user's ability to maintain and improve skills and efficiency, and to maintain adequate awareness and understanding of system processes.

7.2.9.1 In a military system, careful consideration shall be given to the balance of control between the users and the system. In some situations, such as safety-critical operations, it may be necessary to violate this principal to ensure the safety and integrity of the overall system. To ensure that standard operate procedures are carried out correctly, it may be appropriate for the system to control the interaction.

7.2.10 Clarity. The principle of clarity addresses the ease with which the user develops and maintains an understanding of the state of the interface at any time. It includes a number of issues involved in transmitting information from the system to the user. These include the legibility of text, the clutter or density of information, the way in which screen areas are organized and the effectiveness of information coding techniques, as well as any special techniques used to attract user attention.

Clarity includes the principle of making the state of the system observable: ie ensuring that users can tell the state of the system from its visual appearance. For example, highlighting a selected object draws the user's attention to that object, and makes it clear that the system expects that object to be the focus of any immediate input activity. Clarity is concerned with ensuring that the HCI clearly indicates:

(a) What state the system is in (ie whether it is working, busy, waiting for user input, etc).

(b) The options available to the user (ie controls available, as well as any which are usually available, but are not at the present time).

(c) The state of data displayed (for example whether it is in the process of being edited or currently held by the system).

(d) Whether any special conditions exist (such as alerts, faults or safety critical processes).

7.2.11 Provide feedback. Whenever the user interacts with the system, there should be clear feedback of what has been done and what the effect was. This applies to inputs of any type (such as pressing a key, moving a pointing device, actioning a field, selecting an option). Visual and/or other feedback should be shown at the place where the action was taken, and immediately following the action. (For most purposes, "immediately" means within approximately 100 ms.) Where an action initiates a process or operation which involves a perceptible delay (longer than approximately 1-2 s), a visual indication should be provided showing that the process is underway, and, if possible, the state of the process and how long it will be until it is complete. (See **10.4** for detailed guidance on HCI response times.)

7.2.11.1 Where the system detects user errors, feedback on the error should be provided as close as possible both in time and space to the location where the error was made. Feedback should clearly indicate the nature of the error detected and, if possible, provide information to rectify the error. For example, if data in one field (eg MINIMUM) is required to be larger than the value in a related field (eg MAXIMUM), the system should both clearly identify the field which is in error, and indicate the maximum acceptable value, based on the data in the MAXIMUM field.

7.2.12 Use simple concepts. The basic operations available to users shall be explained in simple language with which the user is familiar, and should not require special knowledge or concepts.

7.2.13 Interface Navigation. The user shall, at all times, be able to determine the present location within the structure of the interface, and to deduce the route to any other place. If an interface (or a menu) is structured hierarchically, or has a focal point providing access to all system facilities, a direct route to the top level or focal point shall be achieved with at most two keystrokes or selections.

7.3.14 Avoid modes. Modes exist in an interface when an action has a different effect depending on what state the system is in. In general, modes should be avoided. Actions or commands should have the same effect wherever they are applied. In complex systems however, it may be difficult to avoid some instances of modes. If modes are used, their status shall be explicit, and the current mode shall be discernible to the user. Situations in which modes can be acceptable include:

(a) Long-term modes, where the user is likely to remain in a system mode for a period of at least some minutes. In this case, the layout of the screen, options available, and the behaviour of screen elements may taken on properties which are specific to the particular mode. The underlying principles of the way the HCI works, such as the means of selecting options still apply, although details may specific be to the current mode.

(b) Alert modes, where the user is required to take some immediate action in response to an emergency or time critical event.

7.2.15 Directness. The system shall allow the user to interact directly with objects which are important to the user’s task. Directness involves at least three aspects:

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(a) ensuring that the interface shows the user objects which are of direct interest in performing tasks;

(b) allowing the user to interact with the objects of interest without going through intermediate steps;

(c) ensuring that when the user interacts with an object the result is shown at the place where the interaction took place.

Achieving directness does not depend on the use of a Graphical User Interface. The ability to spatially interact with objects which are represented visually has a very close correspondence with the way in which humans interact with the everyday world. As such, using a pointing device to interact with things of interest which are directly represented on the display may be as direct as can reasonably and reliably be achieved with today's technology. (Other HCI technologies, which have not yet reached maturity or commercial viability for most applications, such as the use of speech input/output, gesture, eye control and virtual displays offer the potential for even more direct interfaces in the future.)

7.2.16 Timeliness. Consideration shall be given to the system response time to user inputs or to complete operations. Timeliness is important both in enabling users to meet the required standard of system performance and in ensuring user acceptance of a system. The absolute time which will be acceptable for an HCI response is dependent on the overall system requirements, and the performance standards required of user tasks. HCI response times which may be relatively slow are generally acceptable to the user provided:

(a) the time taken to carry out a single operation does not vary by more than approximately 15%;

(b) the time is appropriate to the perceived complexity of the operation being performed;

(c) the response time is compatible with task requirements.

7.2.17 Forgiveness. The HCI should expect the user to make mistakes, and be forgiving of those mistakes. This can be achieved:

(a) by ensuring that all user actions are reversible, either by a single key press (eg UNDO), or by a simple reversal of the action taken;

(b) by ensuring that the user does not unknowingly get into a situation which is irrecoverable.

7.2.17.1 Users should be able to recover from simple mistakes without affecting the system or the work in progress. If the user requests a command or operation which is irreversible, the system should provide a prompt or a request for confirmation requiring explicit acknowledgement before proceeding.

7.2.17.2 UNDO. Consideration shall be given to providing UNDO facilities wherever they can reasonably be implemented. Providing UNDO can, however, have significant impact on a system design. Where an operation cannot be reversed, or is not easily reversible, and where the nature of the task allows it, the user should be made aware, and asked to confirm the operation, at the time the operation is requested.

7.2.18 Allow input flexibility. To allow the users to enter data without having to mentally transpose the format, systems should accept data in a number of alternative or incomplete formats. Consideration shall be given to the acceptance of synonyms, abbreviations and the use of direct and indirect operands.

7.2.18.1 Do not insist on optimal strategies. It is common during the HCI design process to base design decisions on the implicit assumption that users will always adopt optimal strategies for performing HCI tasks. This can result in these assumptions becoming embedded into the system design such that to use the HCI effectively, the user is required always to perform optimally. The design of the HCI should allow users to adopt alternative strategies or methods for achieving objectives, even if these may be non-optimal. The formalisation of the user strategies and task flow should be used as walk-through criteria during user trials.

7.2.18.2 Allow for intermission/interruption. Military personnel are often required to address a number of objectives simultaneously. The design of an HCI should support users in adopting appropriate time-sharing strategies, allowing attention to be allocated between parallel tasks.

7.2.19 Minimize demands on the user. The user shall not be expected to remember information or commands accurately. Prompts shall be provided wherever practicable. Where memorizing is unavoidable, prompts or memory aids shall be provided where users are expected to accurately input numbers or non-word text strings in excess of 5 characters. The user should not be required to input information which is already in the system, particularly if the user is aware that it is in the system.

Human capacity for mentally storing, manipulating and recalling information accurately is limited to approximately up to 9 "chunks". (A "chunk" can be individual digits or words, or meaningful combinations of digits or words.) Maintaining items of information in memory interferes with the performance of simultaneous verbal or spatial tasks and quickly creates the subjective impression that a task is difficult.

7.2.19.1 Minimise keystrokes. The number of discrete user actions necessary to carry out an operation shall be kept to a minimum. For frequently used, or crucial operations, the operation should be achieved in not more than 2 keystrokes.

8 Information Presentation

8.1 General. Military computer systems are capable of presenting users with large amounts of rapidly changing information. Humans, on the other hand, are limited in the rate at which they can exchange information with a system. Appropriate consideration of Human Factors issues in designing

8.1 (Contd)

Human Computer Interfaces is necessary to ensure the accurate, reliable and timely exchange of information between a computer system and its human users.

This clause identifies the major Human Factors considerations in the presentation of information at an HCI. It is specific to human-computer interfaces and is additional to the information contained in parts **7, 8** and **9** of this Standard. Readers should also note technologies in this area are developing rapidly.

8.2 Guiding principles Information presented on visual displays shall be clear, meaningful, consistent, legible, discriminable and structured. The application and evaluation of these principles shall be based on an understanding of the tasks to be performed by users. The Design Authority shall ensure that the principles are applied appropriately.

8.2.1 Clarity. Information shall be presented such that it can be quickly located and understood by the intended users under operational conditions. Design considerations affecting clarify include the size, spacing and styling of text and graphics, the spatial arrangement and density of information and the organization of information into groups, pages or forms. Additional areas which should be considered are the relationship between the format in which information is displayed and the manner by which users use the information.

8.2.2 Meaningfulness. Information shall be unambiguous and meaningful to the target user population. Where information coding techniques are used, the meaning associated with codes shall be, as far as possible, based on associations with which the user population can be expected to be familiar (such as "Red = Danger"). Words, names and abbreviations shall be based on language and terminology used by the target user population. Data parameters and units shall use formats which are meaningful to the target users and consistent with the overall task context.

8.2.3 Consistency. The Design Authority shall ensure that information provided on display screens is presented consistently. This includes the format, style and location of information presentation. Consistency applies to the design of individual information items, to consistency between related items on the same display, and to consistency throughout the user’s overall task context (including other computer-based systems with which users can be expected to interact).

8.2.4 Legibility. Text and numeric characters shall be legible to the target user population under the intended conditions of use. Legibility shall be addressed at the lowest unit of text which is intended to convey meaningful information (ie whole words or individual characters).

8.2.5 Discriminability. The design of non-textual display items, including symbols, imagery, charts, tables and other graphical display components, shall ensure that target users can reliably discriminate between display elements. Discriminability shall be addressed at the smallest visual element intended to convey information.

8.2.6 Identifiability. The design of non-textual displayed items, including representative graphics, diagrammatic graphics and iconic graphics, shall ensure that target users can reliably identify a graphic in and out of context. Where a metaphor is being used, the image shall be identifiable in the context of the metaphor. For further details on iconic graphics see **8.9.6.**

8.2.7 Structured layouts. Information presented on display screens shall be structured into organized groups of related information. Display screens shall support users in making visual associations between related items. Information and related controls shall be organized into meaningful groups which are easily distinguished information groupings shall be based on expectations or associations which users can be expected to hold, or on groupings which logically arise out of the tasks supported. Information grouping shall be meaningful in the task context.

8.3 Critical tasks. Special consideration shall be given to the presentation of information and the design of interactive dialogue to support tasks which are considered to be critical. Information may be judged to be critical either due to the importance of the task which it supports or its consequences, or because of the frequency with which the task is performed. Consideration shall be given to methods and devices that allow the user priority access to critical information.

8.4 Screen layout. The layout of the information within a display screen shall be organized and provide perceptual structures to enable the user to quickly locate or predict the location of data. Where the user task involves maintaining an overall awareness of, or monitoring the state of, a dynamic environment, display screens shall support users in perceiving overall patterns and detecting significant changes. Clause **12** of this Standard provides further guidance on display layouts.

8.4.1 Use of screen areas. Display screens should be organized into distinct logical areas. Areas shall be based on an understanding of the user tasks, and the HCI manipulations necessary to control the system. Key information should be placed towards the top and left of each logical display area.

Consistency in the use of screen areas, and effective mapping between screen areas and user tasks and objectives helps the user to form a consistent mental model of the HCI. This both facilitates learning, and supports users in predicting the location of information.

8.4.1.1 Information and controls required for a single task or activity shall be grouped together. As a general rule, systems should allow a minimum of three user tasks to be current at any one time, without requiring the user to store and retrieve data.

8.4.2 Information density. The density of information presented on computer displays can have a significant impact on the ability of users to locate information, detect changes and maintain awareness. Consideration shall be given to both the overall and local information densities, where overall density refers to the amount of information on the entire screen area, and local density refers to how tightly packed the screen is within individual sub-areas of a screen.

8.4.2.1 Density of alphanumeric displays. For alphanumeric displays, the density of information on the display shall be calculated using the procedure described in Tullis (1990).

8.4.2.2 Density of non-alphanumeric displays. Where the ability of users to rapidly locate information on non-alphanumeric displays is critical to operational effectiveness, the Design Authority shall ensure that the

8.4.2.2 (Contd)

density of information, and the manner in which it is presented, supports this requirement.

8.4.2.3 Information filtering. Where displays contain potentially large amounts of information, consideration shall be given to providing users with facilities to manage the amount and types of information displayed at any time. This can, for example, be achieved by providing controls allowing the user to filter a display according to relevant task dimensions (such as hostility, environment or time).

8.4.2.4 The ability to quickly reduce screen areas to a minimal size (such as in iconizing Windows) should be considered. Where information is organized into individually controllable screen areas (such as forms or Windows), providing facilities to enable users to change the size of a display area to suit overall task requirements assists users in effectively managing the amount of information displayed.

8.4.2.5 Summary views. Where large amounts of information is potentially available to users, consideration should be given to providing a high level summary view of data. Users should be able to request more detailed information on specific items of interest as required. Summary views assist users in developing and maintaining situation awareness, while providing access to more detailed data when required.

8.4.2.6 Alternate views. Consideration should be given to the provision of alternate views. Providing alternate views of data is often appropriate in supporting the range of user tasks, or the range of users of a system. (An example would be using PPI displays to represent the tactical situation at a particular point in time, and providing waterfall-type displays to support tasks requiring time-ordered information.) If alternate views are appropriate, they should be selectable to allow the user to chose the view best suited to their current tasks. Where alternate views are provided, all of the information necessary to perform a single activity should be available within any single view.

8.4.2.7 Where information filters, summary views or alternate views of data are provided, critical information shall be brought to the user’s attention when and where it is necessary.

8.5 Use of Windows. This clause discusses the use of Windows as a means of organizing the display screen to support usability. The discussion is concerned with the use of Windows to support user tasks, rather than with Windowing technology as such: the focus is therefore on user purposes, tasks and activities, rather than on display management considerations.

Windowed displays provide 2 basic capabilities:

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(a) The ability to use a restricted screen area to work on a much larger area of data.

(b) The ability to organize the screen into a number of discrete activities.

8.5.1 Windows provide a flexible means of supporting a user performing multiple tasks on the same screen. The visual separation of Windows supports the conceptual distinction between tasks, while the physical surrounds of the display can provide a boundary on higher level or longer term task or role objectives. General requirements for the use of Windows are:

(a) the boundaries of each Window shall be visually distinct;

(b) controls affecting the dimension and position of each Window shall be dedicated to that Window;

(c) the status of each Window should be clearly indicated (ie open/closed, active/inactive);

(d) the data displayed within each Window should be clearly identified and related to a single user objective or set of related objectives;

(e) Windows which have special properties or behave in special ways shall be clearly distinguished visually.

8.5.2 Use of Windows in military systems The use of Windows is becoming pervasive in office computing environments, where it has proven to be an extremely powerful and effective method. A considerable amount of research has been devoted to optimizing Windows for office environments. In considering the application of Window systems to military environments, awareness and consideration of, the characteristics of the intended user population, tasks and operating conditions is vital and would need to be evaluated on early prototypes during the design process.

Military operations can differ significantly from office tasks in two fundamental characteristics:

(a) In office environments, individual display units are typically used by a single person at any time. In military environments, display units are often used by more than one person. The advantage of individual customization of windows to suit an individuals task may therefore not be appropriate for many military applications.

(b) Military tasks are often highly structured and proceduralized. It will often be necessary to constrain the extent to which users are given flexibility over the use of Windows.

8.5.3 Considerations to be addressed for development of a Windows-based interface are:

(a) Windows should bear a clear and direct relationship to tasks or objects which are conceptually distinct in the user’s internal model of the Task domain.

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(b) Windows containing safety-critical information or actions shall be clearly identified as having a special status. Special restrictions on user interaction with such Windows may strengthen the perception that they have a special status.

(c) If the system allows a Window containing data to which a user requires rapid access to be hidden, the user should be able to bring that Window to the front of the screen in an active state, with a single keystroke where possible.

(d) If more than one user shares the same display, consideration shall be given to the impact which the provision of facilities to customize the display to personal preferences or priorities may have on other users of the same display screen.

(e) If a task is highly structured, proceduralized, or imposes other constraints on the way a user performs the task. Windows supporting that task shall reflect the structured nature and constraints of the task.

(f) The workload imposed through users being required to organize the display area should be minimized. The extra effort of manipulating windows can be a distraction from the task in hand, especially if a task requires information to be held in memory.

(g) Dialogue activities should be clearly associated with the window to which they relate.

(h) When interacting with a system, input devices (for example, a keyboard) shall only affect and provide feedback within the active Window.

(i) The design of Window based interaction should provide facilities to enable effective management of the screen.

(j) Each Window shall be given a unique identifier.

(k) The Window currently at the centre of focus for the control devices shall be indicated as currently active. Any system process which reports back through another Window shall not interrupt any interaction, except where an error or alarm message occurs.

8.5.4 Paging scrolling and panning. Facilities to page, scroll or plan through data shall be applied consistently throughout an HCI. The implementation of these facilities shall be user centred and the resulting visual effect shall be consistent with conventional stereo-types and user expectations. If the user initiates a scroll, pan or page in one direction, the displayed data should move in the opposite direction.

8.5.4.1 In all cases, the visual appearance of the system shall clearly indicate the part of the overall data which is currently being viewed. The display shall also indicate the amount of data in each direction which is not being viewed. Where information within the system is organized into local ‘pages’, pages shall be numbered. Both the number of the page currently on display and the number of pages in each direction shall be explicitly presented to the user.

8.6 Display formats. The format in which information is presented shall be appropriate to the nature of the data and the user tasks supported. Common formats include:

(a) Structured data fields.

(b) Free text fields.

(c) Forms.

(d) Tables.

(e) Graphical.

8.6.1 Structured data fields. Are designed to support specific data items. The visual appearance of a field should indicate the format required (unless the format is apparent from the task context). Structured data fields should normally have an associated label. The appearance of field labels shall be such that they are not confused with data fields.

8.6.1.1 Data fields which allow user editing shall be visually distinct from non-editable data fields. Structured data fields should support the editing process and should not require users to enter characters which are predictable from the field format (such as leading or trailing zeroes, or decimal points). On completion of an edit, structured data fields shall be validated against the expected format prior to the data being accepted by the system.

8.6.2 Free text fields. Impose minimum constraints on the format in which data is entered or displayed. They can minimize the need for training or familiarization by making use of everyday language. Disadvantages of free text fields include:

(a) the time required to locate, read and assimilate data can be significant for complex information structures;

(b) locating and reading data can suffer interruptions from other tasks;

(c) it is difficult to provide an overview of the content of the message;

(d) there is limited capability to organize the content of messages to support scanning or location of related items (although highly stylized military message structures, while requiring significant familiarity, can help overcome this difficulty);

(e) they can require considerable display area;

(f) it can be difficult to provide the user with facilities to perform processing or analysis of the content of the message.

8.6.3 Forms. Provide a suitable means of grouping together data fields and controls related to a specific user task within a single unit. A form should normally be organized to contain all the information and control facilities required to perform a single task, or group of related tasks.

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The layout of fields within a form should follow the sequence of operations involved in performing a task. Where appropriate, fields should be organized into sub-groups within a form. Multiple instances of a standard form may be used where the same task is required to be carried out on different sets of data or real world objects.

8.6.4 Tables. Provide a well structured and ordered presentation of data. Consistent location allows users to quickly locate data, and supports the user in comparing data from different objects.

8.6.4.1 Tables can reduce the area required to display large amounts of text or numeric data, by using a highly structured format with a single set of field labels. Tables shall be designed such that columns of data are clearly distinct, while ensuring visual association between data within any row.

8.6.4.2 Users should normally be provided with facilities to alter the basis by which data in a table is ordered to support varying task objectives. (For example, a table associated with a radar-type display might allow the user to choose to order data in the table by range, bearing or hostility.)

8.6.4.3 The visual appearance of a table, or the section of a table which is currently on display, should only change as a result of an explicit user request. Where new data is added to a table, the location shall be appropriate to the nature of the data and to the user's task. It may often be appropriate for new data to be sorted to the correct logical position. Adding new data to the top or bottom of a table can be relatively easy to implement, but may be inconsistent with user task requirements.

8.6.4.4 Tables should provide a visual aid to horizontal scanning by either grouping rows into blocks of three or four, by introducing a graphical effect such as boxes or lines, or by introducing colour grouping. If columns of numeric data are involved, they should be justified on the decimal point. If phone numbers or other standard ordered number sequences are involved, they should be justified around a consistent point (such as the end of the STD). Lists using compound numbers should show the complete number and not be truncated to the field size.

Disadvantages of tabular formats include:

(a) detail can be easily missed;

(b) irregularities in data can be hidden by the strong visual similarities arising from the highly structured presentation;

(c) the highly ordered structure limits the ability to present information relating to a wider context.

8.6.5 Graphical format. Considerations relating to the use of graphical formats are described in **8.9.**

8.7 Information coding

8.7.1 Information coding refers to the use of a variety of techniques to carry additional information about a data item. Appropriate use of information coding techniques can assist users in locating data, identifying relationships and adopting appropriate display monitoring strategies. Effective codes allow users to selectively attend to specific dimensions of a displayed item. Where display coding techniques are used in an HCI design, the codes shall comply with clause **7** of this Standard.

8.7.2 In all cases, the Design Authority shall be responsible for ensuring that information coding techniques are applied effectively. Where combinations of related coding techniques are used on a single display, the extent of training necessary to ensure reliable user performance, and the degree of reliability of the coding techniques adopted shall be established through user testing.

An example of the use of combined codes on a single display is modern Plan Position Indicator displays. A number of items of information can be conveyed using a suitable combination of non-textual coding techniques: the location of an object on the display indicates its relative position in the world (typically distance or range and bearing from the source), while the geometric shape may indicate the type of platform and its colour may indicate hostility. Brightness can indicate whether the object is currently being reported on. Blink coding can also be used to indicate objects which are of particular significance.

8.7.3 Effective information coding techniques for use in HCI design include:

(a) spatial coding;

(b) size and shape coding;

(c) colour coding;

(d) string length coding;

(e) coding by type size and style;

(f) blink coding;

(g) luminance coding.

8.7.3.1 Spatial coding. Information can be conveyed through aspects of spatial arrangement. These include the absolute position of an object, its proximity to related items or its angular orientation. On tactical displays, for example, bearing information is directly imparted by the relative angle between objects and a source. Information near a digit string can identify the category to which it belongs (on charts, for example, tide speed is written beside the symbol for tidal direction). On PPI displays, the physical proximity between a track symbol and its related track number and identity allows the user to visually associate the two items.

8.7.3.2 Size and shape coding. The geometric size and shape of an object can be a powerful means of conveying information about the object. The number of geometric shapes which can be used for coding purposes depends to a large degree on the extent to which the symbol "looks like", the item or

8.7.3.2 (Contd)

function which it represents. A distinction should be made between icons and other graphic symbols. Well designed icons convey a large amount of information about the function they represent. They therefore impose minimal requirements on users to learn the associated meaning. Consequently, the number of icons which can be used effectively in an HCI is potentially very large.

8.7.3.2.1 Graphic symbols generally convey less information than icons and place a greater requirement on users to learn the associated meanings. Where geometric shape coding is used, and each symbol is required to be identified without reference to any other, the number of symbols in the set should normally not exceed 15. This limit may be exceeded where symbols fall into clearly distinct groups, and where the groups can be determined from some aspect of the symbols shape, or where relative discrimination only is necessary. The Design Authority shall provided evidence, based on user trials, of the amount of training necessary for representative users to be able to accurately and reliably discriminate and identify each symbol in the set.

8.7.3.3 Colour coding. The three psychological attributes of colour are hue, saturation and brightness. Colour can present a more attractive display to the user, and also decreases clutter by providing a compact means of coding. The use of colour can improve comprehensibility by providing a readily appreciable way of distinguishing between different features and different classes of information.

However the advantage of colour coding over shape coding diminishes with practice, even at higher levels of display density, colour coding being less marked as density increased.

In a digital chart for example, where many colours are likely to be on display at any one time, colour can effect the task of searching in two distinct ways; firstly by directing attention towards the target, and secondly, by making non-target items more or less distracting.

8.7.3.3.1 In allocating colour coding values to specific classes of information, consideration shall be given to trade-offs between the speed increase due to object information category being of a known colour, and the speed decrease as the number of colours used in the display increases, particularly where the colours of the non-targets/background are heterogeneous or similar to the target colour.

The function of colour in visual search can also differ depending on whether the search is taking place on a global or a local level. At a global level, colour can "pull out" certain features of a display supporting selective attention. At a local level, colour difference can facilitate the discrimination between features which are in close proximity.

8.7.3.3.2 Consideration shall be given to high edge contrast, continuity of contour and homogeneity in the presentation of graphics, as these are particularly important characteristic of a "good figure". Colour can give these characteristics to an otherwise complex structure or haphazard

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configuration, acting as a clarifying or unifying element for same-coloured features, whilst increasing the visual separability of different-coloured features.

NOTE: The International Hydrographic Organization (1987) states that for map graphics and electronic chart the display requires a maximum of 22 colours, including 6 different blues for depth shading.

8.7.3.4 String length. Digit string length often gives an indication of information category. For example, digit strings on charts are normally between 1 and 4 figures long. Speed information is usually 1-2 figures
8.7.3.4 (Contd)

long, depth is 2-3 figures long, bearing is 3 figures long and time is 4 figures long.

8.7.3.5 Coding by type size and style. Consideration shall be given to the use of styles, fonts and font size to code the data being presented. Different classes of information may be written in different styles or fonts. Different sizes of print may also be used. As an example, spot depths on a map display are often presented in relatively small print.

8.7.3.6 Blink coding. Consideration shall be given to the use of blink coding to attract the user's attention to the value or condition of the data. This technique should be reserved to those instances where the change of state or value of the data being presented is an action initiating event or an indication of an emergency condition, or where the user requires to be reminded about the existence of an object. When used, the initiation of the appropriate action or acknowledgement of an emergency condition shall suppress the blink coding.

8.7.3.6.1 Where blink coding is to be used the size of screen area which blinks should be kept relatively small. The blink rate should be between 2 Hz and 4 Hz with 2 to 3 Hz preferred and a minimum on time of 50 ms at an on/off ratio of 50%. The selected blink rate should avoid any interference with the display devices scan rate. If textural data is to be read for confirmation or additional information, then the blink area should be associated with, and restated to, a related or adjacent symbol.

8.7.3.6.2 No more than two different rates should be used to indicate different coded information. If two blink codes are used then their rates should be approximately 4 per second and one per second, where the faster is used for critical information.

8.7.3.7 Luminance coding. The brightness of objects can be used to convey simple categorical information. Where all objects are displayed in a single colour, up to three levels of luminance may be used. On colour displays, due to the co-variance of brightness and colour, a maximum of two levels luminance codes are recommended.

8.8 Textual information

8.8.1 Continuous text. Presented at an HCI should be matched to the user's tasks and should be in a directly usable format. Standard conventions should be used for sentence and paragraphs structure.

8.8.1 (Contd)

Paragraphs should be separated by at least one line and use conventional or formalized punctuation. Text cursors shall be capable of being positioned at any location indicated by the user, including before or after any character.

8.8.1.1 The size of characters, spacing between characters and lines and style of fonts shall conform to the requirements set out in Part 7 of this Standard. Continuous text should always exhibit the following characteristics.

(a) The main topic of the text should appear at the beginning of the sentence.

(b) All information required to support a task or activity should be grouped together. Any grouped data should be arranged consistently throughout the system. The presentation of this textual information should be structured to remove the need for reliance on user memory.

(c) A paragraph should be short and contain a single idea.

(d) If non-connected textural information is to be presented, consideration should be given to applying logical groupings. These groupings can be made by sequence, frequency, functionality, importance and alphabetically.

8.8.2 Emphasising text. Where text or parts of texts require emphasizing, for example because the represent critical information, techniques for emphasizing the appearance of the text should be considered. Methods which may be used to draw attention to key points in text include:

(a) the use of size;

(b) the use of bold characters;

(c) the use of extra spacing on either side of the word;

(d) by preceding or enclosing the text with special symbol (bullets, arrows etc);

(e) by its position relative to other key display elements.

8.8.2.1 Where techniques, such as the use of capitals, underlining, text and background colour, flashing and reverse video are to be used, consideration shall be given to the adverse effects caused by each method on the task efficiency. Table B summarizes the techniques and their respective considerations.

Table B

Summary of Techniques for Emphasizing Text

TECHNIQUE	CONSIDERATIONS
Capitals	Reduces legibility of text. Should only be used for headlines key phrases or acronyms. Leading capitals should be used for the single character in each word in a title or label.
Underlining	Reduces legibility if text is closely spaced. Should only be used for headlines or key phrases.
Text and background colour	See general considerations for colour.
Flashing	Can impair legibility of text. See **8.6.2.6** Blink Coding

8.8.2.2 If information is to be entered from paper forms, then the interface should mirror the paper layout. This can greatly speed up the data entry task.

8.8.2.3 If illustrations are to be used in association with the text, they should be placed close or adjacent to the corresponding text.

8.8.3 Instructions. The presentation of instructions should conform to the guidance and consideration of any text presentation in that they should be simple, clear, concise, unambiguous, ordered and structured. Additionally, the sequence of the instruction should follow the sequence of the task. (For example: "First select the colour of object, then select the mode" and not "Select the mode of operation required" after "select the colour of object").

8.9 Non-textual information

8.9.1 Graphical information. Graphical display formats, (such as bar charts, flow charts, plan position indicator (PPI) or mimic diagrams) can be effective in assisting users to identify relationships between data items. Graphical displays can exhibit different levels of abstraction. Consideration shall be given to the level of abstraction that best supports the user’s task.

There is evidence that the task performance for novices and experienced users during training is directly related to the quality of the schematic representations of the system.

Disadvantages associated with graphical formats include:

(i) training can be necessary to ensure that users understand the symbolic content of the presentation;

(ii) the user requires a high degree of familiarity and understanding of the system or environment being represented;

8.9.1 (Contd)

The three main types of graphical information are:

(a) Representative. Representative graphics include plan position indicator (PPI) displays, mimic displays or simple representations of a system. This format is an obvious choice for applications such as simulators and trainers. It also finds widespread use in remote monitoring stations and control rooms.

(b) Diagrammatic. Diagrammatic graphics, such as bar charts, flow charts or mimic diagrams, can allow information on spatial and temporal relationships to be displayed in a way which maps closely onto the way in which users mentally represent and think about the data. They can also be effective in assisting users to identify relationships between data items. There is evidence that the task performance for novices and experienced users during training is directly related to the quality of the schematic representations of the system.

(c) Iconic. Iconic graphic are normally used in relation to diagrammatic or representative graphics to allow the user to assimilate information about the graphic, whilst not overwhelming the graphic with unnecessary detail.

NOTE: The above descriptions of graphics are not mutually exclusive as diagrammatic icons, representative icons, diagrammatic representations and representative diagrams can be produced. The distinction made above is to allow issues relating to each type to be discussed.

8.9.2 General considerations

8.9.2.1 Drawing speed and order. The principal methods of implementing graphics in computer systems are Bitmap and Vector images. Each of these technical methods can present the user with problems:

(a) Bitmap images can provide near picture quality images on the display, but due to longer load times, can cause long response times.

(b) Vector images can be easier to manipulate in software. However, complex images can lead to the user being aware of the drawing order and of window repair and redraw.

8.9.2.2 The speed at which graphical items are drawn, and the rate at which the items are updated, can both affect the effectiveness of graphical displays. When users can detect the speed at which items are drawn, the eye tends to follow the drawing order and end on the last drawn object. This is sometimes referred to as the ‘dynamic eye fall location’. Consideration shall be given to the impact this effect may have on the use of a display. For example, in vector image displays, advantage can be taken of this effect to guide the eye to significant locations on the screen.

8.9.2.3 Consideration shall also be given to the rate at which graphics and data items are updated. Updates need to be sufficiently fast to ensure that displayed data is as current as task requirements demand. Unsuitable update rates can impair the user’s ability to extract information from the object, and can be distracting from the task.

8.9.3 Representative graphics Representative imagery can be considered as any image reproduced on the display device which is intended to represent a real world object. Such graphic images would include representation of control panels, maps, and physical system layouts.

8.9.3.1 General considerations. Consideration shall be given to the user's perception of the relative importance of displayed objects. Developing an appropriate visual hierarchy allows the user to rapidly scan, interpret and assimilate the large amounts of data. The extent to which one area has visual precedence over another depends greatly on the contrast of the edge. In maps, for example, the level of edge sharpness can create a visual hierarchy for area objects within a map.

8.9.3.2 Special consideration for digital map and chart imagery. Consideration shall be given to the presentation of digital map and chart imagery to the user, including the apportioning of relative emphasis to the elements of subject matter being presented. Generally, stimuli perceived as ordered are interpreted as more meaningful.

8.9.3.2.1 The International Hydrographic Organization ('Electronic Chart Display Systems' Draft Proposals 1987), state that, for the present resolution of even high quality screens, the size of symbols must be approximately 130% of the paper chart symbols.

8.9.3.3 Consideration shall be given to the wide range of potential users of digital maps or charts. Users may have a wide and varied range of tasks which may require execution at various times. Consideration shall be given to the coding requirements for individual tasks, recognizing that an optimal presentation for one task will not necessarily be optimal for another.

8.9.4 Diagrammatic graphics. Diagrammatic imagery can be considered to be any image reproduced on the display device using synthetic graphics which is not is intended to represent a real world object. Consideration shall be given to the pictorial content of any intended imagery, and in particular, the requirements for primary and enabling information.

Primary information in a graphical image refers to the information that is required by the user to undertake their task. Enabling information in a graphical image refers to the information that is required by the user to put the primary information in to context.

An example would be a diagram of a hydraulic system where the state of a valve may be considered to be the Primary information required by the user while the line that represents the connectivity of the system is the secondary information needed to enable the user to put the valve in context.

8.9.4.1 Diagrammatic images should provide sufficient primary and enabling information to support the system tasks. Where pictorial imagery is used, graphical conventions shall be applied consistently throughout the system. The pictorial representation of real world objects should be such as to give it solid forms. Single line representations should be avoided, as they are less discriminable.

8.9.4.2 Where images are direct representations of physical control devices, the appearance, operation and dynamics of the representation should be consistent with the ergonomic principles contained in clause **7** and **10** of this Standard.

8.9.5 Supporting data. Where user tasks may required more detailed specific information about a diagrammatic object, supporting data may be presented in conjunction with the intended imagery in the same approximate location (spatial coded) of the graphical object. In this case, the display of information should be under user control.

8.9.5.1 Where tasks involve detailed manipulation or interaction with data about objects which are represented graphically, supporting information and controls may be presented in a secondary display area. Where two displays simultaneously show data relating to one object, interaction with the data underlying the object on one display should be reflected onto the other.

8.9.6 Iconic graphics. An icon is a small discrete graphical symbol that is identifiable and meaningful to the user. Icons provide an effective means of conveying relatively complex information using a small amount of display space. Icons which are appropriately designed and applied can also support and increase the speed and efficiency of interactive behaviour.

It is useful to distinguish between five main approaches to the design and use of icons:

(a) modification of a repetitive image;

(b) use of culture stereotypes;

(c) action symbol;

(d) abstract;

(e) object-based.

These are represented in table C.

Table C

Examples of Icon Styles

Style	Example		
Modification of Repetitive Image	 Select Data	 Copy Data	 Delete
Culture Stereotype	 Super	 Music	 Spell check
Action Symbol	 Move Object	 Fill	
Abstract	 Undo	 Object	
Object Based	 Alarm	 Save	 Object

8.9.6.1 Designing effective icons requires considerable skills and experience and should not be underestimated. For icons to be effective, it is essential that a strong relationship exists between icon and meaning. The Design Authority shall provide evidence that representative users can readily associate the icon with the appropriate meaning. The procedure for development and testing shall conform with ISO/DIS 9186.

8.9.6.2 Consideration shall be given to the selection of the combination of icon types. Whilst it is acceptable to mix the types within one system, application of icons to functions shall be clear to the user and consistent with each other.

8.9.6.3 Icons shall be recognizable in and out of their context of operation. Where they are used as the primary means of actioning a function, icons should be presented with an associated label. Where icons are presented as a shortcut method, labelling is not a necessity.

8.9.6.4 Icons should not be used on low resolution display devices as the ability to create recognizable images is greatly reduced.

8.9.7 Abstract geometric icons. A symbol set should include a wide variety of shapes, where each symbol subtends a minimum of 20 minutes of arc at the eye when viewed from the user's normal operating position and the stroke width-to-height ratio is 1:8 to 1:10.

8.9.8 Pointing cursors icons. Where an HCI requires the user to indicate positions or make selections using a continuous pointing device (such a tracker ball, light pen or mouse, etc), consideration shall be given to the design of the pointing cursor. The pointing cursor refers to the representation on the display screen of the current position indicated by the pointing device. Pointing cursors shall comply with the legibility and recognition requirements of standard icons.

8.9.8.1 Pointer cursors together with cursors themselves shall be easily seen throughout their movement across the display device. The cursor can be made invisible if no movement is present and keyboard entry is in progress. To indicate to the user that the system is busy, the pointing cursor should either flash at 3 Hz or change form to a time-out icon.

8.9.8.2 The presentation or dynamic behaviour of the cursor shall not distract from other user tasks.

8.9.9 Use of colour. Structure and organization emphasizes areas or particular types of information as follows:

(a) by increasing the quantity of information which can be represented;

(b) by supporting users in selectively attending to or searching for specific categories of information;

(c) by improving the realism of a display;

(d) by increasing user acceptance of a display.

8.9.9.1 The use and specification of colour in HCI developments shall comply with the guidance contained in part **7** of this Standard. Users typically express preferences for colour displays, although it is not always possible to detect performance differences directly arising from the use of colour.

8.9.9.2 In general, colour should be used conservatively and should not distract from the user's task.

8.9.9.3 Displays shall be designed and validated for monochrome viewing. This means that all the information provided by the system shall remain available to the user in the same visual location if the information was to be displayed in monochrome. Consideration should then be given to the use of colour to aid the formatting of the display and enhance user performance. Colour formatting should only be considered as a performance enhancement measure.

8.9.9.4 Consideration should be given to the use of colour to emphasize the logical organization of information displayed to the user. For example, subtle use of colour can assist in providing structure to tables of data, and can assist the user in locating selected rows, columns or cells.

8.9.9.5 Consideration should be given to the use of colour to support user interaction with displays comprising high information densities. If the task requires the potential display of large amounts of data concurrently, then colour coding should be considered to support the user in locating specific types of data.

8.9.9.6 The use of colour on any display shall be consistent throughout the system. The following rules should be used as guidance during the design process:

(a) The number of background, foreground colours combinations shall be limited to a set of less than 24.

(b) Saturated, high luminance colours should be used sparingly. They can be used on or between dull background tones to emphasize aspects and features.

(c) Large areas, background or base-colours should be unsaturated and of sufficiently low luminance to provide adequate luminance contrast with foreground colours. The background colour should be maintained across all related areas of the display.

(d) Large differences in hue are most appropriate for distinguishing a small number of unrelated categories of information. This is because hue can be readily segregated into categories which can be relatively easily named (ie "Red", "Green"). Saturation and luminance are less appropriate for unrelated categories.

8.9.9.7 The use of colour on any display shall conform to existing colour coding in the user's task(s), where these exist, and should convey traditional expected meanings. Consideration should be given to the use of colour in non-standard lighting conditions. If night viewing is required, the background colour should not be brighter than the foreground colours.

8.9.10 Dynamic information. The appropriate use of graphical display formats and dynamic techniques to present changing information can greatly increase the effectiveness of the user interaction with the system.

8.9.10.1 Dynamic/static display. The selection of static or dynamic displays should be representative of the nature of the user's task. Dynamic displays should only be used to monitor or present information of a dynamic nature. Where dynamic displays are to be used, consideration shall be given to presentation devices in order to provide a degree of permanence to the displayed data.

8.9.10.2 Where dynamic information is displayed, the user's extra work load should be supported by continuously tracking and monitoring the changing state of the display. Consideration shall be given to the use of information clarifying techniques such as, track trails, directional indicators on digital readouts and data freeze/snapshot facilities.

8.9.11 Virtual environments. Virtual environments are created when computer-based systems are used to provide users with artificial stimulation in three dimensions. They often involve two or more sensory modalities. These environments also allow users to interact with the simulated environment in three dimensions and in more or less real-time. By monitoring the users head, body, hand or eye positions the computer-system responds to the users behaviour and updates the simulated environment to create the perception that the user is moving within the virtual world.

8.9.11.1 Virtual environments have been used for a number of years in training simulators, and are now being considered for live applications. Where virtual environments are to be used, the key visual stimuli of a given task shall be identified in order that consideration can be given to the viewing distance, makeup and supporting context for each object. The key stimuli identified should be given priority in any scene management to ensure support for the task(s) takes priority.

9 Physical Interaction

9.1 General. In developing an HCI for military equipment, it is essential to address aspects of the physical interaction and environments in which users are expected to operate the system. These considerations will often produce major issues which influence and constrain an HCI design. Equipment to be used on a ship's bridge, or in a tank, for example, will impose major constraints on the selection of control devices, as well as on the choice of dialogue style and the way in which information is organized and presented.

9.1.1 Workplace design

9.1.1.1 Layout of workplaces. In laying-out workplaces, consideration shall be given to the organization of individuals into teams and sub-teams, and requirements for co-operation in the use of computer-based systems which may arise. Workplace layouts should support requirements for communication between individuals and support the allocation of responsibilities between team members.

9.1.1.2 The environment. Noise, motion, vibration and shock, light, heat and cold NBC conditions, barometric pressure and ventilation, if not properly considered and controlled, can adversely affect the performance of manned systems. Parts **5, 6, 7, 8** and **9** of this Standard provide detailed guidance on the effect of environmental factors on human performance.

9.1.1.2.1 At all stages in the development of an HCI, the Design Authority shall demonstrate that adequate consideration has been given to the physical environment in which equipment is to be used. The selection of interactive devices, presentation of information and the design of the interactive dialogue shall, as far as reasonably practical, ensure that environmental conditions do not unduly degrade user performance.

9.1.1.2.2 In general, high levels of any environmental stress can affect the health and safety of individuals. They may also impair cognitive performance, distract attention from a task and may cause users to adopt less than optimal performance strategies. The following list briefly summarizes some of the specific issues (not including health and safety concerns) associated with environmental stressors:

(a) Acoustic noise. Can increase stress, interfere with communication and mask acoustic signals.

(b) Motion and vibration. Motion and vibration can cause discomfort, and impair the ability to read text and perform manual manipulations.

(c) Lighting. The lighting environment can impact on the design of computer displays in a variety of ways, including reducing contrast between display elements, and affecting the levels of luminance at which displays will cause visual discomfort. The lighting environment is a principal consideration in designing colour displays. Displays designed for a particular lighting environment (such as white light) may be ineffective under different lighting conditions.

(d) Extreme temperatures. Cold and hot conditions and humidity can cause fatigue and make it difficult for users to concentrate. The potential impact of protective clothing including the NBC IPE on mobility and the respirator on visual capabilities should be addressed.

(e) Barometric pressure. Consideration shall be given to the effect of barometric pressure on human performance. For example, high altitude effects such as hypoxia can have adverse affects on performance.

(f) Ventilation. Consideration shall be given to the quantity, quality and velocity of ventilation in the workplace/space. The air flow shall not be directed to the rear of the user,and shall be, where practical, directed to the front of the user.

9.1.1.2.3 Combined stressors. Consideration shall be given to the effects of combined stressors {such as high levels of noise and vibration which may occur in cross-country vehicles). For further information see part **5** section **14.**

9.1.1.2.4 The Design Authority shall demonstrate that consideration has been given to environmental issues in the selection, development and evaluation of HCI devices and the development of HCI designs. Where necessary and justified by the potential impact of environmental issues on the effectiveness of an HCI, user trials shall be carried out under realistic environmental conditions as part of the system evaluation process.

9.1.2 Workstation design. The design of workstations to support computer-based work shall comply with the guidance provided in clause **4** of this Standard. ISO 9241 clause **4** specifies requirements for the layout of workstations in office environments.

9.1.2.1 Workstations and consoles. Workstations and consoles shall comply with relevant Health and Safety legislation, with the guidance within clause **4** of this Standard and, where applicable, with the requirements contained within ISO 9241.

9.1.2.1.1 Workstation layout. Users shall be able to locate the most frequently used control devices with a minimal amount of visual guidance. Repetitive groups of controls should have similar spatial arrangements. For further information see part **4** of this Standard.

9.1.2.1.2 Prolonged usage. Prolonged operating periods, particularly under one or more environmental stresses, including the effects of sleep loss can impair mental and physical capacities. In the design, selection and implementation of HCI workstations and devices, consideration shall be given to the potential impact of prolonged operating periods on user performance. Aspects such as dynamic muscle loading, and the speed and accuracy of locating and manipulating control devices and performing critical dialogue tasks shall be addressed. Visual degradation including eye strain, repetitive control operation of data entry devices such as keyboards shall be avoided by providing VDU operators with satisfactory off watch keeping periods (see clause **10.7).**

9.1.2.2 Hand held terminals. Where hand held terminals are to be used, consideration shall be given to the size, weight and shape of the device, to ensure they are appropriate to the user population, conditions of use and tasks to be performed. Consideration shall be given to the design of the interactive software of such devices to ensure they are appropriate for use in the expected conditions and environments. For example, hand-held terminals intended for use on ships may require operation in heavy seas while standing. The illumination of the screen area may also require special consideration.

9.1.3 Protective equipment constraints. Consideration shall be given throughout the design process to constraints which may arise through the wearing of protective equipment or restraints. Equipment to be considered should cover, for example, NBC clothing and combat body armour, fire safety equipment, in service respirators, breathing apparatus or constraints imposed through safety harnesses and seat belts. This shall take into account restrictions on body movement, manual dexterity, vision, and the mobility and agility of the user when wearing such equipment. Where protective equipment may be worn while using the equipment, this shall be replicated during the process of validating the HCI design.

10 Logical Interaction Dialogue Styles

10.1 Dialogue style. The term "interaction", in the context of HCI, refers to the two-way exchange of information and commands between a computer system and its human users. This section provides guidance and recommendations on the principal dialogue styles used in military HCIs. The dialogue styles addressed are:

(a) Question and Answer.

(b) Form Filling.

(c) Menus.

(d) Command Language.

(e) Query Language.

(f) Natural Language.

(g) Direct Manipulation.

10.1.1 Selection of dialogue style. The selection of dialogue style shall be based on considerations including:

(a) the skills and experience of the target user population and the maximum amount of training expected to be required to achieve competence;

(b) the nature of tasks to be performed. This includes the extent to which the sequence of user actions and format of user inputs is structured by task constraints, and the levels of speed, accuracy and reliability required;

(c) the nature of the interactive technology available, including the size of display area provided and the control devices available;

(d) dialogue style should be tested early on in the design process on a prototype system;

(e) the nature of the systems and environment in which the HCI is required to be operated (systems for use in air, land or sea will each impose different constraints on the choice of dialogue style).

10.1.1.1 The results of the considerations in the selection of dialogue style shall be documented in the HCI Design Rationale document.

10.1.2 Mixed dialogues. A single HCI will often involve a number of dialogue styles. Form-filling interfaces, for example, often use menus as a means of providing access to system functions or, where fields can only accept data, from a limited set of options. Similarly, a direct manipulation style of interface can often involve elements of menus, forms and command languages. The selection and mixture of dialogue styles used in a design shall be appropriate to the target user group, their task objectives, and for the detailed dialogue tasks necessary to achieve those objectives.

10.1.2.1 Where mixed dialogue styles are used, the guidance provided in this clause shall be applied as appropriate.

10.1.3 Table D summarizes the principal advantages and disadvantages of each of the dialogue styles.

Table D

Summary of Dialogue Styles

STYLE	ADVANTAGES	DISADVANTAGES
Form Filling	Can simplify data entry Requires modest training Shows context for activity Allows good mapping to task structure Supports local validation of data and input sequences	Can consume screen space Requires typing skills Requires good screen design
Question and Answer	Good for novice users Reduces training requirement Supports structured decision making	Generally requires more keystrokes than other styles Is generally slower
Menus	Support novice users Requires modest training Can reduce keystrokes Structures decision making Constrains input to valid options Available options can be tailored to current valid selections Reduces user error handling requirements Makes system facilities visible	Slows interaction, particularly for experienced users Can consume screen space Can require rapid system responses Naming of menu options, design of menu content and navigation structure non-trivial

Table D - Concluded

STYLE	ADVANTAGES	DISADVANTAGES
Command Languages and Query Languages	Supports flexibility in user interaction Supports user initiative Potentially rapid for complex tasks	Requires substantial training Difficult to remember infrequently used commands Requires sophisticated error handling
Natural Language	User does not need to learn syntax Allows user to think directly in task domain Reduces training Potentially powerful, particularly when combined with direct voice input	Usually requires clarification by further interaction Generally requires more keystrokes Context can remain hidden Can imply a causality Can impose unexpected constraints on users Errors can be difficult to detect Technology immature with few current applications
Direct Manipulation	Close relationship between tasks, user abilities and HCI Visually represents the tasks Can be easy to learn and retain Errors can be minimized Can encourage exploration High Subjective satisfaction	Experienced command language users often experience difficulty transferring to direct manipulation interfaces (due to a lack of object-orientedness) Requires correct identification of interface metaphor

10.1.4 Form filling. Form filling interaction should be considered when a dialogue task involves a high data entry component and where flexibility is required in the way in which the user carries out a task. The technique supports the simultaneous and structured presentation of related data and controls, as well as the inclusion of optional and default data that may not be required to reach occurrence of that interaction.

10.1.4 (Contd)

The presentation of data and functions in forms allows novice or moderately trained personnel to access the functionality and data in the system without incurring high error rates. The computer response can, however, appear to be slower than a command driven system.

10.1.4.1 Form filling dialogues should exhibit the following characteristics:

(a) Meaningful titles. Each form should have a meaningful title.

(b) Visually appealing. The layout of the form should be visually appealing and should be graphically balanced.

(c) Visually distinct fields. All fields shall be visually distinct. Data fields shall be visually distinct from labels. Data fields which users can edit shall be visually distinct from non-editable data fields.

(d) Logical grouping and sequencing of fields. Each form shall present its contents in a logical and sequenced order that supports the user's tasks. The layout of fields in a form should be such that data entry flows in a logical sequence, and is matched to the user's tasks and goals.

(e) Group headings. Fields that are related to a single sub-task or activity should be related by a field group heading. Field group headings should be spatially or graphically related to the group. For example, the use of a containing box with the heading centred at the top.

(f) Field labels. Each field within a form shall have a label which, through its positioning or appearance, clearly relates to the associated field. Field labels shall use terminology familiar to the user. Where special terminology, abbreviation or acronyms are used, these shall be consistent throughout the whole system.

(g) Labels for equipment or tactical units shall use the names by which users are expected to refer to the equipment or unit in normal speech. Where abbreviations are used, they should follow the guidance contained in clause **7** of this Standard.

(h) Where the units required to be entered into a data field may not be obvious, the expected or default units shall be indicated by a following label.

(i) The labelling of control or action fields should clearly describe the action supported. Where units of measurement are to be entered, a secondary label shall be placed adjacent to the field. This label should conform to the accepted standard of measurement used by the users.

(j) Related fields. Fields which are logically related (for example, because the range of data which is acceptable for the field depends on the value of data in other fields in the form) shall be grouped together, behave similarly and support interaction as a logical unit.

10.1.4.1 (Contd)

(k) Convenient cursor movement. The method of moving quickly and conveniently between the field areas with the cursor presented to the user. On completion of editing a field, and where fields can be expected to be edited in a pre-defined sequence, the cursor should automatically be re-located to the next logical field in the sequence. The cursor shall clearly indicate the current edit point.

(m) Comprehensible instructions. Each form shall present the user with a comprehensible set of instructions to guide the user in completing the form. Clear, concise prompts should normally be available for each field unless the content or effect is clearly obvious from the context, field content or field label. For data fields, prompts should indicate the type, format and, where necessary, constraints on the data required. The context and expected content of each field shall be indicated. For control or action fields, prompts should indicate the effect of selecting the field. Instructions should describe the consequences of critical actions.

(n) Default data. Data fields should contain default data wherever logical defaults can be identified. Users should not be required to enter redundant data, undertake any data bookkeeping or enter the same data twice.

(o) Data field editing. The point at which an edited field replaces exiting data in the system shall be clear to the users, and shall involve a discrete action by the user (such as pressing an Enter key). Until an edit is committed to the system, users shall either be able to see both the original and the edited data, or be provided with a simple method for returning to the pre-edited data. Where a field contains data which has been edited, but is not yet in the system, the edit status of the field shall be apparent from the visual appearance of the field.

(p) Alternate edit methods. As far as possible, alternate methods of editing data fields shall be provided. For example, these may be by typing, by menu selection or, in a direct manipulation interface, by pointing at the object from which data is required.

(q) Error correction. The user shall be presented with a method of error correction for individual characters and entire fields. The visual appearance of fields which are detected as being in error shall be obvious, and differ from the appearance of a non error field.

(r) Error messages. The user shall be presented with error messages for unacceptable values entered into the form. Messages should be presented on completion of editing a field, wherever logically possible, rather than on completion of the form. Validation should, where possible, be completed before the user is permitted to advance to the next entry.

(s) Optional fields. Where option fields are used to support enhanced operation, the user shall be made aware that they are not essential.

10.1.4.2 Form-filling dialogues shall comply with ISO 9241, clause **17** so far as considerations of military applications allow.

10.1.5 Question and answer. Interfaces can be viewed as a special case of form filling interfaces. This style of dialogue is suitable where routine data entry tasks are required to be performed by inexperienced users. Considerations for form filling interfaces shall apply where they are relevant.

10.1.5.1 In general, the major difference between question and answer interfaces and form filling interfaces is the reduced level of control the user has over the dialogue sequence and the level of guidance which is provided. The interface should provide the user with the facilities to backtrack, abort, exit and where practicable, accept default settings.

10.1.5.2 Consideration shall be given to the level of guidance or explanation provided by the system, particularly where users may not understand the context or reasons for questions. This should be assessed against the user profile and task needs.

10.1.6 Menu dialogues. In general, a menu dialogue style occurs in any situation in which a user is allowed to select one or more options from a range of valid alternatives. Menu dialogues should exhibit the following characteristics:

(a) Use consistent terminology. Terminology in menus shall be consistent and meaningful to the intended users. The names of menus should clearly indicate the options contained within the menu. Menu names should be based on the language, expectations and training of the target user populations as specified by the customer.

(b) Present the location. The design and appearance of menu hierarchies shall be such that the user is always aware of their current location in the overall menu structure.

(c) Organization of menus. The content of menus, structure of the menu hierarchy and naming of menu options shall be based on an understanding of the organization of user tasks. For example, where menu items form natural or conventional groupings, or form groups which users can be expected to know, then items should be organized according to these groupings.

(d) Use a broad, shallow structure. Menu hierarchies should be broad and shallow rather than narrow and deep. Where a hierarchical menu structure is necessary, users shall be provided with a clear indication of the current position in the hierarchy. Within a hierarchical menu structure, a single key action shall return the user to the level above.

(e) Allow shortcuts for experienced users. The functions presented by the menu should be accessible by alternative short cut methods to enable experienced users to bypass sequences of menu selections. Where menu selection is undertaken by code, the code should be:

- entered into a standard way

- consistently allocated throughout the system

- a letter which is easily related to the name of the menu option (eg X for eXit)

10.1.6 (Contd)

(f) Show options not currently available. The presentation of functions and options should show any options not currently available within the present mode or state.

(g) Provide a consistent starting point. The presentation should allow the user to start the selection process from a consistent point.

(h) Provide rapid access to common options. The most commonly used options or groups of options should be placed near the position where the cursor is located when the user enters the menu.

(i) Allow access to the main menu. Where a main menu exists, it shall be accessible to the user at all times.

10.1.6.1 Menu dialogues shall comply with ISO 9241, Part **14** so far as considerations of military applications allow.

10.1.7 Command languages. Command languages provide more direct access to a system's functionality than other dialogue styles. They provide a powerful and flexible means for experienced users to interact with a system rapidly, with a minimum of constraints. They can, however, require considerable learning and experience.

10.1.7.1 Command language dialogues should exhibit the following characteristics:

(a) Entry area. An appropriate entry area should be provided to allow the user to enter and visually confirm the command before actioning it.

(b) Be tolerant of mis-spelling. The mis-spelling of commands should not cause errors through misinterpretation, through failure to execute a command, or through failure of the system to accept a sequence of commands.

(c) Naming. Command names shall be unambiguous and should reflect both user tasks activities and user understanding of the operation of the system.

(d) Abbreviations. The system should support the use of abbreviated commands. This can be achieved by either dynamic interpretation of the command on entry or by the use of predefined codes.

(e) Non-recognition. If the system fails to recognize a command, a clarification message should be presented, with an indication of the most probable commands and their meanings.

(f) Upper and lower case. The system should not discriminate between upper and lower case commands.

10.1.7.2 Command language dialogues shall comply with ISO 9241, Part 15 so far as considerations of military applications allow.

10.1.8 Query languages Are a specialized form of command languages with a dedicated domain of operation. Query languages are often used in database systems where user's tasks involve locating specified items of data. Query languages assist users in developing strategies for locating the required information. They are typically mixed dialogues involving combinations of menu selection, form-filling and command languages and direct manipulation. Where a query language is used, considerations for other dialogue styles shall apply where they are relevant.

10.1.8.1 Particular consideration shall be given to methods of supporting and guiding users in formulating search strategies. Suitable techniques can include:

(a) displaying all the strategy nodes attempted and allowing the user to return to any node to apply a different strategy or

(b) embedding a template of a strategy into the system to allow the user to query at a higher level.

10.1.9 Natural language dialogues. By exploiting everyday language as the means of communication between users and a system, natural language interfaces are potentially available to users with little or no prior training or experience, providing immediate access to a system's data and functionality. Currently, natural language technologies are not yet mature and have few general applications. However, natural language dialogues have been used successfully to allow users to formulate queries on database systems. The extent of application of a natural language interface depends on the size and sophistication of the vocabulary and language processing capability provided by the system.

10.1.9.1 Natural language dialogues should exhibit the following characteristics:

(a) Task compatible vocabulary. The extent of the vocabulary understood by the system shall be sufficient to support user tasks and allow flexibility in the users input. The system should be capable of interpreting the meaning of words from the context both of the general interaction, and of the immediately associated words.

(b) Task compatible grammar. The extent of the grammatical interpreter embedded in the system shall be sufficient to support the expected user population.

(c) Task semantics. Both the computer and task semantics should be represented in a logical and structured way.

(d) Clearly defined domain The scope of the domain in which the system is capable of interpreting user inputs shall be clear from the context of the interaction and design of the HCI.

10.1.10 Direct manipulation. Direct manipulation interfaces allow the user to interact with and manipulate objects and data, using basic perceptual-motor skills. They minimize the need for users to learn or use special skills or abstract methods to manipulate data or objects. Objects and data are presented and behave in a manner which is directly representative of real-world appearance and behaviour.

10.1.10 (Contd)

Direct manipulation interfaces are typically based on visual metaphors or the real world. Metaphors are a powerful means of conveying and supporting users in developing an appropriate conceptual model of the system. Direct manipulation interfaces are generally appropriate for applications which have a strong visual element or involve reasoning about, or manipulation of, spatial relationships between objects. They generally do not suit tasks that principally involve abstract or logical reasoning. Direct manipulation dialogues do not necessarily require a Graphical User Interface (GUI).

10.1.10.1 Direct manipulation dialogues should exhibit the following characteristics:

(a) The design of the interface should be based around objects which are meaningful to users in the context of the HCI tasks they are required to perform.

(b) Present visualization of objects. Objects which users require to interact with shall be represented visually.

(c) The facilities and methods by which users interact with data in the system should relate closely to the basic perceptual-motor abilities and skills of the users, and to the nature of the physical and cognitive tasks users are required to perform.

(d) Rapid actions. The user shall be presented with a mechanism that allows rapid incremental and reversible actions by manipulating the objects presented in relation to one another.

(e) Visible results. The effects of user actions on the interface shall be represented visually.

10.1.10.2 Where possible, the visual representation (simulation or metaphor) and methods of manipulating the interface should conform to a coherent and consistent view of the real world and should reflect user objectives.

10.1.10.3 Gesturing. The use of physical gestures can be an effective method allowing users to execute functions and achieve results which are difficult or complex to express in concrete terms. Gesturing requires the system to interpret continuous spatial movements of a pointing device in terms of system functions. For example, the gesture can be used to represent the function "Delete". The gesture could instruct a function to select or apply a defined operation to all objects within the area indicated.

10.1.10.3.1 Gesturing has been shown to be effective with dedicated trained users, though it is less suitable for novices. Where gesturing is used then the set of gestures supported should conform to stereotypes in the user population.

10.1.10.4 Direct manipulation dialogues shall comply with ISO 9241, Part 16 so far as considerations of military applications allow.

10.2 Error handling. Systems shall be capable of detecting errors of data or logic in the dialogue. Error messages shall be expressed in text format using clear, simple language, unless a more informative non-textual format has been demonstrated as more effective. Error messages shall be designed to ensure that the user is clear as to which part of an input led to the error. When multiple errors are covered by a single measure, the error message and associated visual effects should identify all errors covered by the message.

10.2.1 The content of error messages shall be kept as short and concise as is consistent with ensuring that users are clearly aware of the error. Users shall not be expected to refer to user manuals to interpret common interaction errors. All error messages shall, however, be included and expanded upon in the system documentation and in on-line help facilities where they are provided. When an error is detected, the system shall inform the user of:

(a) the nature of the error;

(b) where it occurred;

(c) how to resolve it.

10.2.2 Errors may be shown as coded references where the error detected has not arisen as a direct consequence of the user input, or where the error is due to a fault in system hardware or software.

10.2.3 The status of error messages shall be clearly identifiable through their visual appearance, location or behaviour. Where possible, error messages should be positioned in close proximity to the item in error, or close to the user field of view. Where this is not possible, error messages should be presented in a consistent location. Techniques for attracting user attention to error messages should be used where the location of an error message may fall outside the user’s prime viewing area.

10.2.4 The system response should ensure that errors of data or dialogue are detected and indicated to the user before the user is permitted to progress to the next phase or step in data entry.

10.3 Text handling. Methods of text handling shall be considered and related to the objectives of user tasks. Text and data shall be protected against unintentional data loss, and allow recovery in the event of accidental corruption. These measures should be automatic where possible, and activated through explicit and consistent user action.

10.3.1 In the event of an action threatening data security, the user shall be warned by the use of a Message Dialogue Box. Consideration shall be given to methods of handling all predictable control entries, including the handling of incorrect control entries.

10.3.2 Text entry. During text entry design consideration shall be given to the variety of order and alternative formats in which the user may require to input text.

10.3.3 The system shall provide facilities to allow the user to handle the data quickly and easily. These facilities shall reduce the need for retyping of data and shall minimize reliance on particular formats while entering data. Consideration shall be given to the techniques such as 'Cut and Paste', 'Drag and Drop' of data objects and the context selection of data.

10.3.4 Users shall be provided with the following keys to support text entry:

(a) backspace without deleting a character;

(b) delete the previous character;

(c) cursor keys;

(d) end and home keys,

The effect of each of these keys shall be clearly defined and visually apparent.

10.3.5 Standard word processing features. Where an HCI provides facilities for user entry and manipulation of continuous text, standard word processing features shall be provided. These should normally include:

(a) facilities to insert and delete text at any location selected by the user;

(b) facilities to select areas of text from individual characters, words, sentences, paragraphs or larger units;

(c) facilities to search for specified items of text, and to search and replace specified items of text. As a minimum, search and replace criteria shall be able to be specified as text strings;

(d) word-wrap shall be automatic, keeping whole words intact;

(e) users shall be able to specify the size of a page, and insert page breaks as required. Pagination shall be automatic;

(f) unless otherwise specified, continuous text should normally be left-justified;

(g) pre-defined standard formats should be provided;

(h) on completion of an edit, users shall be able to specify whether to save changes as a new document or as changes to an existing document;

(i) users shall be able to edit text without having to select a separate text editing mode.

10.4 HCI response times. The term 'HCI response time' refers to the time delay between the end of a user input and completion by the system of the associated operation including displaying the result. The term does not cover the time taken for the user to perform the actions leading to the input (these can be termed 'dialogue performance time'). The main issues affecting the acceptability of HCI response times are:

10.4 (Contd)

(a) user expectancy;

(b) consistency/variability;

(c) compatibility with task requirements.

10.4.1 User expectancy. The absolute HCI response times which users will find acceptable depends to a large extent on their expectations. User expectations are based on experience both with the particular system, and with other similar systems. Expectations also depend on user perception of the difficulty of the task the system has to perform. For operations perceived as trivial (such as displaying a character in response to a key press), any delay which interrupted the flow of action or thought would be likely to be considered unacceptable. For operations which are perceived as requiring the system to do some "work", users expect and will accept some delay. The length of delay which will be considered acceptable depends on the perceived complexity of the "work".

NOTE: The users perception of the difficulty of a system task can be very different from the actual processing effort involved. For example, changing range on a radar display or sorting a table of data may be perceived by a user as "simple" HCI operations. However, such operations can impose a considerable load on the system and are unlikely to be completed "immediately".

10.4.2 Consistence/variability. The variability in the time it takes a system to respond to a single operation on different occasions is almost as important as the absolute delay on any one occasion. Variability shall be less than half of the average time to complete an operation and should be no more than 15% of the average time.

10.4.3 Compatibility with task requirements. HCI response times shall be compatible with task requirements. There is generally an upper limit (between about 0.1 and 0.2 s) beyond which users will be unlikely to notice or be affected by variations in HCI response times. There is little to be gained by increasing response times beyond this limit.

10.4.4 Some HCI tasks require more or less continuous interaction and demand high levels of concentration. Any system-induced delay which interrupts the continuous flow of such tasks is likely to be seen as unacceptable. Tasks of this type can be expected to require response times of less than 2 s for the great majority of operations.

For tasks which are inherently intermittent or occasional, and where the user does not use the system interactively, longer response times are likely to be acceptable.

10.4.5 In all cases, if the HCI response time is likely to exceed more than approximately 2s, the system shall display an acknowledgement that the operation is in progress. If the delay is likely to exceed 15s, an indication of delay shall be displayed. If possible, the current state of the operation or the estimated time to complete should also be displayed.

Table E summarizes considerations relating to gross ranges of HCI response times.

10.4.5 (Contd)

Table F indicates HCI response times which users will usually find acceptable.

Table E

Summary of Gross Ranges of HCI Response Times
(after Boff and Lincoln, 1988)

RANGE(S)	CONSIDERATIONS
<2	Normal range of response times for most interactive tasks.
2 to 5	Too slow for continuous tasks requiring high levels of concentration.
5 to 15	Too slow for interactive dialogue. Frustrates users in problem-solving and data entry activities. Long enough to allow the user to perform other tasks while waiting for the system to respond.
>15	Too slow for conversational dialogue. Message of expected delay should be displayed. User should be able to return to observe results without affecting or delaying other system processes.

Table F

Examples of HCI Response Times Which Will Usually be Acceptable

TIME	ACTION - DISPLAY
<50 ms	From movement of pointing device to movement of cursor or marker.
100 msecs	Pressing a key to character being displayed.
200 msecs	Selection of displayed object (field, button, menu option) to object appearing as selected. Selection of menu header to menu being displayed. Selection of scroll button to completion of scroll of one line of text.
1 - 2 s	Completion of user input to display of error indication.
2 s	Request for next page of information to completion of one page change. Completion of user input to completion of simple process. Completion of display manipulation request to completion of display change (eg open a window; Zoom).

Table F - Concluded

Examples of HCI Response Times Which Will Usually be Acceptable

TIME	ACTION - DISPLAY
5 to 10 s	Completion of user input to completion of frequently performed complex operation.
>10 s	Completion of user input to completion of infrequent, complex process.
15 -60 s	Request for loading or restarting. Formatting a diskette

10.5 User support. User support facilities, including on-line help, shall be provided as an integral component of the system. User support facilities shall include, as a minimum, appropriate Prompts and Error messages, User Manuals, and may include on-line HELP. Requirements for Prompt and Error Messages are covered elsewhere in this clause.

10.5.1 On-line help. On-line help facilities shall not simply be implemented as an on-line version of a user manual. Help facilities shall, as far as possible, be context sensitive and shall be accessible to the user at all times, unless the system is in training mode. In training modes, the availability of Help should be at the discretion of the training instructor.

10.5.1.1 Where it is provided, on-line help shall provide the user with the ability to:

(a) access information appropriate to the current selection, displays or part of the system with which the user is currently interacting;

(b) access information on specific topics based on a key word search;

(c) view an index of topics;

(d) obtain information on how to carry out specific dialogue tasks;

(e) obtain access to a dictionary of abbreviations and acronyms.

10.5.1.2 Each separate item in the Help facility shall provide the user with relevant information on the topic addressed. As far as possible, information shall be structured such that it is based around user tasks or elements of the HCI.

10.5.1.3 The presentation of Help statements shall be such that the user can view the contents whilst interacting with the dialogues to which it refers. In complex situations, Help statements should reference other relevant material, such as the user manual or training material.

10.1.5.1.4 All material presented within online Help shall also be available in supporting system documentation.

10.5.2 Help and error messages. Shall be constructed to support and educate the user in regard to the system architecture and functions and should be structured to take account of user knowledge. The presentation of messages shall be informative, positive to the user (Active Voice), meaningful, presented in a simple structure, and complete (requiring no additional searching).

10.5.2.1 Each message shall contain information at a minimum of two levels, with the first level being a summary, and the second providing detailed descriptions and instructions to guide appropriate user actions. Where the message is related to an error, the second level should provide information instructing the user how to correct the error.

10.5.2.2 Error messages should be structured as follows:

(a) General principles, and information relevant to the wider context which users may need to learn about the system or HCI, should be at the beginning.

(b) Explanation of the specific topic, where necessary, should be in the middle.

(c) Items to be recalled to resolve the immediate issue should be at the end.

10.5.2.3 If an error requires a complex set of instructions to correct it, then it shall be possible for the user to view and carry out the instructions simultaneously.

10.6 Multi-user systems. Where users work in teams, or conduct separate tasks using an integrated system, consideration shall be given to the additional complexities which may arise from team working. The system should support the co-operative working of users by providing mechanisms that assist the goal and objectives of the co-operative tasks.

10.6.1 Consideration shall be given to the communication requirements between users. Consideration should be given to the introduction of methods to support the sharing and transmission of information within the system.

10.7 Safety critical systems. This clause provides an overview to the major HCI related considerations of a safety critical system. For further information regarding safety critical systems, refer to Def Stan 00-55 and Def Stan 00-56.

10.7.1 Operator workload. The Design Authority shall assess the risk that errors occur as a result of excessive workload. This consideration will include but not be limited to:

(a) The user’s non-HCI tasks.

(b) System objective driven tasks and activities.

(c) Screen management activities.

10.7.1.1 Where operator workload is identified as representing a significant risk to the system's operation requirements, consideration shall be based on a systematic workload analysis. It shall also be explicitly addressed during user trials.

10.7.2 Operator reliability analysis. Appropriate activities for identifying and evaluating the reliability of user interactions with the system shall be applied. This may include assessment of the probability of each type of user error occurring, and the potential consequences. This consideration will include, but not be limited to:

(a) Communication with other users.

(b) Assessment of data presented to the user.

(c) Inconsistencies between system and users conceptual models of the system.

(d) Task errors.

(e) Activities errors.

10.7.2.1 To ensure that the appropriate level of integrity has been built into the system, consideration shall be given to the consequences of an HCI error. This consideration shall include, but not be limited to:

(a) Error recovery activities.

(b) Error recovery times.

(c) System commitment.

(d) Potential secondary errors.

10.7.3 Where it is required, the consideration of human reliability shall be based on a systematic analysis that identifies, quantifies and categorizes potential user errors. This analysis shall be related to the analysis of HCI-induced workload. Methods for assessing human reliability are described in Kirwan (1993).

11 Support Facilities

11.1 Embedded training. Consideration shall be given to the integration of embedded training functionality into the system. For further information see Defence Standard 00-25 part 14 (Guidance on Training and Instruction).

11.1.1 While in training mode, users shall be made aware that training mode is active. This will be done in a clear and unambiguous manner. Failing to ensure user awareness of training mode activity can impact on the safety and integrity of the system.

11.1.2 Consideration shall be given to handling real alerts while in training mode. The status of real system alerts which are presented to users in training mode shall be unambiguously identifiable.

11.1.3 The system shall provide the training supervisor/instructor with a means to view global scenario data as well as the data being presented to individual trainees.

For further information regarding training systems and the training needs analysis process refer to Def Stan 00-25 clause 14.

11.2 System documentation. Consideration shall be given to the production, content and presentation of the documentation provided with the system.

The user documentation should be in a different volume to the system documentation. The structure of the documentation shall follow the envisaged tasks to be undertaken by the users of the system. This will include, but not be limited to the following sections:

(a) Start up.

(b) Key concepts.

(c) Task procedures.

(d) Explanation of errors.

(e) Maintenance.

11.2.1 The text within the documentation should reflect on-line help text and should be cross referenced to the on-line help where appropriate. As a minimum, the documentation shall provide a description of each logical screen area, the design metaphor, a description of the expected concern and context of each displayed object.

11.2.2 The presentation of the documentation should comply with the guidance found in the Department of Trade and Industry’s "Instructions for Consumer Products".

Section Four. Interface Requirements

12 Input and Control Devices

12.1 General. This Section identifies considerations relating to the use of input and control devices for military HCIs. The Section summarizes characteristics of commonly used devices, and provides guidance on issues which need to be addressed in selecting and implementing devices for computer-based equipment. The Section particularly emphasizes considerations which may be controlled or affected by the design of HCI software. The guidance contained in this Section applies to both physical devices as well as to representations of devices implemented on computer displays, where appropriate.

12.1.1 Input and control devices shall comply with the general guidance and requirements contained in clauses **10** and **11** of this Standard.

12.1.2 In selecting, designing and implementing input and control devices, the Design Authority shall provide evidence that relevant Human Factors issues have been identified and that appropriate consideration has been given to them. Results of these considerations shall be documented in the HCI Design Rationale document.

12.1.3 Further information. For further information regarding input and control devices refer to Def Stan 00-25 clause 10. Detailed requirements and recommended test methods for control devices can be found in ISO 9241 (clause **4** for keyboards and clause **9** for non-keyboard input devices).

12.2 Guiding principles. The following guiding principles shall be considered during the design, selection, implementation and evaluation of input and control devices.

(a) the assessment and testing of HCI devices shall be based on production standard equipment, and shall involve real or representative workplace layouts, environmental conditions and task requirements. Assessments should address both the physical characteristics of the devices used as well as those aspects affected by system design considerations (such as the sensitivity of pointing devices);

(b) where the combination of devices could impact on the individual efficiency of one device a trade-off analysis shall be carried out in the context of the workplace and task requirements.

12.3 Device characteristics. Input and control devices shall exhibit the following characteristics:

(a) be appropriate to the characteristics of user tasks, including the frequency, importance, sequence and urgency of use, required standards of tasks performance and the environmental conditions in which tasks are expected to be performed;

(b) be self descriptive in the context of the task and environment;

(c) be consistent with user expectations in function and use;

(d) be resilient to inadvertent operation or misuse;

12.3 (Contd)

(e) support learning and promote transfer of skills between devices;

(f) promote efficiency and comfort in usage;

(g) be safe and stable in normal working practice and avoid sharp edges and corners;

(h) provide adequate feedback;

(i) minimize both mental and physical demands on the user and minimize static muscle loading;

(j) be designed to operate within the optimum dynamic reach space of the user;

(k) take into account the position of the input device on the work surface in relation to other devices, including, where necessary, requirements for locating and operating devices without visual guidance;

(l) be easily maintained.

12.3.1 Selection. When selecting input or control devices, consideration shall be given to the nature of the users and their tasks, any physical constraints (such as the space available will provide adequate arm support), the operational environment and possible interference between HCI devices and other non-HCI related tasks and activities expected to be performed by the users. Consideration shall also be given to the context of the HCI dialogue tasks in which devices are expected to be used, and to the combination of input devices which may be involved. (For example, dialogue tasks may require a user to identify an object (using a pointing device), apply a function (which may require a function key) and enter data (possibly using a keyboard).

12.3.2 Table G summarizes general characteristics of a range of common input devices with respect to generic dialogue tasks. The table indicates the extent to which each type of input device is appropriate for the various types of dialogue tasks.

Table G

Summary of HCI Input Devices for Generic Dialogue Tasks

DEVICE TYPE	DIALOGUE TASK					
	DATA ENTRY	HIGH PRIORITY FUNCTIONS	DRAWING	OBJECT SELECTION	CONTINUOUS CONTROL	CURSOR POSITIONING
Alpha-numeric keyboard	High	Low	Low By defining data points in a form	Low Very Indirect	N/A	Low Very Indirect
Function Keys	N/A (Though can input default data)	High	N/A	N/A	N/A	N/A (Though can be used to reset cursor position)
Mouse	Medium Discrete choices	Medium By object selection	Medium Limited resolution	High Depends on sensitivity and object size and location	Medium Depends on task and sensitivity	High Depends on sensitivity
Joystick	Medium Discrete choices	Medium By object selection	Low Limited resolution	Medium Depends on dynamics and object size and location	High Depends on task and dynamics	Medium Depends on dynamics
Tracker-ball	Medium Discrete choices	Medium By object selection	Low Limited resolution	Medium Depends on dynamics and object size and location	Medium Depends on task and dynamics	Medium Depends on dynamics
Light pen	Medium Discrete choices	Medium By object selection	Medium Limited resolution	Medium Suitable for large and dispersed objects	Low Depends on task and sensitivity	Medium Not suitable for fine positioning
Tablet	Medium Discrete choices	Medium By object selection	High	Medium Depends on object size and location	Low Depends on task and sensitivity	High
Cursor keys	N/A	Low Slow positioning	Low Low resolution	Medium for Data fields Low for graphics	Low	Medium for Data fields Low for graphics
Touch screen	Medium Discrete choice	High	Low Very low resolution	Medium Suitable for large objects	N/A	Low Low resolution
Voice	Low Useful for restricted data sets	Medium Not suitable for critical functions	N/A	Low	No	Low Possible, though slow and inaccurate

12.3.3 Table H summarizes some general considerations in the selection of input and control devices.

Table H

Summary of Considerations Relating to the Selection of HCI Print Devices

DEVICE		NOTES
Keyboard	General	Should be considered where alpha-numeric or numeric data entry is required.
	Standard keyboards	Unless otherwise constrained a standard keyboard should be used for alpha-numeric or numeric data entry.
	Non standard keyboards	Wherever possible non-standard keyboards should use the same conventions as a standard keyboard.
2D Pointing Device	General	Should be considered for the selection of points in a single plane. Sensitivity and control order often under software control.
	Mouse	Suitable for main item selection, scrolling, data retrieval and data entry.
	Joy Stick	Suitable for continuous control. Do not use for cursor positioning where speed and accuracy are important.
	Tracker Ball	Suitable for data pick-off. Do not use for automatic scroll at edge of screen.
	Light Pen	Should be considered for rapid pointing at large dispersed targets. Should be considered for cursor placement text selection and command initiation. Not for frequent use.
	Tablet	Suitable for data pick-off and pointing in land systems mobile platforms. Should be considered for entry of points, generation of free drawn graphics.
	Cursor Control	Should be considered for gross or constrained movements of the cursor for tasks that involve typing and pointing at few targets. Should be considered as a support method for other devices.

Table H - Concluded

DEVICE		NOTES
2D Pointing Devices (Contd)	Touch Screens	Suitable for main item selection, scrolling, data retrieval. System should accept only one command at a time. Not recommended for continual use.
3D Pointing Devices	General	Should be considered for the selection of points in a virtual 3 dimensional space. Sensitivity and control order under software control.
	Space Ball	Suitable for continuous control. Should be used with other devices for selection.
	Data Glove	Should be considered for selection and manipulation of discrete items within a virtual 3 dimensional space.
Voice Activation/ Input Systems	General	Voice activation/input should be considered as a supplementary input device when: 1. Users hands are busy undertaking simultaneous tasks. 2. Mobility is required. 3. Users eyes are occupied undertaking simultaneous tasks. 4. Harsh or cramped conditions preclude the use of other devices. Should be limited to simple input tasks. Should provide feedback appropriate to the task. Should not be used in noisy environments in air-systems amplified voice inputs through a microphone used for communications. Should be avoided in stressful applications such as operational combat areas. Should be avoided in stressful application.

12.3.4 Feedback. Input and control devices shall present the user with feedback in an appropriate format, level and type and when and where it is expected. Feedback should be such that the user is confident:

(a) when the control is activated and;

(b) that the use of the device has produced the expected response.

Appropriate feedback can involve the properties of the device itself (ie its physical, mechanical and acoustic response), of the hardware and software interfacing with the device, and of the software controlling the display of information to the user.

12.4 Non-standard keyboards. Non-standard keyboards shall comply with the guidelines in part **10** (Controls) of this Standard and, where appropriate, with requirements imposed under relevant Health and Safety legislation. Where non-standard keyboards are to be used in addition to a standard keyboard, they should be designed to be compatible to the Standard (eg the same angle, level, colour and range of adjustment).

12.4.1 Layout of keys. Consideration shall be given to the layout of any dedicated keys or controls on a non-standard keyboard such that they are grouped in a logical way. Function keys should be easily distinguished from others and clearly labelled. Where keys have a major, irreversible or catastrophic effect, special consideration shall be given to their design and implementation to minimize the likelihood of inadvertent operation. Numeric keyboard layouts shall be consistent throughout the entire military workplace. (NB Both keyboard and telephone numeric layouts shall be designed into the same workplace.)

12.4.2 Use of modifying keys Modifying keys should be used to provide an alternative means of accessing existing functions. Consideration shall be given to the importance, criticality and frequency of the action in the allocation of functions to dedicated or combinations of key presses. No more than three simultaneous key presses should be required to use a modifying key.

13 Display Devices

13.1 General. Display devices shall comply with the guidance given in clauses **7, 8, 9** and **11** of this Standard and part **7** (Visual Displays) of this Defence Standard. Displays should normally comply with the relevant Parts of ISO 9241 (Parts 3, 7 and 8) unless the type of display or conditions of use are such that the Standard does not apply.

13.1.1 In selecting display devices, the Design Authority shall provide evidence that relevant Human Factors considerations have been identified and that appropriate consideration has been given to them. Results of these considerations shall be documented in the HCI Design Rationale document. The Design Authority shall also identify and document constraints (such as the number of colours which may be used in a design) which the selection of display devices or device drivers may impose on the design of the HCI.

13.1.2 In addition to satisfying the general requirements for display devices. These display devices shall exhibit the following characteristics:

13.1.2 (Contd)

(a) Be appropriate to the quantity, format and dynamic nature of the information to be displayed. Screen size should be determined by the amount of information required to be viewed and take into account the viewing distances and angles of all relevant users.

(b) Provide the minimum of constraints on the presentation of information and style of HCI dialogue.

(c) Physical characteristics (such as the size of pixels or images) should not reduce the ability to identify and discriminate graphic objects or their colour.

13.2 Visual display devices. Unless superseded by the specific requirements for a system, display characteristics shall ensure that users:

(a) do not perceive any disturbance flicker;

(b) can adjust the contrast ratio between 5:1 and 10:1;

(c) can adjust the display luminance over a range which is appropriate to the operational environment and conditions.

NOTE: In normal office-type environments, this will be between 80 cd/m^2 and 160 cd/m^2. Military environments ambient light levels maybe more extreme (see part **6** of this Defence Standard).

(d) do not perceive a persistence lag in a changing image;

(e) do not perceive reflectance glare in the surface of the display;

(f) do not perceive a scan line or matrix spots.

If no adjustment of the display is possible, practical or desirable during operation then the default settings should conform to the above.

13.3 Colour rendering. The display device shall render colours to ensure:

(a) colour uniformity across the display device;

(b) minimal colour misconvergence;

(c) consistent character height and object size;

(d) good colour discriminability;

(e) minimal background and surround image effects;

(g) minimal chromostereopsis or other unintended perceptual effects.

13.4 Multi-screen systems

13.4.1 Multi-screen systems can be considered to be of two general types:

(a) systems with two or more distinct physical displays, and

13.4.1 (Contd)

(b) systems in which a single display screen is organized into two or more areas which are used for clearly distinct purposes (such as distinct graphical and alphanumeric areas).

As well as increasing the amount of display area available, systems which use two or more physically distinct displays provide a number of advantages, such as:

(a) individual displays can be configured to specific users and uses;

(b) displays can be tailored to different viewing conditions (such as sitting and standing users);

(c) they can support the users conceptual model of a system by helping to emphasize differences and relationships between information and sources.

13.4.2 There are two main ways of making use of physically distinct screens:

(a) all screens are integrated to provide an increased display area, and

(b) one or more screen is dedicated to interaction, and the others are used solely for the presentation of data.

Where multiple screens are used to increase display data, consideration shall be given to using a single higher resolution screen with suitable information presentation, structure and coding techniques to replace the multiple screens.

13.4.3 Where the screens work as one system consideration shall be given to the physical positioning, alignment and spacing of the screens. The organization of data and controls between screens should be designed to ensure that no set of data or control which any of the systems users may need to use to carry out a single short-term task is spread over two or more screens. Where the screens are used by a single user, the monitors shall be positioned relative to the user such that parallel effects parallax do not occur.

13.4.4 Consideration shall be given to the design of the dialogue by which the user accesses information on different physical screens or logical display areas. For example, selection of an object or data on one screen should be clearly reflected on all screens in which the selected object or data is represented. Where it is possible for data on different screens or display areas to show different values for the same data item, (for example where the user edits data on one screen), the status of the data on the different screens needs to be clearly represented.

13.4.5 The design of multi-screen systems shall ensure that the relationships between the various screens and between the screens and the equipments or objects they represent are clear. This can be achieved through the appearance and physical location of screens and the dynamic behaviour of items represented on the screens. Where appropriate, and particularly where the type of data or display on a screen can vary, each screen or logical area should be clearly labelled.

13.4.6 In all cases consideration shall be given to increased screen glare and the effect of multiple radiation (EMR) and additional light sources. General requirements for individual displays shall apply to all displays used in a multi-screen system.

13.5 Audio or speech display devices

13.5.1 Consideration shall be given to the use of audio or speech devices to support the transfer of data and the awareness of the user to system condition and states. The use of audio code should be in line with the requirements alarm policy for specific auditory signals. See part **8** (Auditory Information) of this Defence Standard. For more detailed information the reader is directed to audio and speech controls and displays, handbook of Human Factors, Wiley Interscience 1987, by Salvendy G and the Derivation of Human Factors Guidelines for Applications of Speech Controls and Displays in the Military Fast Jet Phd, Cranfield University 19944 by Enterkin P.

13.5.2 Where audio or speech devices are used the design shall allow the user to test the audio facilities so that they can ensure that they are still working. The design of the audio display codes should preclude the user from misinterpretation or confusion with other codes.

13.5.3 Consideration shall be given to the design of the audio or speech device so that the audio signal:

(a) does not startle users;

(b) is easily audible above background and transient noise;

(c) is discernible and distinguishable from other devices in the area of operation. For details see part **8** of this Defence Standard.

Section Five. Quality and Compliance

14 Compliance Criteria and Test Methods

14.1 Compliance with this part of the Standard shall be achieved by demonstration that the documentation described in Section Two has been prepared and maintained in an appropriate format. Compliance with this part shall be achieved separately for each relevant stage in a system procurement.

14.2 Compliance shall not be achieved if either of the following conditions are met:

(a) the HCI Operability Risk Identification has not been carried out, is incomplete or otherwise does not meet the conditions specified in **5.2;**

(b) an HCI Design Rationale document has not been prepared and maintained or does not satisfy the requirements specified in **5.4.**

15 Quality Control and Assurance

The main aspects of quality control, related to the design of the HCI elements of a system are as follows:

(a) Human factors and ergonomics risks and requirements have been identified and have had sufficient impact on the design process.

(b) Appropriate use has been made of user representatives and competent HCI persons throughout the development stage.

(c) The information gleaned from user evaluations and other Human Factors and ergonomics activities have had an appropriate impact on the HCI and system.

Definition of Terms

Alphanumeric Keyboard
A matrix of keys representing the following set of characters:

26 upper case letters of the Latin alphabet (A to Z)
26 lower case letters of the Latin alphabet (a to z)
10 digits (1 to 0). (Alphanumeric numeric layouts have (1) on the upper left position above the alphabet layout and (1) in the lower left position on the numeric keypad.
Non printing graphic space
Punctuation signs and other graphics as required

Chromaticity
A combined terms referring to hue and saturation of a colour.

Chromostereopsis
Stereopsis results from the shorter wavelength light being refracted more than longer wavelength as it passes through the eye and focuses on the retina. This leads to a perceived difference in distance of different coloured objects from the eye (also known as Depth Effect).

Colour Rendering
The term applied to a light source to describe how it effects the appearance of the coloured surfaces it illuminates.

Context-Sensitive Help
Help in which the help text or range of help users is derived from the contextual information associated with the user's last input, selected object, or the current location within the system or application.

Convergence
The exact alignment (intersection) of electron beams of a colour CRT at a specific point on the plane of its phosphor screen.

Cursor Key
Keys which control the movement of the cursor about the display.

Depth Effect
See chromostereopsis.

Dialogue
An interaction between a user and a system to achieve a particular goal.

Discrimination
The detection of difference between stimuli (eg for colour - detection of chromatic difference between visual stimuli.

Display Screen
The display screen is the physical screen (ie glass) of the terminal.

Display Resolution
The number of separately addressable pixels on a display screen.

Effectiveness
The accuracy and completeness with which users achieve specified goals.

Error
A mismatch between the user's goal and the response of the system. Errors can include navigation errors, syntax errors, conceptual errors, etc.

Field
An area on a display in which data is entered or presented.

Flicker
Perception of a quickly recurring variation of luminance or colour valence without the single phases being clearly distinguishable from each other.

Feedback
Output presented by the system in reaction to the user's input.

Help Facilities
Browsable Help
Help in which access to help is independent of the current task context. Help topics may be addressed in a variety of sequences, and users can navigate between topics.

Browsable help differs from an on-line users guide in that the information within a broad topic area is not restricted to serial access.

On-line Help
Additional user guidance information beyond prompting, feedback, status and error messages that can be obtained at the user's initiative or at the initiative of the system. Help typically includes information about features of the system and dialogue and how they can be used to aid the user in completion of his/her tasks.

Hierarchical Menus
Series of menus which are structured in a hierarchical or "tree-like" manner, where the selection of an initial option leads to another menu containing additional options, which may lead to another menu, etc, until the desired results are obtained.

Icon
AN icon is a pictorial representation of an object consisting of an image, image background, with or without a label, may also be a graphical symbol presented on a display screen that provides a visual reminder of the name, structure, appearance or purpose of the entity that it represents.

Keyboard
An arrangement of typing and function keys laid out in a specified manner.

Luminance
The amount of light per unit area leaving a surface (candelas per square metre).

Luminance Contrast (Contrast Ratio)
The difference in luminance of the features of the object being reviewed, in particular of the feature to be discriminated by contrast with its background.

Menu
A set of selectable options.

NOTE: Menu options may be presented to the user by means of visual display devices, or auditory. A menu may contain multiple option groups, but unless only one choice is allowed across groups, each group would be considered a menu.

Misconvergence
The mis-alignment of red (R), green (G) and blue (B) electron beams.

Monochrome Display
A display rendering images in one hue.

Navigation (Menu)
Orientation within a menu structure, movement from option to option within a menu panel and movement from menu panel to menu panel within a menu structure.

Navigation (Form Filling)
Navigation for form filling dialogues refers to the user's ability to proceed forward and backward through a form and move from form to form.

Numeric Keyboard
An array of three rows of three keys (for the numerals 1-9), a zero/decimal area and any additional optional keys. (NB The telephone layout has (1) in the upper left position in the first row.)

Overlapping Window
In an overlapping format, the set of windows visible on the screen is like a collection of pages on a desktop. Just as pages may be arranged so that a page partially or fully overlaps the pages behind it, so windows may be arranged so that a single window partially or fully overlaps the windows behind it.

Stoke Width
The width of a single line drawn on the display. Since the luminance distribution of the edge will be a blur, and not a sharp edge, the edge is defined as the 50% luminance point of the blur.

Tiled Window
In a tiled format, the set of windows visible on the screen is like a collection of tiles arranged to form a solid surface. As with tiles, no part of any window's border or interior overlaps another window's border or interior.

Window
An independently controllable area on the display screen, usually rectangular and usually delimited by a border, used to present objects and/or conduct a dialogue with the user. User's may provide inputs to the system and/or received outputs from a system within a window.

A.2 Index List

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B.1 The documents and publications referred to in this Part of the Standard are as follows:

BR 8710 Design of Combat Management Systems User Guide (CSUG).

BS 5378 Procedure for the Development and Testing of Public Information Symbols.

BS 7179 Ergonomics of Design and Use of Visual Display Terminals (VDTs) in Offices.

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Def Stan 00-35 Environmental Handbook.

Def Stan 00-55 The Procurement of Safety Critical Software in Defence Equipment.

Def Stan 00-56 Hazard Analysis and Safety Classification of the Computer and Programmable Electronic System Elements of Defence Eqpipment.

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ISO 10075 Ergonomics Principle Related to Mental Work Load.

MIL-STD-1472D Human Engineering Criteria for Military Systems, Equipment and Facilities.

MIL-H-46855B Human Engineering Requirements for Military Systems, Equipment and Facilities.

SSCP10 Warship Project Managers Guide for Human Factors Integration Plans.

SSCP1l Human Factors Guide for Management and Design in Royal Naval Combat Systems.

SSCP12 Human Factors Guide for Marine Engineering Systems.

STANAG 3705 Principles of Presentation of Information in Aircrew Stations Standardization Agreement.

STANAG 3994 Application of Human Engineering to Advanced Aircrew Stations.

B.2 The following publications may also be found useful when considering the design of Human Computer Interaction

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Contract Requirements

When Defence Standards are incorporated into contract users are responsible for their correct application and for complying with contract requirements.

Revision of Defence Standard

Defence Standards are revised when necessary by the issue either of amendments or of revised editions. It is important that users of Defence Standards should ascertain that they are in Possession of the latest amendments or editions. Information on all Defence Standards is contained in Def Stan 00-00 (Part 3) Section 4, Index of Standards for Defence Procurement - Index of Defence Standards and Specifications published annually and supplemented periodically by Standards in Defence News. Any person who, when making use of a Defence Standard encounters an inaccuracy or ambiguity is requested to notify the Directorate of Standardization without delay in order that the matter may be investigated and appropriate action taken.