INTERNATIONAL STANDARD

ISO 9241-11

First edition
1998-03-15

Ergonomic requirements for office work with visual display terminals (VDTs) —

Part 11: Guidance on usability

Exigences ergonomiques pour travail de bureau avec terminaux à écrans de visualisation (TEV) —

Partie 11: Lignes directrices relatives à l'utilisabilité

Reference number
ISO 9241-11:1998(E)

Contents

Page

1 Scope **1**

2 Normative reference **1**

3 Definitions **2**

4 Rationale and benefits **2**

5 Specifying and measuring the usability of products **3**

6 Specification and evaluation of usability during design **6**

7 Specifying and measuring a work system in use **7**

Annex A: Example of how to specify the context of use **8**

Annex B: Examples of usability measures **10**

Annex C: Example of a usability requirements specification **14**

Annex D: Relationship to other International Standards **19**

Annex E: Bibliography **21**

International Organization for Standardization
Case postale 56 • CH-1211 Genève 20 • Switzerland
Internet central@iso.ch
X.400 c=ch; a=400net; p=iso; o=isocs; s=central

Printed in Switzerland

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 9241-11 was prepared by Technical Committee ISO/TC 159, *Ergonomics*, Subcommittee SC 4, *Ergonomics of human-system interaction.*

ISO 9241 consists of the following parts, under the general title *Ergonomic requirements for office work with visual display terminals (VDTs):*

— *Part 1: General Introduction*
— *Part 2: Guidance on task requirements*
— *Part 3: Visual display requirements*
— *Part 4: Keyboard requirements*
— *Part 5: Workstation layout and postural requirements*
— *Part 6: Environmental requirements*
— *Part 7: Requirements for display with reflections*
— *Part 8: Requirements for displayed colours*
— *Part 9: Requirements for non-keyboard input devices*
— *Part 10: Dialogue principles*
— *Part 11: Guidance on usability*
— *Part 12: Presentation of information*
— *Part 13: User guidance*
— *Part 14: Menu dialogues*
— *Part 15: Command dialogues*
— *Part 16: Direct manipulation dialogues*
— *Part 17: Form-filling dialogues*

Annexes A to E of this part of ISO 9241 are for information only.

Introduction

The objective of designing and evaluating visual display terminals for usability is to enable users to achieve goals and meet needs in a particular context of use. ISO 9241-11 explains the benefits of measuring usability in terms of user performance and satisfaction. These are measured by the extent to which the intended goals of use are achieved, the resources that have to be expended to achieve the intended goals, and the extent to which the user finds the use of the product acceptable.

ISO 9241-11 emphasizes that visual display terminal usability is dependent on the context of use and that the level of usability achieved will depend on the specific circumstances in which a product is used. The context of use consists of the users, tasks, equipment (hardware, software and materials), and the physical and social environments which may all influence the usability of a product in a work system. Measures of user performance and satisfaction assess the overall work system, and, when a product is the focus of concern, these measures provide information about the usability of that product in the particular context of use provided by the rest of the work system. The effects of changes in other components of the work system, such as the amount of user training, or the improvement of the lighting, can also be measured by user performance and satisfaction.

The term usability is sometimes used to refer more narrowly to the attributes of a product which make it easier to use (see Annex D). Requirements and recommendations relating to the attributes of the hardware, software and environment which contribute to visual display terminal usability, and the ergonomic principles underlying them, are provided in other parts of ISO 9241.

Ergonomic requirements for office work with visual display terminals (VDTs) —

Part 11:
Guidance on usability

1 Scope

ISO 9241-11 defines usability and explains how to identify the information which is necessary to take into account when specifying or evaluating usability of a visual display terminal in terms of measures of user performance and satisfaction. Guidance is given on how to describe the context of use of the product (hardware, software or service) and the relevant measures of usability in an explicit way. The guidance is given in the form of general principles and techniques, rather than in the form of requirements to use specific methods.

The guidance in ISO 9241-11 can be used in procurement, design, development, evaluation, and communication of information about usability. ISO 9241-11 includes guidance on how the usability of a product can be specified and evaluated. It applies both to products intended for general application and products being acquired for or being developed within a specific organization.

ISO 9241-11 also explains how measures of user performance and satisfaction can be used to measure how any component of a work system affects the whole work system in use.

The guidance includes procedures for measuring usability but does not detail all the activities to be undertaken. Specification of detailed user-based methods of measurement is beyond the scope of ISO 9241-11, but further information can be found in Annex B and the bibliography in Annex E.

ISO 9241-11 applies to office work with visual display terminals. It can also apply in other situations where a user is interacting with a product to achieve goals. ISO 9241 parts 12 to 17 provide conditional recommendations which are applicable in specific contexts of use. he guidance in this Part of ISO 9241 can be used in conjunction with ISO 9241 Parts 12 to 17 in order to help identify the applicability of individual recommendations.

ISO 9241-11 focuses on usability and does not provide comprehensive coverage of all objectives of ergonomic design referred to in ISO 6385. However, design for usability will contribute positively to ergonomic objectives, such as the reduction of possible adverse effects of use on human health, safety and performance.

ISO 9241-11 does not cover the processes of system development. Human-centred design processes for interactive systems are described in ISO 13407.

2 Normative reference

The following standard contains provisions which, through reference in this text, constitute provisions of this part of ISO 9241. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this part of ISO 9241 are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 6385:1981, *Ergonomic requirements in the design of work systems.*

3 Definitions

For the purposes of this part of ISO 9241, the following definitions apply:

3.1 usability: Extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use.

NOTE — See Annex D for other approaches to usability.

3.2 effectiveness: Accuracy and completeness with which users achieve specified goals.

3.3 efficiency: Resources expended in relation to the accuracy and completeness with which users achieve goals.

3.4 satisfaction: Freedom from discomfort, and positive attitudes towards the use of the product.

3.5 context of use: Users, tasks, equipment (hardware, software and materials), and the physical and social environments in which a product is used.

3.6 work system: System, consisting of users, equipment, tasks and a physical and social environment, for the purpose of achieving particular goals.

NOTE — The context of use consists of those components of the work system which are treated as given when specifying or measuring usability.

3.7 user: Person who interacts with the product.

3.8 goal: Intended outcome.

3.9 task: Activities required to achieve a goal.

NOTE 1 These activities can be physical or cognitive.
NOTE 2 Job responsibilities can determine goals and tasks.

3.10 product: Part of the equipment (hardware, software and materials) for which usability is to be specified or evaluated.

3.11 measure (noun) : Value resulting from measurement and the process used to obtain that value.

4 Rationale and benefits

Usability is an important consideration in the design of products because it is concerned with the extent to which the users of products are able to work effectively, efficiently and with satisfaction.

The usability of products can be improved by incorporating features and attributes known to benefit the users in a particular context of use. In order to determine the level of usability achieved, it is necessary to measure the performance and satisfaction of users working with a product. Measurement of usability is particularly important in view of the complexity of the interactions between the user, the goals, the task characteristics and the other elements of the context of use. A product can have significantly different levels of usability when used in different contexts.

Planning for usability as part of the design and development of products involves the systematic identification of requirements for usability, including usability measures and verifiable descriptions of the context of use. These provide design targets which can be the basis for verification of the resulting design.

The approach adopted in ISO 9241-11 has benefits which include:

— The framework can be used to identify the aspects of usability and the components of the context of use to be taken into account when specifying, designing or evaluating the usability of a product.

— The performance (effectiveness and efficiency) and satisfaction of the users can be used to measure the extent to which a product is usable in a particular context.

— Measures of the performance and satisfaction of the users can provide a basis for the comparison of the relative usability of products with different technical characteristics which are used in the same context

— The usability planned for a product can be defined, documented and verified (e.g. as part of a quality plan).

5 Specifying and measuring the usability of products

5.1 Framework for specifying usability

5.1.1 Purpose

The framework describes the components of usability and the relationship between them.

5.1.2 Components of usability

In order to specify or measure usability it is necessary to identify the goals and to decompose effectiveness, efficiency and satisfaction and the components of the context of use into sub-components with measurable and verifiable attributes. The components and the relationships between them are illustrated in figure 1.

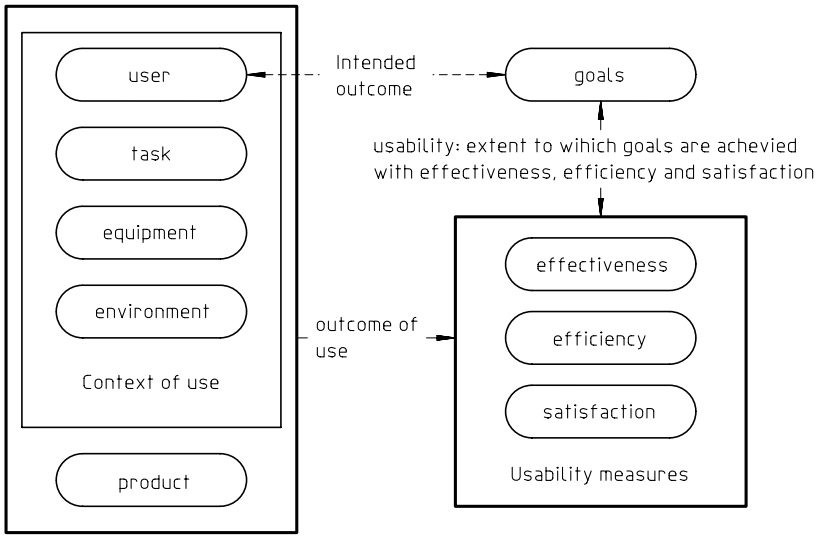

Figure 1 — Usability framework

5.1.3 Information needed

When specifying or measuring usability, the following information is needed:

— a description of the intended goals;

— a description of the components of the context of use including users, tasks, equipment, and environments. This may be a description of an existing context, or a specification of intended contexts. The relevant aspects of the context and the level of detail required will depend on the scope of the issues being addressed. The description of the context needs to be sufficiently detailed so that those aspects of the context which may have a significant influence on usability could be reproduced;

— target or actual values of effectiveness, efficiency, and satisfaction for the intended contexts.

5.2 Description of goals

The goals of use of a product should be described. Goals may be decomposed into subgoals which specify components of an overall goal and the criteria which would satisfy that goal. For example, a telephone sales clerk might have the goal to "Maintain customer orders". This overall goal might then be decomposed into subgoals such as:

— "Make accurate record of all orders placed by customers";

— "Provide information rapidly in response to customer inquiries about orders placed".

The level at which the overall goal is set is a function of the boundary of the work system which is under consideration and which provides the context of use. In the example above, the work system under consideration consists of clerks taking telephone orders.

5.3 Context of use

5.3.1 Description of users

Relevant characteristics of the users need to be described. These can include knowledge, skill, experience, education, training, physical attributes, and motor and sensory capabilities. It may be necessary to define the characteristics of different types of user, for example users having different levels of experience or performing different roles.

5.3.2 Description of tasks

Tasks are the activities undertaken to achieve a goal. Characteristics of tasks which may influence usability should be described, e.g. the frequency and the duration of the task.

Detailed descriptions of the activities and processes may be required if the description of the context is to be used as a basis for the design or evaluation of details of interaction with the product. This may include description of the allocation of activities and steps between the human and technological resources. Tasks should not be described solely in terms of the functions or features provided by a product or system. Any description of the activities and steps involved in performing the task should be related to the goals which are to be achieved.

For the purposes of evaluating usability, a set of key tasks will typically be selected to represent the significant aspects of the overall task.

NOTE — User tasks and subtasks can be identified by task analysis (for more information see the bibliography in Annex E).

5.3.3 Description of equipment

Relevant characteristics of the equipment need to be described. The description of the hardware, software and materials associated with a visual display terminal may be in terms of a set of products (or system components), one or more of which may be the focus of usability specification or evaluation, or it may be in terms of a set of attributes or performance characteristics of the hardware, software and other materials.

5.3.4 Description of environments

Relevant characteristics of the physical and social environment need to be described. Aspects which may need to be described include attributes of the wider technical environment (e.g. the local area network), the physical environment (e.g. workplace, furniture), the ambient environment (e.g. temperature, humidity) and the social and cultural environment (e.g. work practices, organisational structure and attitudes).

5.3.5 Examples

Annex A gives examples of how the components of the context of use can be described in terms of characteristics which may be relevant to usability.

5.4 Usability measures

5.4.1 Choice of measures

It is normally necessary to provide at least one measure for each of effectiveness, efficiency and satisfaction. Because the relative importance of components of usability depends on the context of use and the purposes for which usability is being described, there is no general rule for how measures should be chosen or combined.

The choice of measures and the level of detail of each measure, is dependent on the objectives of the parties involved in the measurement. The relative importance of each measure to the goals should be considered. For example where usage is infrequent, high importance may be given to measures of learning and re-learning.

If it is not possible to obtain objective measures of effectiveness and efficiency, subjective measures based on the user's perception can provide an indication of effectiveness and efficiency.

5.4.2 Effectiveness

Measures of effectiveness relate the goals or subgoals of the user to the accuracy and completeness with which these goals can be achieved.

For example if the desired goal is to accurately reproduce a two-page document in a specified format, then accuracy could be specified or measured by the number of spelling mistakes and the number of deviations from the specified format, and completeness by the number of words of the document transcribed divided by the number of words in the source document.

5.4.3 Efficiency

Measures of efficiency relate the level of effectiveness achieved to the expenditure of resources. Relevant resources can include mental or physical effort, time, materials or financial cost. For example, human efficiency could be measured as effectiveness divided by human effort, temporal efficiency as effectiveness divided by time, or economic efficiency as effectiveness divided by cost.

If the desired goal is to print copies of a report, then efficiency could be specified or measured by the number of usable copies of the report printed, divided by the resources spent on the task such as labour hours, process expense and materials consumed.

5.4.4 Satisfaction

Satisfaction measures the extent to which users are free from discomfort, and their attitudes towards the use of the product.

Satisfaction can be specified and measured by subjective rating on scales such as discomfort experienced, liking for the product, satisfaction with product use, or acceptability of the workload when carrying out different tasks, or the extent to which particular usability objectives (such as efficiency or learnability) have been met. Other measures of satisfaction might include the number of positive and negative comments recorded during use. Additional information can be obtained from longer-term measures such as rate of absenteeism, observation of overloading or underloading of the user’s cognitive or physical workload, or from health problem reports, or the frequency with which users request transfer to another job.

5.4.5 Further examples

Further examples of measures that can be used for assessing usability are included in Annexes B and C.

5.5 Interpretation of measures

Care should be taken in generalizing the results of any measurement of usability to another context which may have significantly different types of users, tasks or environments. If measures of usability are obtained over short periods of time, the values may not take account of infrequent events which could have a significant impact on usability, for example intermittent system errors.

For a general-purpose product, it will generally be necessary to specify or measure usability in several different representative contexts, which will be a subset of the possible contexts and of the tasks which can be performed. There may be differences between usability in these contexts.

6 Specification and evaluation of usability during design

6.1 Specification of the intended context of use for a product

Information about the characteristics of users, their goals and tasks and the environments in which the tasks are carried out provides important information for use in the specification of overall product requirements, prior to development of specific usability requirements.

6.2 Specification of usability requirements for a product

Prior to development, an organisation seeking to acquire a product specifically adapted to its needs can use the information in ISO 9241-11 as a framework for specifying the usability requirements which the product should meet and against which acceptance testing may be carried out. Specific contexts in which usability is to be measured should be identified, measures of effectiveness, efficiency and satisfaction selected, and acceptance criteria based on these measures established (an example is given in Annex C).

6.3 Product development

The definition and framework for usability can be used by product development teams to establish a common understanding of the concept of usability, and can help product development teams address the breadth of issues associated with product usability.

A developer can use the guidance in ISO 9241-11 to help specify usability targets for the product (see Annex C). At various stages during the development process the developer can measure the usability achieved against these targets. This information enables objective decisions to be taken about the need for design changes to enhance usability, and about trade-offs which may be appropriate between usability and other requirements.

6.4 Specification or evaluation of product attributes

The guidance on context of use can be used to identify the users, tasks and environments so that more accurate judgements can be made about the needs for particular product attributes.

6.5 Usability measurement

ISO 9241-11 provides information to support measurement of usability. For example, description of the characteristics of users can assist with the selection of users to participate in evaluation. Identification of user's goals can assist with the selection of appropriate tasks for usability testing or reviews. The characteristics of the environment in which a product is likely to be used need to be described if that environment has to be simulated to ensure the validity of test results.

ISO 9241-11 also provides a basis from which measures of usability can be generated. Product developers can develop appropriate measures of efficiency, effectiveness, and/or satisfaction (see Annex B).

6.6 Usability input to a quality plan

The activities listed in 6.1 to 6.5 can provide a basis for defining, documenting and verifying usability as a part of a quality plan. Figure 2 outlines the relationship between these activities and the resulting documents and other forms of output. These could be included in a quality plan (e.g. as described in ISO 9000-3).

6.7 Comparative evaluation of products

The guidance in ISO 9241-11 can be used to assist in making a choice between products already available. Having specified the usability requirements in terms of the intended goals, context of use and which measures of effectiveness, efficiency and satisfaction are to be used, the guidance can then be used to specify test conditions and evaluation criteria. The test conditions should be representative of important aspects of the overall context of use.

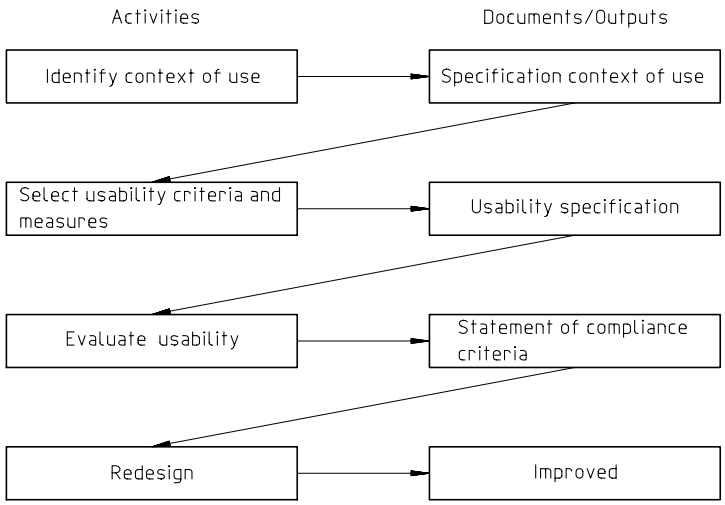

Figure 2 — Usability activities and associated documents

6.8 Use with other International Standards

Other parts of ISO 9241, such as ISO 9241-14, contain recommendations which are applicable in particular contexts of use. The guidance in ISO 9241-11 can be used to provide a framework for identifying the goals and context of use which is relevant to the design decision to be made. Annex D contains more information on the relationship with other parts of ISO 9241 and other International Standards.

7 Specifying and measuring a work system in use

7.1 Relationship to usability

If the aim is to improve the overall work system, any part of the work system can be the subject of design or evaluation. Measures of effectiveness, efficiency and satisfaction can be used to evaluate any component of the work system. For example, it may be appropriate to consider the amount of user training to be provided, changes in lighting, or re-organisation of the task. In each case the element which is the object of design or evaluation is considered to be subject to potential variation, while the other elements of the work system are treated as fixed. When a product is the focus of concern, these measures provide information about the usability of that product in the particular context of use provided by the rest of the work system.

7.2 Examples of application

7.2.1 Design of a complete work system

When designing a complete work system usability can be optimised by changing components of the context of use of a product, such as the version of the operating system, lighting or amount of user training. In this case measures of effectiveness, efficiency and satisfaction can be used to specify or evaluate the effect of a new version of the operating system, different types of lighting, or different amounts of user training respectively.

7.2.2 Diagnostic evaluation

If a work system is judged to be unsatisfactory, systematic analyses of the contribution of different components of the context of use should be conducted. Both direct contributions and the interactions between the components of the context of use should be considered in order to determine the principal causes of the problems. This process may also be used to identify which components are amenable to change, in order to bring about improvements in the overall work system. Diagnostic activity relating to the context of use is often necessary to determine whether problems are due to the product or other components of the work system.

Annex A
(informative)

Example of how to specify the context of use

Table A.1 (based on E.2.2 and E.2.18) gives an example of how the context of use can be specified in terms of attributes which may be relevant to the usability. A product to be used in a particular context can be specified under these headings. Specifications may be either in terms of relevant characteristics, or the identification of a specific instance. When specifying a particular instance of a product which can be customised, adaptations which have been made to the default characteristics of the product should be specified.

Verifiable and repeatable descriptions of usability require measures of usability which can be repeated in a specified context. Unless evaluation of usability can take place in conditions of actual use, it will be necessary to decide which attributes of the actual or intended context of use are to be represented in the context which is specified for evaluation. When specifying or evaluating usability it is therefore important that the context selected is representative of the important aspects of the actual or intended context of use. Particular attention should be given to those attributes which are judged to have a significant impact on the usability of the product.

Not all the attributes in the example in table A.1 will be relevant in any particular case, and additional attributes may need to be used.

Table A.1 — Example of attributes of the context of use

Users	Tasks	Equipment
User types Primary Secondary and indirect users **Skills and knowledge** Product skill/knowledge System skill/knowledge Task experience Organizational experience Level of training Input device skills Qualifications Language skills General knowledge **Personal attributes** Age Gender Physical capabilities Physical limitations and disabilities Intellectual ability Attitude Motivation	Task breakdown Task name Task frequency of use Task duration Frequency of events Task flexibility Physical and mental demands Task dependencies Task output Risk resulting from error Safety critical demands	**Basic description** Product identification Product description Main application areas Major functions **Specification** Hardware Software Materials Services Other Items

	Environment	
Organizational environment **Structure** Hours of work Group working Job function Work practices Assistance Interruptions Management structure Communications structure **Attitudes and culture** Policy on use of computers Organizational aims Industrial relations **Job design** Job flexibility Performance monitoring Performance feedback Pacing Autonomy Discretion	**Technical environment** **Configuration** Hardware Software Reference materials	**Physical environment** **Workplace conditions** Atmospheric conditions Auditory environment Thermal environment Visual environment Environmental instability **Workplace design** Space and furniture User posture Location **Workplace safety** Health hazards Protective clothing and equipment

Annex B
(informative)

Examples of usability measures

B.1 Overall usability

Usability measures of effectiveness, efficiency and satisfaction can be specified for overall goals (e.g. produce a letter) or for narrower goals (e.g. perform search and replace). Selecting usability measures for the most important user goals may mean ignoring many functions, but is likely to be the most practical approach. Examples of appropriate measures are given in table B.1.

Table B.1 — Examples of measures of usability

Usability objective	Effectiveness measures	Efficiency measures	Satisfaction measures
Overall usability	Percentage of goals achieved; Percentage of users successfully completing task; Average accuracy of completed tasks	Time to complete a task; Tasks completed per unit time; Monetary cost of performing the task	Rating scale for satisfaction; Frequency of discretionary use; Frequency of complaints

B.2 Measures for desired properties of the product

Additional measures may be required for particular desired properties of the product which contribute to usability. Examples of some of these properties and additional specialised measures are given in table B.2. In addition, where appropriate the measures given in table B.1 can also be used for the usability objectives given in table B.2.

Table B.2 — Examples of measures for desired properties of the product

Usability objective	Effectiveness measures	Efficiency measures	Satisfaction measures
Meets needs of trained users	Number of power tasks performed; Percentage of relevant functions used	Relative efficiency compared with an expert user	Rating scale for satisfaction with power features
Meets needs to walk up and use	Percentage of tasks completed successfully on first attempt	Time taken on first attempt[1)]; Relative efficiency on first attempt	Rate of voluntary use
Meets needs for infrequent or intermittent use	Percentage of tasks completed successfully after a specified period of non-use	Time spent re-learning functions[1)]; Number of persistent errors	Frequency of reuse
Minimization of support requirements	Number of references to documentation; Number of calls to support; Number of accesses to help	Productive time[1)]; Time to learn to criterion[1)]	Rating scale for satisfaction with support facilities
Learnability	Number of functions learned; Percentage of users who manage to learn to criterion	Time to learn to criterion[1)]; Time to re-learn to criterion[1)]; Relative efficiency while learning	Rating scale for ease of learning
Error tolerance	Percentage of errors corrected or reported by the system; Number of user errors tolerated	Time spent on correcting errors	Rating scale for error handling
Legibility	Percentage of words read correctly at normal viewing distance	Time to correctly read a specified number of characters	Rating scale for visual discomfort

1) In these examples the resources should be measured in relation to a specified level of effectiveness.

B.3 Choosing usability criteria

The choice of criterion values of measures of usability depends on the requirements for the product and the needs of the organisation setting the criteria. Usability objectives may relate to a primary goal (e.g. produce a letter) or a subgoal (e.g. search and replace) or secondary goals (e.g. learnability or adaptability). Focusing usability objectives on the most important user goals may mean ignoring many functions, but is likely to be the most practical approach. Setting usability objectives for specific subgoals may permit evaluation earlier in the development process.

It may be necessary to specify criteria both for the minimum acceptable level of usability and for the target level of usability.

When setting criterion values for a group of users, the criteria may be set as an average (e.g. average time for completion of a task to be no more than 10 min), for individuals (e.g. all users can complete the task within 10 minutes), or for a percentage of users (e.g. 90% of users are able to complete the task in 10 min).

When setting criteria, care should be taken that appropriate weight is given to each measurement item. For example, to set criteria based on errors, it may be necessary to assign weightings to reflect the relative importance of different types of error.

B.4 Types of measure

Measures of usability should be based on data which reflect the results of users interacting with the product or work system. It is possible to gather data by objective means, such as the measurement of output, of speed of working or of the occurrence of particular events. Alternatively, data may be gathered from the subjective responses of the users expressing feelings, beliefs, attitudes or preferences. Objective measures provide direct indications of effectiveness and efficiency while subjective measures can be linked directly with satisfaction.

It should be noted that it is possible to obtain data relating to each component of usability from objective or from subjective measures. For example, satisfaction can also be inferred from objective measures of the behaviour of the users, and estimates of effectiveness and efficiency can also be derived from subjective opinions which the users express about their work and its outputs.

The validity of the data gathered to predict the level of usability achieved when a product is actually used will depend upon the extent to which the users, tasks and context of use are representative of the real situation and the nature of the measures chosen. At one extreme one may make measurements in the "field" using a real work situation as the basis for the evaluation of the usability of a product. At the other end of the continuum one may evaluate a particular aspect of the product in a "laboratory" setting in which those aspects of the context of use which are relevant are re-created in a representative and controlled way. The advantage of using the laboratory based approach is that it offers the opportunity to exercise greater control over the variables which are expected to have critical effects on the level of usability achieved, and more precise measurements can be made. The disadvantage is that the artificial nature of a laboratory environment can produce unrealistic results.

Evaluations can be conducted at different points along the continuum between the field and laboratory settings depending upon the issues which need to be investigated and the completeness of the product which is available for test. The choice of test environment and measures will depend upon the goals of the measurement activity and their relationship with the design cycle.

B.5 Measures of effectiveness and efficiency

B.5.1 Measuring effectiveness

Effectiveness is defined as the accuracy and completeness with which users achieve specified goals.

To measure accuracy and completeness it is necessary to produce an operational specification of the criteria for successful goal achievement. This can be expressed in terms of the quality and quantity of output, for example, the specification of a required format for output documents together with the number and length of documents to be processed.

Accuracy can be measured by the extent to which the quality of the output corresponds to the specified criteria, and completeness can be measured as the proportion of the target quantity which has been achieved.

If a single measure of effectiveness is required, it is possible to combine measures of accuracy and completeness. For example, completeness and accuracy can be calculated as percentages and multiplied together to give a percentage value for effectiveness [E.2.2, E.2.19]. In cases where it is not appropriate to trade accuracy off against completeness, the two measures should be considered independently.

B.5.2 Measuring efficiency

Efficiency is measured by relating the level of effectiveness achieved to the resources used. For example temporal efficiency can be defined as the ratio between the measure of effectiveness in achieving a specified goal, and the time it takes to achieve that goal. Similar calculations can be made with respect to efficiency in the use of mental or physical energy, materials or financial cost.

B.5.2.1 Workload

Workload includes both physical and mental aspects of tasks. Measures of efficiency should take into account physical demands caused by high rates of input and sustained periods of activity.

The cognitive resources expended in the conduct of tasks can also be measured. The effects of cognitive workload have certain special characteristics in that both under- and over-loading can result in lowered efficiency and health and safety problems. A task demanding too little mental effort may result in a lowered efficiency because it leads to boredom and lack of vigilance, which directly lowers effectiveness. In such a case both effectiveness and efficiency would be enhanced by increasing demand. Excessive cognitive workload may also result in lowered effectiveness, if it causes information to be missed and results in errors. This is a particularly important issue in situations where safety is critical, e.g. air traffic control and process control. Measures of cognitive workload can be used to predict these types of problems.

See E.2.7, E.2.14 and E.2.21 for examples of questionnaires which measure cognitive workload so that its impact on efficiency can be assessed.

B.6 Measures of satisfaction

Satisfaction (defined as freedom from discomfort and positive attitudes to the use of the product) is a response of users to interaction with the product. Satisfaction can be assessed by subjective or objective measures. Objective measures can be based on observation of the behaviour of the user (e.g. body posture, body movement, frequency of absences) or can be based on monitoring the physiological responses of the user.

Subjective measures of satisfaction are produced by quantifying the strength of a user's subjectively expressed reactions, attitudes, or opinions. This process of quantification can be done in a number of ways, for example, by asking the user to give a number corresponding to the strength of their feeling at any particular moment, or by asking users to rank products in order of preference, or by using an attitude scale based on a questionnaire.

Attitude scales, when properly developed, have the advantage that they can be quick to use, have known reliabilities, and do not require special skills to apply. Attitude questionnaires which are developed using psychometric techniques will have known and quantifiable estimates of reliability and validity, and can be resistant to factors such as faking, positive or negative response bias, and social desirability. They also enable results to be compared with established norms for responses obtained in the past. See E.2.9, E.2.10 and E.2.12 for examples of questionnaires which measure satisfaction with computer-based systems.

Annex C
(informative)

Example of a usability requirements specification

This example shows how a usability requirements specification might be written to assist a development team to consider usability in a systematic way during the development process. The usability requirements specification defines the intended goals and context of use, and specifies measures and criterion levels for effectiveness, efficiency and satisfaction for the product under development.

The specification is based on the framework provided by ISO 9241-11 for considering the relevant factors. The specification has two main sections which provide the minimal information required about context of use and measures of usability (see 5.1.3). The format of the specification closely follows the structure of 5.2, 5.3 and 5.4 of ISO 9241-11. The format is not critical and can be adapted, as appropriate, provided the relevant information is provided in a sufficiently precise form.

The team involved in producing such a usability requirements specification might typically involve a human factors specialist with experience in usability engineering, and other relevant professionals, for example from marketing, product management and software development. There should also be input from representative end users.

[Comments on the content of the specification are given in italic.]

NAME AND PURPOSE OF THE PRODUCT

[This section identifies the product and describes its overall purpose. The product and its name have been invented for this example.]

This specification defines usability requirements for the Videophone professional viewing terminal (VidiPro).

The purpose of VidiPro is to increase the effectiveness of telecommunication by providing a combination of voice and visual information.

CONTEXT OF USE

This section provides information following the guidance in 5.3 of ISO 9241-11. Aspects of the context of use are described where these are critical for the usability of the product, for example:

Specification of users:

> *It is assumed that users are familiar with the most common features of business telephone systems. Some potential users would therefore have to acquire this knowledge before they could use VidiPro successfully. However, no skills or knowledge are assumed with regard to Videotelephony (system knowledge and task experience), and this is explicitly stated.*

Specification of environments:

> *Access to an ISDN socket and mains power are mentioned because without these VidiPro could not be used at all.*

Specification of equipment:

> *The essential parts of VidiPro are listed. This is important where equipment consists of a number of hardware and/or software components, all of which are necessary.*

Specification of tasks:

> *A product such as VidiPro might be used for many purposes. However, the product is intended to help the user to achieve certain particular goals and these are stated here.*

A number of specific tasks are mentioned where the usability of VidiPro is critical, i.e. installation, call set-up, programming and extended use. At a more detailed level, display legibility is mentioned as this is a condition for usability.

Specification of users

VidiPro is intended for use by any person with the characteristics given in Table C.1.

Table C.1 — User characteristics

Attribute	Requirement
Skills and knowledge	
Product experience	use of business telephone system with "hold", "transfer" and "call diversion" features
System knowledge	none required
Task experience	none required
Organisational experience	none required
Training	none required
Keyboard and input skills	use of telephone keypad
Qualifications	none required
Linguistic ability	minimum reading age = 11 years[1)]
Physical attributes	
Vision	(corrected) normal vision measured using standard test
Hearing	normal hearing measured using standard screening test[2)]
Manual dexterity	one hand with normal dexterity (VidiPro operable with one hand)

1) For reading help and other information on display.
2) Hearing not required for operation of video features.

Specification of environments

The following connections must be available:

— an ISDN telephone socket

— a mains power supply of 230 V ± 10%

In order to meet the usability objectives, VidiPro should be used in an environment which conforms to relevant ergonomics standards, in particular:

— ISO 9241-5, Workstation layout and postural requirements

— ISO 9241-6, Environmental requirements

Specification of equipment

The main hardware components of VidiPro are an ISDN telephone terminal, a multiplexer, a video codec, a CCD camera and a 20 cm colour CRT.

Specification of tasks

The primary intended goal of VidiPro is to enable two users to communicate by voice and to share visual information about objects which are found in an office environment, e.g. sketches, printed text and graphics, maps, photographs and models.

Secondary goals of VidiPro include general audio and video communication in an office environment, i.e. without viewing objects. VidiPro could also be used in other environments (e.g. domestic) to provide enhanced interpersonal communication.

This usability requirements specification applies to the following specific tasks:

— Installation: Make VidiPro operational, i.e. ready to make or receive calls, or to be programmed.

— Video call set-up: Set up a video call to enable visual information to be shared.

— Programming: Change VidiPro default setting or information stored.
Example tasks are to set up call diversion and to enter name and number in the directory.

— Extended use: Communicate by voice and share visual information about objects in an office environment over an extended period.

An additional usability requirement for a desired property of the product is:

— Legibility: Read system messages and instructions displayed on screen.

SPECIFICATION OF MEASURES OF USABILITY FOR PARTICULAR CONTEXTS

[This section specifies the usability goals, targets or objectives for the product by defining both measures and criterion values of the measures for each of the critical tasks listed above. To supplement the general description of the intended context of use, additional information is provided about the specific context of use for each task. At least one measure and criterion value is provided for effectiveness, efficiency and satisfaction following the guidance given in 5.4 of ISO 9241-11.

The particular measures chosen and the criterion levels specified will depend on the priorities set by the development team taking the needs and requirements of potential customers into account. In this example the criterion for the efficiency of installation has been specified as completion of the installation task within 10 min. (ISO 9241-11 does not and cannot provide guidance with respect to particular criterion levels.)

By producing a specification which follows the guidance of ISO 9241-11, it is made clear to all parties concerned in what way and under what conditions the product will be usable, and how to check whether this level of usability has been achieved during the evaluation of the product.]

Installation

Task:

Make VidiPro operational, i.e. ready to make or receive calls, or to be programmed.

Specific context:

Start with VidiPro in original packaging. No additional support or tools are provided. Users are completing the procedure for the first time.

Effectiveness:

Accuracy: All components are correctly connected to each other.

Completeness: VidiPro is connected to a mains power supply and an ISDN line.

Efficiency:

Installation to be completed by the user within 10 minutes.

Satisfaction:

Less than 10% of users report dissatisfaction with installation procedures.

Video call set-up (initial use)

Task:

Set up a video call to enable visual information to be shared.

Specific context:

Standard on-line and off-line user guidance are available. Users are completing the procedure for the first time.

Effectiveness:

Accuracy and completeness: Called party can see object (e.g. A4 document) within field of view of camera.

Efficiency:

Video call set-up to be completed within 2 min.

Satisfaction:

Less than 10% of users report dissatisfaction with video call set-up procedures.

Programming (initial use)

Task:

Change VidiPro default setting or information stored:

1) set up call diversion

2) enter name and number in the directory

Specific context:

Standard on-line and off-line user guidance are available.

Users may be completing the procedure for the first time.

Effectiveness:

Accuracy: No errors in information entered.

Completeness: No omissions in information to be entered or deleted.

Efficiency:

Call diversion to be programmed within 2 minutes.

New name and number to be entered into directory within 3 minutes.

Satisfaction:

Less than 10% of users report dissatisfaction with programming procedures.

Extended use

Task:

Communicate by voice and share visual information about objects in an office environment over an extended period.

Specific context:

Users have used VidiPro to share visual information at least 60 times over a period of at least one month.

Effectiveness:

Accuracy: Less than 2% of all calls placed result in connection to wrong numbers.

Completeness: At least 95% of intended calls are completed successfully.

Efficiency:

Average video call set up time to be no more than 30 s.

Satisfaction:

At least 90% of users prefer VidiPro to alternative equipment, e.g. telephone plus fax machine.

Legibility

Task:

Read system messages and instructions displayed on screen.

Specific context:

Range of illumination levels from 50 lx to 5000 lux.

Effectiveness:

Accuracy: At least 98% of words used in system messages and instructions can be read correctly at normal viewing distance.

Annex D
(informative)

Relationship to other International Standards

D.1 Definition of usability in ISO/IEC 9126

The term usability is often used to refer to the capability of a product to be used easily. This corresponds with the definition of usability as a software quality in ISO/IEC 9126:

"a set of attributes of software which bear on the effort needed for use and on the individual assessment of such use by a stated or implied set of users".

However the attributes which a product requires for usability depend on the nature of the user, task and environment. A product has no intrinsic usability, only a capability to be used in a particular context. Usability cannot be assessed by studying a product in isolation.

Therefore, there are three potential ways in which the usability of a product could be measured:

1) By analysis of the features of the product, required for a particular context of use.

Usability could be measured by assessing the product features required for usability in a particular context. Appropriate features are specified in other parts of ISO 9241. However ISO 9241 only gives partial guidance. Of the many potential design solutions compatible with ISO 9241, some will be more usable than others.

2) By analysis of the process of interaction.

Usability could be measured by modelling the interaction between a user carrying out a task with a product. However, current analytic approaches do not give very precise estimates of usability. As the interaction is a dynamic process in the human brain, it cannot be studied directly.

3) By analysing the effectiveness and efficiency which results from use of the product in a particular context and measuring the satisfaction of the users of the product. These are direct measures of the components of usability. If a product is more usable in a particular context, usability measures will be better.

It should be noted that usability as defined in ISO 9241-11 also depends on software qualities which are distinct from usability as defined in ISO/IEC 9126, such as functionality, reliability and computer efficiency. These software qualities all contribute to quality of the work system in use.

Usability defined in terms of the quality of a work system in use necessarily depends on all factors which can influence the use of a product in the real world, including organisational factors such as working practices and the location or appearance of a product, and individual differences between users including those due to cultural factors and preferences. This broad approach has the advantage that it concentrates on the real purpose of design of a product - that it meets the needs of real users carrying out real tasks in a real technical, physical and organizational environment. This is consistent with the objectives of ISO 9241 as described in ISO 9241-1.

D.2 Use in conjunction with other parts of ISO 9241

D.2.1 Relationship of context of use to usability

Any component of the context of use (user, equipment, task or environment) may be manipulated in order to change the usability of a product. The user interface may be improved by conforming to good dialogue design practices (e.g. ISO 9241 Parts 10 and 12 to 17). In addition the fit between the user and the rest of the context of use may be improved through means such as selection and training. The task may be designed appropriately (e.g. ISO 9241-2).

Aspects of the working environment such as lighting, noise, workstation design might be improved (e.g. ISO 9241 Parts 3 to 9). However, when evaluating the usability of a product, the focus is on optimising the product for a given context.

A software designer needs to identify the anticipated users, tasks and environments, using ISO 9241-11, before designing appropriate usability attributes into the software following the guidance and requirements of ISO 9241 Parts 10 and 12 to 17. However, this alone will not guarantee that a product reaches a required level of usability, as ISO 9241 does not provide an exhaustive specification of how to apply the general principles that make a product usable.

D.2.2 Use in conjunction with ISO 9241-10

The way in which each dialogue principle in ISO 9241-10 should be applied to the design or evaluation of a product will depend on the context of use. It is necessary to identify the relevant characteristics of the intended users, tasks and environments before applying the dialogue principles for design or evaluation. Although all aspects of the context of use should be considered for every dialogue principle, "suitability for the task" deals with design issues which are closely associated with the task characteristics. When applying this principle particular consideration should be given to those tasks which particular types of user may need to perform to meet the goals of the user organisation. "Suitability for learning", "suitability for individualisation", and "conformity with user expectations" deal with design issues which are closely associated with the user characteristics. When applying these principles particular consideration should be given to the needs of different types of intended users when performing intended tasks in particular situations.

The dialogue principle "suitability for learning" refers to the attributes of a product which facilitate learning. Actual learnability in a specific context can be measured by comparing the usability of a product for one user over time, or comparing the usability of a product for an experienced and inexperienced user.

The dialogue principle "suitability for individualisation" refers to attributes of the product which facilitate adaptation to the user's needs for a given task. Actual flexibility of use by different users for different tasks can be assessed by measuring the usability in a number of different contexts.

The dialogue principles are stated in terms of characteristics of software. Some of the principles are related to usability objectives which are desired properties of the product, e.g. achievement of goals, error tolerance and learnability (see Annex B).

Annex E
(informative)

Bibliography

E.1 ISO Standards

NOTE: Other parts of ISO 9241 are listed in the Foreword.

E.1.1 ISO 9000-3, *Quality management and quality assurance standards — Part 3: Guidelines for the application of ISO 9001:1994 to the design, development, supply, installation and maintenance of software.*

E.1.2 ISO/IEC 9126, *Information technology — Software product evaluation — Quality characteristics and guidelines for their use.*

E.1.3 ISO 13407, *Human-centred design process for interactive systems*.

E.1.4 ISO/IEC 14598-1, *Information technology — Software product evaluation — Part 1: General overview.*

E.2 Relevant publications

E.2.1 Bevan, N. (1995) Measuring usability as quality of use. *Journal of Software Quality*, **4**, 115-130.

E.2.2 Bevan, N. and Macleod, M. (1994) Usability measurement in context. *Behaviour and Information Technology* **13**, 132-145.

E.2.3 Bevan N and Azuma M (1997) Quality in use: Incorporating human factors into the software engineering lifecycle. In: *Proceedings ISESS'97, Third International Software Engineering Standards Symposium, June 1-6, 1997, Walnut Creek, California, USA*. IEEE Computer Society.

E.2.4 Chin,J.P., Diehl,V.A., and Norman,K.L.(1988). Development of an instrument measuring user satisfaction of the human-computer interface. *Proc. ACM CHI'88 Conf. (Washington, DC 15-19 May*), 213-218.

E.2.5 Dumas S D and Redish J C (1994) *A practical guide to usability testing*. Ablex Publishing Corporation.

E.2.6 ETSI (1991) *Guide for usability evaluations*. ETSI/TC-HF(91)4.

E.2.7 Houwing E.M., Wiethoff M., and Arnold A.G. (1993). *Introduction to cognitive workload measurement*. Delft University of Technology, Laboratory for Work & Interaction Technology (WIT Lab).

E.2.8 Johnson P J (1992) *Human Computer Interaction: psychology, task analysis and software engineering*. McGraw Hill.

E.2.9 Kirakowski J & Corbett M, (1993), SUMI: the Software Usability Measurement Inventory, *B. J. Ed. Technol.* **24**.3, 210-214.

E.2.10 Kirakowski J (1996) The software usability measurement inventory: background and usage. In: P Jordan, B Thomas, & B Weerdmeester, *Usability Evaluation in Industry*. Taylor & Frances, UK.

E.2.11 Kirwan B and Ainsworth L.K. (eds) (1992) *A guide to task analysis*. Taylor and Francis (London and Washington).

E.2.12 Lewis, J.R. (1995) IBM computer usability satisfaction questionnaires: psychometric evaluation and instructions for use. *Int. J. Human-Computer Interact*, **7**(1), 57-78.

E.2.13 Macleod M, Bowden R, Bevan N and Curson I (1997) The MUSiC performance measurement method, *Behaviour and Information Technology*, **16.**

E.2.14 Nasa-Ames Research Center, Human Performance Group (1986) *Collecting NASA Workload Ratings: A Paper-and-Pencil Package*. Moffet Field, CA: NASA-Ames Research Center.

E.2.15 Nielsen J (1993) *Usability Engineering*. Academic Press.

E.2.16 Shneiderman, B (1992) *Designing the User Interface. Strategies for Effective Human-Computer Interaction*, Addison-Wesley, Reading, MA.

E.2.17 Snyder, K.M. (1991) *Guide to software usability*. IBM Corporation, Order No. SC26-3000-00.

E.2.18 Thomas C and Bevan N, eds (1995) *Usability Context Analysis: A practical guide*, Version 4. National Physical Laboratory, Teddington, UK.

E.2.19 Thomas C and Curson I, eds (1996) *Performance measurement handbook,* Vol. 3. National Physical Laboratory, Teddington, UK.

E.2.20 Whiteside J, Bennett J, Holzblatt K (1988) Usability engineering: our experience and evolution. In: *Handbook of Human-Computer Interaction*, Helander M (ed). Elsevier.

E.2.21 Zijlstra, F.R.H. (1993) *Efficiency in Work Behaviour: a Design Approach for Modern Tools*. Delft: Delft University Press.

ICS 13.180; 35.180

Descriptors: ergonomics, office machines, computer peripheral equipment, text processing, data terminal equipment, display devices, specifications, reflection.

Price based on 22 pages