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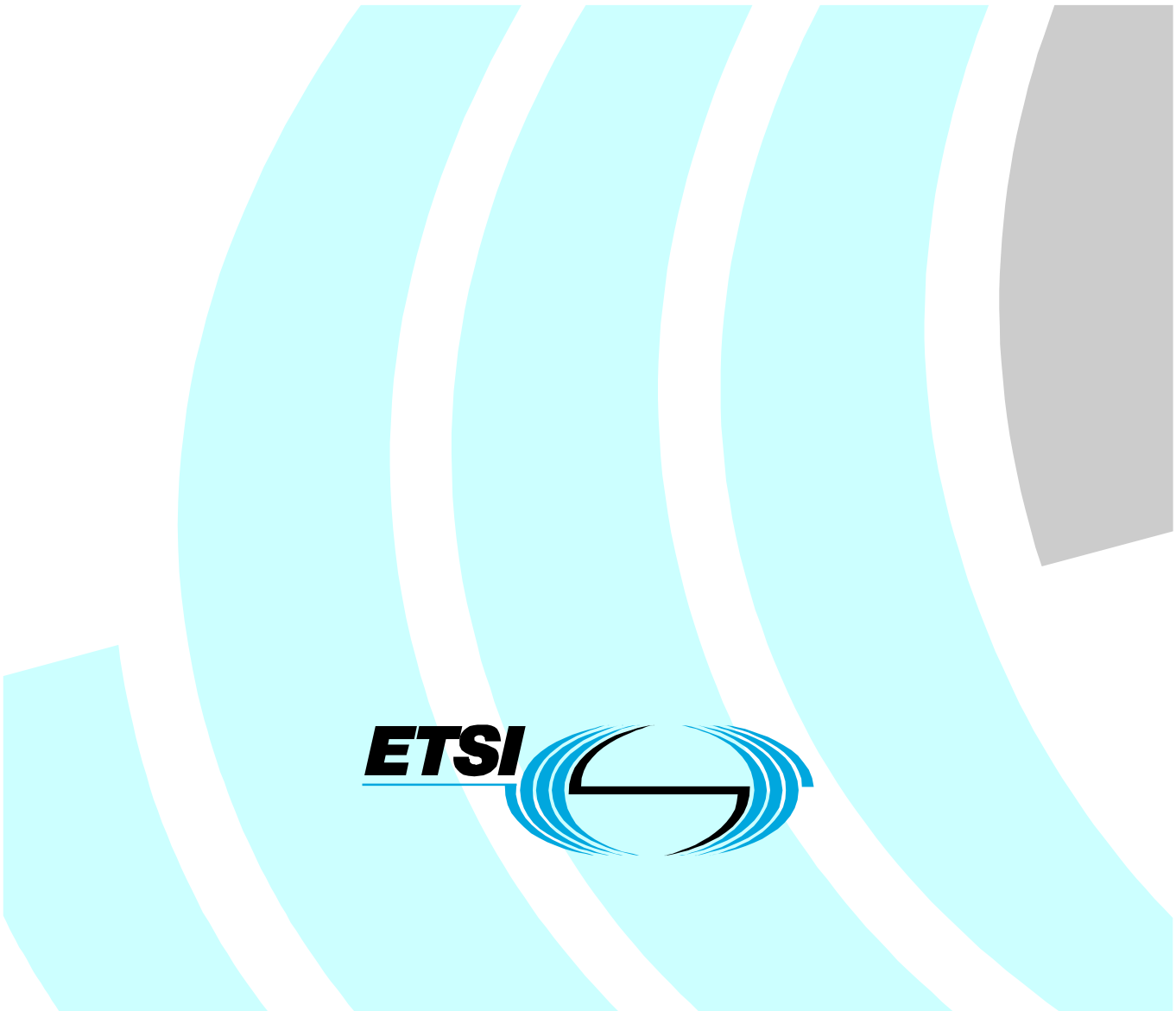
"Design for All"



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Contents

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Foreword

This ETSI Guide (EG) has been produced by ETSI Technical Committee Human Factors (HF).

Introduction

ETSI HF produced three very significant deliverables that provided guidance to the designers of communications products and services:

- ETR 029: "Human Factors (HF); Access to telecommunications for people with special needs; Recommendations for improving and adapting telecommunication terminals and services for people with impairments" [10];
- ETR 116: "Human Factors (HF); Human factors guidelines for ISDN Terminal equipment design" [14];
- ETR 166: "Human Factors (HF); Evaluation of telephones for people with special needs; An evaluation method" [15].

These three deliverables were produced in 1991, 1994, and 1995 respectively and since then the technologies to which the guidelines relate have changed significantly. The "Design for All" approach made it imperative that a revised document integrating the best elements of these documents into a coherent whole was produced to replace these separate documents. The advice given in each guideline was incorporated into this new single updated document.

1 Scope

The present document gives guidance to Information and Communication Technology (ICT) product and service designers on Human Factors issues, good Human Factors design practice, and relevant international and national standards. In particular, it aims to help designers to maximize the level of usability of products and services by providing a comprehensive set of Human Factors design guidelines.

The guidelines are intended to encourage a "Design for All" approach so as to make products and services accessible to as many people as possible, including elderly people and persons with disabilities, without the need for adaptation or specialized design.

The present document is applicable to ICT products with a user interface that are connectable to all kinds of fixed and mobile telecommunications networks. This includes products such as telephones, Multimedia terminals, Personal digital Assistants (PDAs) and services such as e-mail, Short Message Services (SMS) and voice messaging. It is applicable to public and private access devices and services.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication and/or edition number or version number) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.

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[7] ETSI ES 202 076 (V1.1.1) "Human Factors (HF); User interfaces; Generic spoken command vocabulary for ICT devices and services".

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3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

assistive technology device: device used by a disabled person to prevent, compensate, relieve or neutralize any resultant handicap and which has the ability to interface to an ICT device

"Design for All": design of products to be usable by all people, to the greatest extent possible, without the need for specialized adaption

ICT device: device for processing information and/or supporting communication which has an interface to communicate with a user

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

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

ADSI	Analogue Display Services Interface
AHL	Average Hearing Loss
ANEC	European Association for the Co-ordination of Consumer Representation in Standardization
CEN	Comité Européen de Normalisation
CENELEC	Comité Européen de Normalisation Electrotechnique
CET	Central European Time
CRT	Cathode Ray Tube
DTMF	Dual Tone Multi-Frequency
ECMA	European Computer Manufacturers Association
GMT	Greenwich Mean Time
GSM	Global System for Mobile communication
GUI	Graphical User Interface
HUFIT	Human Factors in Information Technology (an Esprit Project)
ICT	Information and communications technology
ISDN	Integrated Services Digital Network
LCD	Liquid Crystal Display
LED	Light Emitting Diode
MMI	Man Machine Interface
PABX	Private Automatic Branch eXchange
PIN	Personal Identification Number
PiP	Picture-in-Picture
PSTN	Public Switched Telephone Network
RNIB	Royal National Institute of the Blind
RSI	Repetitive Strain Injury
SMS	Short Message Service
TETRA	Terrestrial Trunked RAdio
TFT	Thin-Film Transistor (Matrix) (LCD Flat Displays)
UPT	Universal Personal Telecommunications
VFD	Vacuum Fluorescent Display
VPN	Virtual Private Network
WIMP	Windows, Icons, Menu and Pointers
WYSIWYG	What You See Is What You Get

4 Human Factors and Design for All

4.1 Introduction

The need to use telecommunications and Information and Communications Technology (ICT) is central to the everyday lives of the overwhelming majority of people in the industrial world. The aim of incorporating Human Factors in the design process is to improve the usability of products and services in these fields. By usability we mean the extent to which a product can be used by specific users to achieve specific goals with effectiveness, efficiency and satisfaction.

As the telecommunications and the Information Technology industries grow closer, the products on offer become more complex and feature rich, and the need to ensure they are easy to use becomes increasingly important and challenging to the designer. The best way to meet this challenge is to consider the requirements of the people who will use the product, or service, at the very start of the design process.

4.2 The usability gap

Technological advances and market pressures have made telecommunications and ICT products and systems increasingly complex and feature rich. At the same time, because of customer demand and the reduced cost of technology, products and services that people used to be trained for, are now available to all, the users have become less and less specialized. This produces the usability gap shown in figure 1.

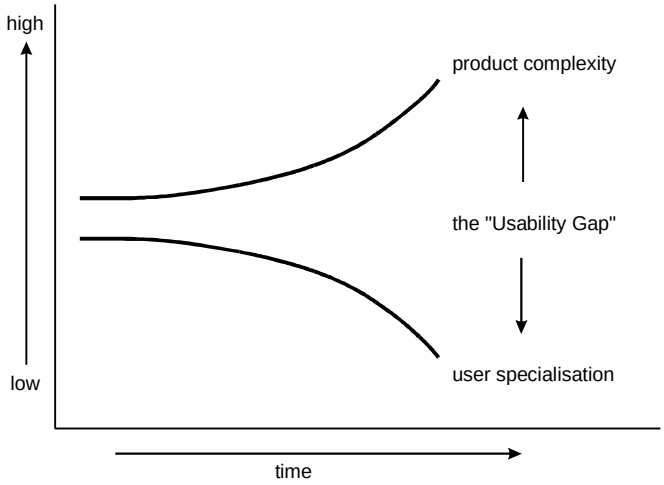


Figure 1: The usability gap

For example, the user facilities on a Private Automatic Branch Exchange (PABX) were originally principally for the operator to help them assist their extension users. Untrained users did not handle call transfers or multiparty calls without the operator's assistance. Subsequently, PABX features have been transferred to the extension user who can invoke Hold, Transfer, Conference, Call Divert, Follow me all from the comfort of their basic telephone. What happened, also occurred all too often in other technologies, an increase in product complexity was paralleled with a decrease in user specialization, creating problems that can be described as a gap in product usability.

However, technological advances are also providing an opportunity to narrow the usability gap because products can often be designed with considerable flexibility, in both the hardware and the software. This flexibility can allow alternative modes of interaction with products and services, (including alternative modes of navigation through them) the availability of built-in multiple facilities should particular users wish to use them, and facilities for the user to attach add-on devices. The challenge then, for Human Factors in the product design process, is to reduce the usability gap and keep the user interface in line with the increasing complexity of products and decreased specialization, while at the same time increasing the flexibility of the user interface.

4.3 Design For All?

4.3.1 Why design for all

The population of Europe is ageing and the number of people with impairments and disabilities is also increasing (see clause 5 for more detailed demographic information). At the same time there is a growing recognition of the need to integrate older people and people with disabilities into society by enabling them to sustain independence for as long as possible. ICT plays an important part in this integration process.

Taking the needs of a broader spectrum of people into account in the design process is called "Design for All", "Barrier Free Design", or "Universal design" - the term more often used in the US. The philosophy behind "Design for All" is to ensure that mainstream equipment and services can be used by a wide range of users, including older people and those with disabilities.

The philosophy is best summarized in the widely accepted definition of "Design for All": "The design of products, services and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design".

4.3.2 What does it mean in practice?

However, "Design for All" does not mean that designers are expected to design every product to be usable by every consumer, this would be impracticable, if not impossible. It is acknowledged that there will always be some people who, because of their severe impairments, need specialist equipment or assistive technology to modify the method of making input to, or receiving output from, a piece of mainstream technology. Further information on the subject can be found in TR 102 068 [42].

Adopting "Design for All" when designing ICT products and services results in a three level model:

1) mainstream products designed according to good Human Factors practice, incorporating considerations for people with impairments, that can be used by a broad range of users;

2) products that are adaptable to permit the connection of assistive technology devices;

3) specially designed or tailored products for very disabled users.

The present document focuses on the first level of this model, and provides designers with the information they need in order to increase the range of people who can successfully use mainstream products and services. As long as "Design for All" is adopted from the start of the design process, then it is possible to design products that are accessible to a significant number of disabled and elderly people, with minimum effort and cost.

It is important to remember that all users may frequently benefit from the increased usability that "Design for All" brings. For example:

- providing volume control on a phone not only assists people with hearing difficulties but also helps others operating in a noisy environment;

- design that considers individuals who have difficulty moving around can also helps those struggling with children or luggage;

- taking account of the needs of people with visual impairment helps all users trying to read a display in poor lighting conditions or without their reading glasses at hand.

It is also important to remember that in most cases there is no clear line between people who are categorized as "disabled" and those who are not. Performance, or ability distribution, for a given skill/ability is generally a continuous function. For example, for every person who has severe visual problems there are numerous others who wear glasses or who could benefit from a larger label on a product that is easier to see in the poor light.

In practice adopting the "Design for All" approach means considering the needs and requirements of people at the ends of the population continuum rather than just those in the middle. This somewhat new way of thinking is summarized by the following seven basic principles (identified by the Center for Universal Design at North Carolina State University [141]).

Seven principles of "Design for All"

1. **Equitable Use:** the design must be useful and marketable to any group of users - avoiding segregation or stigmatization of any users.

2. **Flexible in use:** the design must accommodate a wide range of individual preferences and abilities.

3. **Simple and intuitive to use:** the design must be easy to use and understand, regardless of the user's experience, knowledge, skills or concentration level.

4. **Perceivable information:** the design must communicate necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities.

5. **Tolerance for error:** the design must minimize hazards and the adverse consequences of accidental or unintended actions.

6. **Low physical effort:** the design must be usable efficiently and comfortably and with minimum fatigue.

7. **Size and space for approach and use:** appropriate size and space must be provided for approach, reach, manipulation and use, regardless of the user's body size, posture or mobility.

The practical implications of these principles on the design of telecommunications and ICT products is considered in "General Design Issues" in clause 7 and the recommendations in clause 8 are made on a "Design for All" basis.

4.3.3 What are the benefits for business?

Designing more usable mainstream products based on the "Design for All" philosophy is not only of benefit to the end user - it also offers benefits to business.

- **Increased potential market**

  The number of elderly people is increasing and the characteristics of older people are also changing. The expectations of the upcoming older adults are increasing and their disposable income is growing [140]. They have largely grown up with consumerism, and are discerning consumers, demanding products that perform well and are easy to use. Elderly people form a significant buying force and manufacturers need to respond to their needs in order to increase their customer base.

  Experience has shown that improving usability does not have to increase design and production costs. It can cost little if considered at the design phase. Consideration of disabilities and the functional limitations associated with age in mainstream design is very definitely feasible from both an economic and practical standpoint. In the majority of cases, accessibility can be added to a product's design for little or no cost.

  For example, a large computer company has incorporated several special features directly into their standard operating system to accommodate individuals with various disabilities. One such feature is "Sticky Keys" which enables the user to type the keys sequentially rather than concurrently. The feature is activated by tapping 5 times on the shift key and deactivates should any two keys be depressed simultaneously (as a normal typist would). Thus the feature is transparent to those users who do not need it. Another, example is "Mouse Keys" which allow individuals who do not have the motor control necessary to operate a mouse to control the cursor using the keys on the numeric keypad. Both of these features are of negligible costs and take up minimal memory space on the disk and so are included in every system shipped.

  It is not only a consideration of physical limitations that brings benefits. One recent study estimates that 30 % to 40 % of the adult population has a vague feeling of "Techno-stress" [140]. They feel insecure and humiliated by their incapacity to handle new technologies and thus try to avoid the unpleasant contact with them. Considering the needs of older and mentally disabled people can help create simple and error-friendly products, which reach this much broader market of people who are at the moment "technologically abstinent".

- **Increased marketability - by increasing functionality for all users**

  By designing mainstream products for users with special requirements, products can often benefit other users as well and thus increase a product's marketability.

For example, volume amplification control in telephones was originally developed for people with hearing problems, but it is also useful for anyone using a telephone in a noisy environment, for example, in an airport, hotel or factory. Thus a telecommunications design that kept the needs of the greatest number of people in mind (including people who are hard of hearing) provided an attractive feature for all users. Again, when volume amplification is built into the original design of a telephone, the cost is inconsequential.

Another example is provided by a telephone manufacturer that designed a series of telephones with elderly and disabled customers in mind. The telephones incorporated features such as in-coming and out-going amplification (the latter for people with a faint voice), larger than normal LCDs and buttons, a hands-free option and a headset facility which meant that users could also add a second earpiece. The series is a commercial success, and has even sold to business despite being originally aimed at the domestic market. As a result the company recognized that large keyboards in particular were useful for everyone so all its subsequent domestic terminals adopted this design feature. The company does not label the handsets as being "telephones for disabled people". This is a general policy, although including features that are especially useful for elderly and disabled customers the telephones are sold as off-the-shelf, mainstream equipment [140].

- **Total cost reduction**

  In some cases, creating a design that is more accessible can decrease the costs involved in manufacture or maintenance/support of a product. One example can be found in lift design. Individuals in wheelchairs or with walking difficulties had problems with "banks" of lifts in large buildings - they often could not get to the correct lift before the doors closed. The solution adopted was to have both visual and audible indicators showing which lift was coming next, enabling people to position themselves in front of the correct lift and board more quickly. The result is that it is possible either to design a building with fewer lifts thus reducing costs, or have a system that is more efficient for everybody. Thus the shift in thinking required to accommodate people with special needs can lead to an overall reduction in costs.

- **Improved market share by improving customer loyalty**

  Customer loyalty is important for repeat business and attracting new customers by word-of-mouth. By providing user-friendly products and services to households that include people with special needs it is possible to improve customer loyalty.

- **Reduction in "hidden" costs**

  Companies tie up valuable resources in answering customers' enquiries about how to set-up and use the products they have bought, or in dealing with complaints. If better design is achieved by adopting the "Design for All" approach, then the number of customers who need to call a customer service line or Help Desk will be reduced, thus alleviating some of these costs.

- **Potential spin-offs**

  Products developed for people with disabilities sometimes provide new ideas and features for mainstream products.

  For example, audio-cassette versions of books were first developed for people with visual impairment, but have developed into a much wider market. A baby monitor which provides a visual indication of the loudness of sounds from a baby's room is useful both to those with hearing difficulties or carers in a noisy environment.

  Another example is speech recognition technology, where in the early stages the research funds were often motivated by the importance of the technology to people with disability. This technology has since developed into a wider mass market with huge potential.

- **Improved access to the US market**

  In order to maintain and develop sales in the US market European telecommunications companies need to be aware of the growing amount of legislation in the US in this field (see clause 4.2.4.1 for details.) For example, under regulations which took effect in the US in June 2001, issued under section 508 of the Rehabilitation Act of 1973, all technology purchased by federal agencies in the US must be accessible to disabled users, with few exceptions.

As a result, typical changes that are becoming apparent are government Webcasts captioned for the deaf and fax machines accessible to employees in wheelchairs. The US Postal Service, for example, which operates 37 000 stamp vending machines, will now only buy vending machines which are accessible to people with little, or no, vision.

One effect is that large American corporations are already incorporating accessibility, or "Design for All", into their products. The reason being that they do not want to develop separate products for this market and they also see the demand for accessible products expanding to state governments and schools.

The outcome for European companies wishing to maintain/develop their US market is that they also need to adopt a "Design for All" approach for their products.

4.3.4 What are the benefits to the individual and society?

The potential benefits to individuals and society are more self-evident. Essentially:

- the general population will benefit because they will have access to more user-friendly products and services and a wider range of people will be able to benefit from the increased flexibility that ICT products can provide;
- older adults and people with disabilities will benefit because they will have a greater number of mainstream products and services that meet their needs. Along with increased choice they will also benefit from the economies of scale and have access to more affordable products;
- society as a whole will benefit by:
  - reducing the amount that needs to be spent in providing assistive technology products;
  - achieving a higher degree of social equality;
  - ensuring a successful telecommunications industry.

4.3.5 Legislation, political initiatives and standardization

4.3.5.1 Legislation and regulation

There are currently few European standards directly addressing the issue of "Design for All" but there is an increasing move to incorporate the philosophy into standards. Internationally, ISO and IEC issued a policy statement in June 2000 entitled "Addressing the needs of older persons and people with disabilities in standardization work". The statement principally aims to encourage the development of national and international standards that enables the use of products and services by older persons and people with disabilities. A guide was subsequently produced (ISO/IEC Guide 71 [65]) and under EC mandate 283, a European version, CEN/CENELEC Guide 6 [1] was published which gives general guidance to standards writers on the different human abilities they need to consider when writing standards.

ANEC, the European Association for the Co-ordination of Consumer Representation in Standards, has also issued a policy statement on "Barrier-free Standardization, or Standardization and Consumers with Special Needs." The policy states: "Products and services should be designed barrier-free. A barrier-free design of consumer products and services is not (or should not be) separate from standard mass market design." It explains that this it to be achieved "through the identification of special requirements consumers with special needs have in consumer products and services" and that these requirements will be fed into the European standardization process. ANEC has subsequently started to release documents including "Consumer Requirements in relation to ICT Standardization" which provide the information about these requirements.

In the United States there is more legislation in the area of "Design for All" (called Universal or Accessible design in the US) including:

- the Rehabilitation Act 1973 and amendments;
- the Telecommunications Accessibility Enhancement Act of 1988. This requires that the Federal telecommunications system be fully accessible to individuals with hearing and speech disabilities;
- the Technology-Related Assistance to Individuals with Disabilities ("Tech") Act (1988);

- the Television Decoder Circuitry Act (1990);
- the Americans with Disabilities Act (ADA) 1991. This act guarantees the civil rights of people with disabilities, but has limited specific coverage of telecommunications issues;
- the Telecommunications Act (1996) - accessibility guidelines for telecommunications equipment and customer premises equipment;
- the Telecommunications for the Disabled Act of 1982 and The Hearing Aid Compatibility Act 1998.

4.3.5.2 Political initiatives

There have been a number of political initiatives in Europe including:

- EC Mandate 273: "Design for All and assistive technology in information society standardization". Under this mandate a report was prepared on the needs for standardization in various information society areas, to take into account the needs of older persons and people with disabilities and thus achieve a "design for all".
- EC Mandate 283: "Guidance document in the field of safety and usability of products by people with special needs (e.g. elderly and disabled)". Under this mandate a general guidance document was produced for standards writers, partially based on the ISO/IEC Guide 71 [65].
- "*e*Europe An Information Society For All": this political initiative aims to ensure the European Union fully benefits for generations to come from the changes the Information Society is bringing. It aims at ensuring this change towards the Information Society is cohesive not divisive, integrating not fragmenting, an opportunity not a threat. In essence *e*Europe aims at bringing the benefits of the Information Society to the reach of all Europeans.

One of the actions under this initiative is Action 7 - "*e*Participation for the disabled" which states that:

- "Developments in digital technologies offer extensive opportunities to overcome barriers for people with disabilities. Accessible technologies which address their specific needs enable their participation in social and working life on an equal basis. A challenge for the upcoming years is thus to reduce the remaining gaps between technologies and this user group.
- On the 25th September 2001 the European Commission, as part of the *e*Europe 2002 action plan, adopted a Communication on improving the accessibility of public web sites endorsing the WAI guidelines as being the best practice in design for all for the Internet. The EU and the fifteen member states have all committed themselves to adopt the guidelines for public web sites.
- The importance of accessibility has also recognized by UN member states who signed the "UN Standard Rules on the Equalization of Opportunities for Persons with Disabilities" and the "UN Principles for Older Persons".

4.3.5.3 Standardization

There are few standards directly aimed at design for all but ETS 300 381 [31] on inductive coupling of telephone earphones to hearing aids, ETS 300 488 [33] on telephones with receive amplification for the hearing impaired, ETS 300 767 [39] on tactile identifiers on prepayment cards and EN 301 462 [6] on symbols to identify telecommunications facilities for the deaf and hard of hearing, all describe features that should be incorporated in relevant products to make them design for all.

CEN/CENELEC Guide 6 [1] is aimed primarily at standards writers but also gives useful information on the needs of older persons and persons with disabilities.

A number of groups provide practical guidelines, including:

- COST 219 [103] and COST 219bis - publications and website describing the results of research in the field of telecommunications and teleinformatic services. (http://www.stakes.fi/cost219)
- INCLUDE - project funded by the EC, produces publications and website with information on various aspects of "Design for All" in ICT. (http://www.stakes.fi/include)

- TIRESIAS - the research arm of the Royal National Institute for the Blind (RNIB) in the UK - provides information on designing ICT devices for people with visual disabilities. (http://www.tiresias.org)
- The Center for Universal Design at North Carolina State University - publications and website describing material for designers and consumers about the characteristics of more usable products and environments. (http://ncsudesign.org/content/)
- The Trace Research & Development Center, part of the University of Wisconsin, USA. The Trace website includes general concepts, Universal Design Principles and Guidelines. (http://trace.wisc.edu)
- Older Adult data - handbook of measurements and capabilities of the older adult, although published by the Department of Trade and Industry in the UK, includes European and international data.

5 Users

5.1 Introduction

This clause examines some of the issues concerned with those who will be using ICT products and services. In Human Factors terms, "user" refers to any person who uses, maintains or is affected by the use of the system under consideration. With a computer or a cashpoint terminal there is only one user at a time, whereas in a normal telephone call, there are usually two users; the initiator of the call and the receiver of the call.

Whatever the role of Human Factors within the overall design process, knowing and understanding the intended user is at its core. A proper analysis of the user requirements is essential and should be included in the initial requirements specification. It is instructive here to consider the group of users that is all too often the apparent model user for equipment and service designers. This user is likely to be male, late 20's to late 40's, an engineer or at least a university graduate, and familiar with technology and its potential benefits.

In order to have achieved this status, it is likely that they will have average hearing, sight and manual dexterity, as all education systems unfortunately tend to select, by default, in these areas. They will, however, have a 7 % (i.e. 1 in 14) chance of being red green colour blind.

This somewhat extreme model is, however, quite obviously faulty. It fails to recognize the differences even within the business community in the face of social changes, which have increased the number of female members of this group, the movement of labour within the European Union, and the changes that occur with age. Further, since age changes begin to take effect even from the mid 40's, assumptions of ability at age 30 may not apply so readily at 48.

Within the Design for All process, the designer must consider the user populations and their characteristics. It is necessary to decide who are the intended users of a product, what is spread of their characteristics and what are their individual differences. Within this process, the designer should aim to ensure that all user requirements are addressed and should give positive support towards integrating the requirements of children, the elderly and other people with special needs.

This approach has the effect of broadening the market for ICT products.

5.2 User Populations and their Characteristics

5.2.1 What is the market?

A key question that needs to be answered before a product is developed and released is "What is its market?" and hence "Who are the intended users?". A PC might be aimed at the whole population, whereas a game system might be aimed primarily at younger users. As far as telecommunications is concerned, the product or service might be aimed at all members of a local, national or international population or at some selected group within these populations that can be characterized by a particular requirement or activity that may be occupational, vocational, medical, recreational or social. These user groups will vary in size and in the characteristics that can be used to describe them.

5.2.2 User characteristics

There are a large number of attributes that can be used to distinguish between people in a population. The ones that should be considered to have direct impact on the successful use of ICT products and services [1] include:

- **Sensory abilities** such as seeing, hearing, touch, taste, smell and balance.
- **Physical abilities** such as speech, dexterity, manipulation, mobility, strength and endurance.
- **Cognitive abilities** such as intellect, memory, language and literacy.

Allergies can also be a significant factor in some products.

The individual user may have excellent ability in some areas and yet be poor in others. For the population as a whole there can be a wide variability in any one attribute. The complexity of the problem increases dramatically as more attributes are considered.

5.2.3 Distribution of characteristics

5.2.3.1 Hand size

A variable factor that has particular significance when operating ICT equipment is hand size. Where it is necessary to provide clearance between two connectors, for example, to the designer should consider the upper range of male finger sizes. Where hand reach or span is relevant, it is necessary to take into account the lower range of female dimensions, and in some cases the size of children's hands.

To assist in these decisions, dimensions of the male and female hands and fingers are provided in table 1, which gives the dimensions (shown in figures 2 and 3) which have been extrapolated from a British survey completed in 1981 of 300 male and 300 female hands [118]. Designers may need to seek anthropometric data for their own country if they perceive that there may be significant ethnic variations from the British data given in table 1.

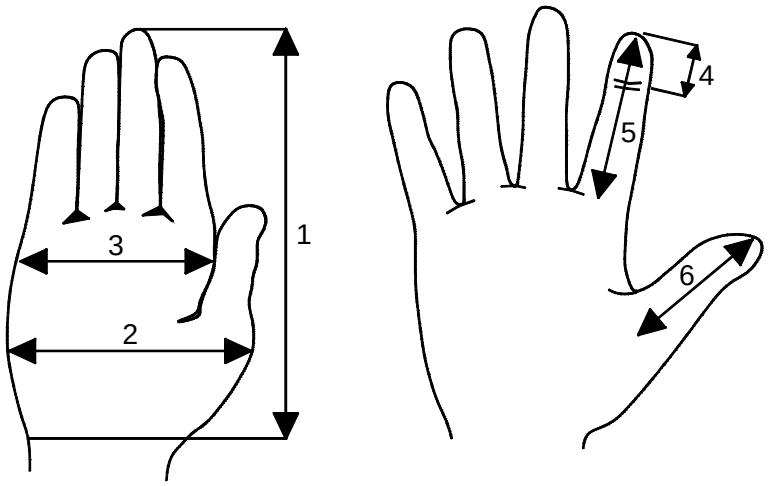


Figure 2: Hand dimensions after Kember et al [118]

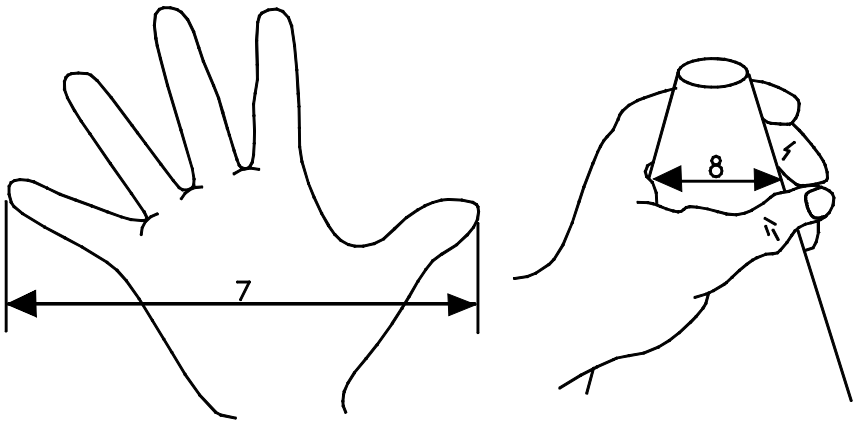


Figure 3: Hand dimensions (after Pheasant) [125]

Table 1: Anthropometric data for hands and fingers, for dimensions shown in figures 2 and 3

Dimension (in millimetres)		Percentile 1st	5th	50th	95th	99th
1 Hand length	Female	157	162	174	186	191
	Male	171	177	190	204	209
2 Hand breadth	Female	81	84	92	100	103
	Male	93	97	106	115	118
3 Hand breadth (excluding thumb)	Female	69	72	78	84	86
	Male	78	81	88	94	98
4 Index finger tip length	Female	2,1	2,2	2,2	2,3	2,4
	Male	2,3	2,4	2,5	2,6	2,6
5 Index finger length	Female	57	60	67	74	77
	Male	61	64	72	79	82
6 Thumb length	Female	38	41	47	54	57
	Male	41	44	52	59	63
7 Spread	Female		165	190	215	
	Male		178	206	234	
8 Hand grip diameter	Female		43	48	53	
	Male		45	52	59	

(The term **percentile**, as used in table 1, denotes the percentage of individuals that fall below any specified measure. Using female hand length as an example: the 1st percentile of 157 mm means that only 1 % of all women have a hand length of 157 mm or shorter, while 99 % of all women have a hand length of more than 157 mm; and the 99th percentile 191 mm means that 99 % of all women have a hand length of 191 mm or less, while only 1 % of all women have a hand length of more than 191 mm. The percentile is a very useful way to describe various group characteristics statistically.)

5.2.3.2 Height

Another important factor is height. Table 2 gives data on the UK adult population.

Table 2: Height dimension for the UK adult population

Dimension (in millimetres)		Percentile 5th	50th	95th
1 Height	Female	1 620,02	1 514,4	1 725,6
	Male	1 755,1	1 641,0	1 869,2

The height of the female population has a standard deviation of 64,4 mm and that of the male population 69,9 mm.

This suggests that the range of heights of 99 % of the male population would be approximately 210 mm. For the same proportion of the female population the range would be approximately 193 mm.

This range of variability can be an important factor particularly when considering the placing of notices. The range would be wider if children were to be considered.

There is therefore a need to allow for a wide range of physical characteristics that applies to all users whether in the general public or in a specialist sector of the market.

5.2.4 Changes of relevant characteristics with age

When considering design for all, ageing of the population is an important factor. The proportion of the population over 60 is expected to increase to over 25 % in 2020. As a result of prolonged life expectancies, the percentage of the very old (80+) is also expected to increase substantially: from 4 % in 1999 to about 10 % in 2050. In absolute terms, 37 million people are expected to be aged 80 and over in 2050, an increase of almost 160 % compared with 1995 [145].

Elderly people can thus clearly be seen as a significant proportion of the population of those likely to be using ICT products and services. It is forecast they are likely to be more affluent than in the past, making them a valuable marketing opportunity. If this opportunity is to be realized, the particular characteristics of the elderly need to be understood.

Elderly people generally widen and skew the distribution of a given human characteristic, as some of them will experience a change or degradation of that characteristic. In general, most functional abilities will change. For example, older people tend to lose their ability to detect higher frequency sounds and many use a hearing aid. The incidence and severity of visual impairment increases with age and the changes in the physical structure of the eye will lead, among other effects, to loss of visual acuity (the ability to see fine detail), the inability to accommodate changes of focus from short to long distances and a loss of speed of adaptation to changing light levels. Manual dexterity, mobility, strength and endurance decline. These effects are often accompanied by a slowing of the brain's ability to process information, causing difficulty in taking in, attending to and discriminating sensory information. This has the effect of causing an overall slowing of "behaviour" and the phenomenon which is generally referred to as "loss of memory". CEN/CENELEC Guide 6 [1] provides further information on the affect of ageing on human abilities. It should be noted that the "normal" changes related to ageing are usually not regarded as disabilities, even though the impairments incurred by ageing may be indistinguishable from those of younger disabled people.

5.2.5 Disability and ability

Recognizing the variance in ability across a sample of population, there is clearly a point at which ability becomes so far from the expected range for the population that it has to be considered outside (above or below) the expected range. Disability, by its definition, occurs where some ability falls below the expected range. Population figures are, however, very difficult to collect because of difference between the various national views of the onset of disability and the differing methods of collecting national statistics.

Even the Statistical Office of the European Communities (Eurostat) states in its disabled persons statistical data [141] that "in spite of the large number of disabled persons, there are still no reliable European-level statistics in this field". This publication gives the information that exists, but it is limited in the countries covered and the information provided.

Some data derives from censuses and national surveys (which refer to the total population of disabled persons), some from social security organizations which concern themselves with certain groups of beneficiaries. In some countries, for example, soldiers wounded in action are not counted as "disabled", for reasons such as pension schemes, even though their physical or cognitive impairments make them just as disabled as those who are registered as disabled.

In the Eurostat publications for example, information on the type of impairment is available from 10 countries, whilst information on the severity of impairment is only available for five. Clearly much published data must be derived from extrapolation.

In 2001 Eurostat published the results of a survey on disability [142] in 14 European countries (the EU 15 minus Sweden for which no data was available). This survey showed that, of the population aged from 16 to 64, 4,5 % suffered from severe disability and another 10 % suffered moderate disability.

Unfortunately, this survey did not include those under 16, and more importantly, those over 64.

Figure 4 shows how the percentage of people reporting disability in any age group increases with age. It can therefore be expected that the population aged 65 and over would report significantly increased percentage of disability. Reference [141] suggests that in the over 80 age group some 50 % to 60 % are disabled, the figures varying from country to country and ranging from approximately 50 % (Greece) to 80 % (Spain).

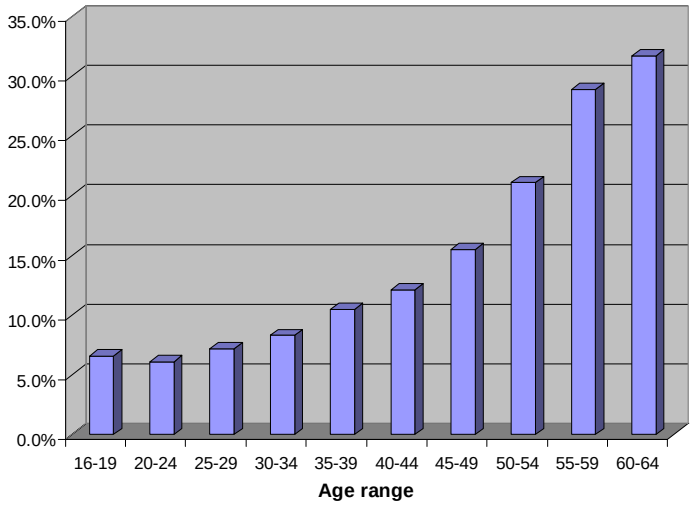


Figure 4: Age-specific percentages of persons reporting disability

Assuming some 20 % of the population to be over 65 [129], this would suggest that approximately an additional 6 % of the population are disabled and elderly, giving a total of about 20 % of the population with moderate or severe disability.

This figure indicates the potential size of this market as a proportion of the entire market for ICT products and services.

Useful information on the effects of age and disability can be found in CEN/CENELEC Guide 6 [1], in ETR 334 [22] and in the RNIB Publication "Which Button" [113]. These sources have been heavily drawn on for the following clauses. Further information can be found in "Bridging the GAP? Access to telecommunications for all people" [129].

5.2.6 Sensory disabilities

5.2.6.1 Sight

Sight (or vision) refers to the ability to sense the presence of light and to sense the form, size, shape and colour of visual stimuli. There are a number of visual impairments that can lead to a disability when using ICT equipment. Most simple refractive errors such as myopia (short sightedness), Hypermetropia (longsightedness) and astigmatism can normally be corrected with suitable lenses. Loss of accommodation or presbyopia, which inevitably occurs with ageing, may require the use of bi-focal lenses which can make it difficult to read a computer screen without getting a stiff neck! Another effect of ageing is the slowing down of the ability for the sight to adapt to changes of ambient illumination. This can give problems when the illumination on a control panel differs greatly from that of the object being controlled.

Even when vision is suitably corrected, there can still be difficulties with small print and poor contrast. Typically, the simpler the image and the clearer its definition, the easier it is to read. Some liquid crystal displays with poor contrast may be difficult to read.

Approximately 7 % of all males, but less than 0,5 % of females have problems in distinguishing red from green, an effect known as protanopia and deuteranopia. Perception of colour can also be affected by ageing, by diabetes or glaucoma. In these cases the effect is towards the violet/blue end of the spectrum. Colours should therefore never be used alone to indicate vital functions and messages. There should always be additional modes of information (redundancy). Colour contrasts between violet and blue or within the green/yellow/orange red segment of the spectrum should be avoided. Colours should be chosen so that they are easy to separate into distinct grey-tones when transformed into the monochrome grey scale.

Cataracts, causing one or more opacities of the crystalline lens of the eye can produce effects similar to looking through a dirty or a yellowed windscreen. Some types of cataract can cause multiple images.

Diabetic retinopathy is the largest single cause of registerable visual impairment. The fine network of blood vessels in the retina becomes damaged and causes local loss of function. The poor circulation, which is also caused by diabetes, can also lead to the poor tactile sensitivity which means that few diabetics are able to read Braille. Macular degeneration is also a significant cause of visual disability where the photosensitive cells at the centre of the retina suffer failure.

In general, in these cases, magnification and a high level of illumination (but without glare) may assist reading and other near vision tasks. Multimodal capabilities in ICT products and services, making it possible to present the information in audio form, can be of great assistance.

The most severe form of visual disability is blindness or loss of central vision. Blindness can be classified in terms of perception of light. Some people cannot perceive light at all, some can distinguish between brightness and darkness, some can perceive slight movement or some images. Loss of sight can involve one eye, leading to a loss of depth perception, or can involve both eyes. When vision is reduced to 10 % of normal vision or less in the best eye, a person is generally considered "legally blind".

Any form of blindness or tunnel vision makes activities such as reading or writing very difficult if not impossible. Blind people usually cannot effectively use ICT products and services that rely on visual displays. They have to rely on tactile and audible signals. This can make design for all impractical except for some expensive public terminals and users have commonly to rely on assistive devices. Nevertheless design for all should allow for the connection of such devices through a suitable interface.

There is a significant memory load when using large text on a screen and design for all should try to reduce this load. Effort should also be made to enable users to locate information quickly.

5.2.6.2 Hearing

There is a fairly wide spread in hearing ability, such that a deviation of ±20 % about the nominal is considered within the normal range of hearing [112]. Although there are other more complex types of hearing defect that cannot be easily classified, people with impaired hearing are often broadly divided into categories according to the seriousness of the hearing loss [110]:

- People who are moderately hard of hearing (with an average hearing loss (AHL) of the order of 50 dB to 60 dB)
- People who are severely hard of hearing (with an average hearing loss of the order of 70 dB to 90 dB)
- People who are profoundly deaf (with an average hearing loss greater than 92 dB)

Hearing ability alters with age and people between the ages of 20 and 80 experience changes in hearing thresholds continuously throughout adulthood (as shown in figure 5) with an average change of 1dB per year at 8 kHz. The rate of change is lower for speech frequencies (0,5 kHz to 2 kHz).

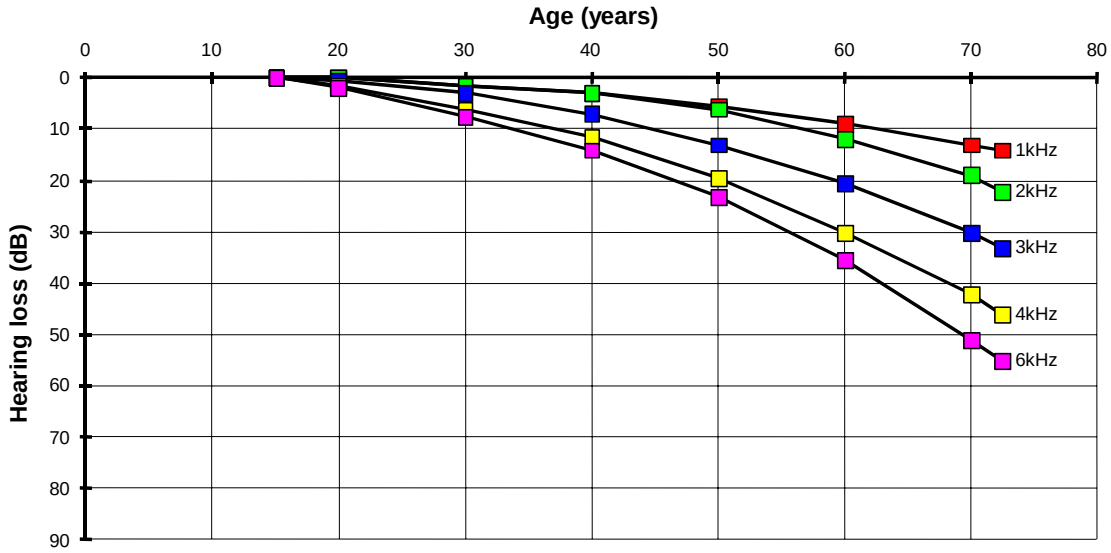


Figure 5: Hearing level as a function of age for non-noise exposed subjects (after Glorig)

By the age of about 50, there is typically sufficient hearing loss to bring about impairment in some of the more demanding listening situations such as hearing faint sounds, listening with excessive background noise, hearing with multiple sources (e.g. picking out a single voice in a din of voices, the "cocktail party" effect).

It has been reported [114] that people with AHLs in the range 24 dB to 34 dB, who report some difficulty in normal conversation do not have appreciable problems using the telephone, and that people with AHLs of up to 54 dB can hear satisfactorily over the telephone at normal speech levels. The use of a second earpiece can be beneficial to people with a more serious hearing loss.

People who are moderately hard of hearing may have difficulty in hearing warning tones call progress tones and telephone ringers. They benefit from multimodal presentation of the signals provided by, for example, flashing lights or vibration capabilities.

People who are severely hard of hearing generally use hearing aids. It is beneficial to provide inductive coupling facilities for such hearing aid users.

Hearing loss can basically be classified into conductive and sensori-neural loss. Conductive loss occurs when some defect, infection or damage to the outer or middle ear makes the ear less efficient in transmitting vibrations to the inner ear. Conductive deafness is often treatable and can often be helped by a hearing aid.

Sensori-neural loss occurs in the inner ear when the nerves which transmit sound in the inner ear do not work properly and can be congenital or acquired. It is commonly called nerve or perceptive deafness. Sensori-neural loss cannot be cured but can sometimes be alleviated by a hearing aid.

Profoundly deaf people are traditionally divided into two categories:

- People who have pre-lingual deafness.
- People who have post lingual deafness.

People who are born deaf, or have lost their hearing before they learnt to speak, are called pre-lingually deaf. These people will typically have no speech or poor speech intelligibility and poor or no reading abilities. This is because for most of these people their first language will be the manual sign language of their country and not the native tongue spoken in their environment.

People who lose their hearing later in life, after they have acquired a basic spoken language, are called adventitiously or post-lingually deaf. Depending on the time of onset of deafness, these people may retain anything from intact and fully intelligible speech to very unintelligible or no speech at all. The reading abilities of post-lingually deaf people are normally also retained, but some post-lingually deaf people may not be able to read or not read very well.

People who are deaf and cannot hear over a telephone, but have a reading ability, require some form of text communication. Text telephones and relay services are necessary to enable them to communicate with telephone users without that facility. Guidelines for such services are provided in TR 101 806 [40]. People who rely on sign language require video communication associated, if necessary, with a video relay service.

5.2.6.3 Touch

The sense of touch refers to the ability to sense surfaces, their texture or quality and temperature. As people age, they lose tactile sensitivity and may no longer be able to rely on touch and pain to give early feedback on temperature or injury. In conjunction with changes in fine motor control this means that any manipulation that requires very fine adjustment or touch discrimination will be compromised.

It is unfortunate that the poor circulation that occurs with diabetes is a major cause of loss of tactile sensitivity and is often also associated with diabetic retinopathy. This leads to the outcome that few diabetics are able to read Braille.

Those who lack touch sensation, particularly those with prostheses, may not be able to use touch sensitive screens or touch-pads on computers.

Some people have hypersensitive touch and are hurt by stimuli, for example by sharp points and edges, which might only cause discomfort to others. Surfaces should therefore be free from sharp points and edges.

5.2.6.4 Taste and smell

Although taste (gustation) and smell (olfaction) are separate senses they have been grouped together as they have similar practical applications. Smell relates to the use of receptors in the nose to sense odours and smells. Taste relates to sensing four basic qualities through receptors in the tongue: bitter, sweet, sour and salty. The two senses are used together to identify the range of flavours which can normally be distinguished.

The ability to detect odours diminishes as people get older. In some groups in Kenya a man is considered old [22] when the smell of food no longer awakens him!

Impairment of the sense of taste and smell reduces the body's defence against toxic materials. People may not be able to smell the presence of gas or taste the deterioration of food.

At the moment, neither of these senses has much direct applicability to the ICT environment although with future developments they may become significant. Nevertheless, the need to disguise unpleasant odours has been known in telecommunications for nearly a century. The natural smell of bakelite, once used in telephone handsets, is rather obnoxious and it was traditionally perfumed with a more pleasant masking odour.

5.2.6.5 Balance

The ability to maintain balance so as to avoid falling over is dependent on a complex system which requires the co-ordination of visual stimuli, feedback from the balance mechanism in the inner ear and the appropriate movements of limbs. Most activities require the control of balance.

The incidence of balance impairments increases with age. This, combined with age related attention deficits and visual impairments, can reduce the ability to avoid hazards and so increase the risk of falling. Slips and trips, even over small edges and protrusions can produce disturbances greater than an impaired balance control system can cope with and so lead to injury.

Equipment intended to be operated when standing up can sometimes benefit from the provision of a hand hold or something to lean against to provide additional stabilizing support.

5.2.7 Physical disabilities

5.2.7.1 Speech

For ICT products and services, speech is the most important sound produced by the voice. Speech production occurs in the mouth and larynx and depends on the coordinated action of many muscles. Age changes that affect breathing will also affect sound production and the ability to control voice volume and the precision of pronunciation and intonation diminishes. Age changes in the larynx lead to voice changes in pitch and strength and the voice tends to grow less powerful and restricted in range, becoming quite high pitched in some people. In addition, hearing impairments may affect speech due to changes in the perceived feedback.

Problems of stammering can be accentuated by excessive echo or sidetone, the effect of hearing one's own speech in the earphone. Weak speech cannot safely be compensated by simple amplification due to the possibility of overloading the network. People with severe speech defects, often linked with deafness, may use text based communication. Others may use synthetic speech generators which will require to be linked to an ICT device through a suitable interface.

Video telephony can provide support for lip reading or manual sign language, although this facility is sometimes not useful to those who lack control of lip movement due, for example, to cerebral palsy. Some people with speech of low intelligibility can benefit from the use of a relay service with a suitably trained operator [40].

5.2.7.2 Dexterity

Dexterity is defined as the skill of manipulation. It implies co-ordinated use of hand and arm to pick up and handle objects, manipulating and releasing them using the fingers and thumb of one hand. Significantly, and from its Latin derivation, it can also mean right-handedness.

Dexterity impairment includes an inability to bring fingers and thumb together or an inability to separate them normally. More complex operations, such as simultaneous push and turn, which require both sustained pressure and twisting of the wrist, may be painful or impossible. People with involuntary movements or spasms have problems with tasks that require precision.

People with limited dexterity may endanger themselves by incorrect operation of controls.

A study performed by Welford, Norris and Shock (1969) [132] illustrated that ageing has an effect on dexterity with a set of measurements relating accuracy of movements to speed of movements and distance of movements. The general conclusions are that accurate movement depends on a complex relationship between hand/eye co-ordination, absolute positioning skills, control skills, kinaesthetic feedback and decision skills. Further that it is predictable that older people will have problems where a complex relationship exists between a number of processes being applied simultaneously.

This is indeed the case, as shown in figure 6, with significant loss of accuracy occurring even within the working age range.

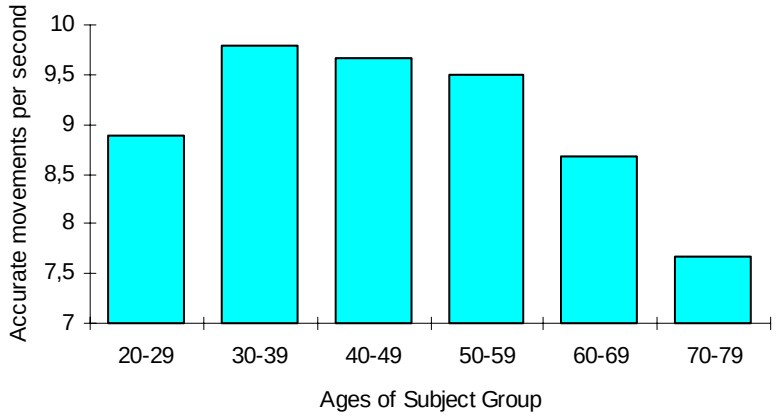


Figure 6: Accuracy of movement compared across various age groups

A good design should avoid the necessity for rapid motor activity during tasks, should provide sufficient size and spacing of keys and should avoid rotary controls that rely on small angles of rotation. There should be a distinct haptic feedback (tactile/kinaesthetic, i.e. the combined sensations of touch and movement) on key pressing. Some people may find it difficult to use a mouse and it is very easy for them to make mistakes by clicking on the wrong part of the screen. They can be aided by alternative navigation methods through the keyboard.

It can be difficult for dexterity impaired users to hold down multiple keys simultaneously. Severe dexterity problems may be assisted by voice control of the device, although some difficulties such as tremor are often associated with speech difficulties.

5.2.7.3 Manipulation

Manipulation is closely allied to dexterity and is conventionally defined [1] to relate to activities such as carrying, moving and manipulating objects and includes actions using legs, feet arms and hands - reaching, lifting, putting down, pulling, pushing, kicking, grasping, releasing, turning, throwing and catching.

Manipulation can be impaired by the inability to use both hands (or feet) when carrying out some function or can also be affected by reduction in joint movement. The speed of manipulation tends to slow with age.

People with impaired manipulation may risk injury from the resultant clumsiness and product design should aim to minimize the resultant hazards.

5.2.7.4 Mobility

Mobility is the ability to move freely from place to place. Mobility problems can extend from minor difficulties in movement, to being confined to a wheelchair or being bedridden. Some people with impaired mobility have difficulty with control, where muscles are tense and contracted (spasms). They may have extra, involuntary, uncontrolled and purposeless movements. They may have small or missing limbs. Common difficulties caused by ageing include limited ability to bear weight on the legs, reduced walking speed, restricted movement in the joints of arms, legs, pelvis and spine and difficulties in carrying out controlled and coordinated movement.

Design for all should ensure suitable space around public terminals to permit free and unimpeded access for mobility impaired users. Such terminals should be located to allow for wheelchair approach and manoeuvring. A suitable provision to "park" a walking stick should be provided.

Wheelchair users often find that the use of mobile or cordless telephones is very convenient.

5.2.7.5 Strength and endurance

Strength relates to the force generated by the contraction of a muscle or muscle group and can be the force exerted with a specific part of the body on a specific object. It also depends on endurance or stamina (the capacity to sustain such a force) and can be related to heart and lung function.

Ageing commonly brings with it a reduction in muscle power and loss of stamina which can make it difficult to operate a device against significant resistance or torque. A weak grip may make it difficult to hold a handset, particularly for extended periods. The provision of a hands-free facility in telephones will be of help in these cases.

Public terminals that may have to be used for long periods should offer some sort of support or "perch" to assist users with reduced stamina.

5.2.8 Cognitive disabilities

5.2.8.1 Intellect

Intellect is the capacity to know, understand and reason. As people get older they have more difficulty concentrating and paying attention to a task. Recent research has shown that people keep their basic intellectual abilities (that we call intelligence) throughout life, provided they are not affected by illness such as dementia, Alzheimer's or strokes which are more prevalent with older people. However, as people get older they require more time to perform tasks, and memory for new information deteriorates.

Thus, time-outs should either be generous or variable and there should be no need to memorize information to perform a task. En-bloc dialling (as used on mobile phones) can be much better for older people than overlap dialling (as on ordinary telephones), since it will allow them to compose and check a telephone number before "sending" it to the network. However, a life-long use of overlap dialling may tend to make it difficult to remember the new procedure.

Impairment of intellect leads to difficulties in perception and problem solving and can include difficulty in taking in information. People with intellectual impairment will typically not have the necessary reading skills to read written instructions. They can often recognize simple icons and abbreviations and may be able to follow graphic instructions. They can often function well in a familiar environment but can easily be confused when required to respond quickly.

5.2.8.2 Memory

Failing memory affects people's ability to recall and learn things and may also lead to confusion. Either, or both, short term and long-term memory can be affected. Short-term memory is more important to the use of ICT products and services. With ageing the memory span is reduced and it can be difficult to remember long numbers [122] and [128].

People with impaired short term memory can forget where they are in a sequence of operations.

Equipment should have a simple input interface which does not burden the memory.

5.2.8.3 Language and literacy

Language and literacy are the specific mental functions of recognizing and using signs, symbols and other components of language. Ageing is not of itself a cause of loss of language ability but such impairment can be caused by a stroke or dementia. Sufferers may be able to think as before, but be unable to express their thoughts in words.

Dyslexia is often considered an impairment of language, although there is some evidence that it can be classed as a defect of vision. People of all ages with dyslexia have difficulty with reading and writing. Mild forms of dyslexia are very common, and it is therefore very important to keep the wording of signs and instructions as simple and short as possible.

People with a language impairment may be put at risk if they are unable to comprehend written warnings or instructions.

5.2.9 Allergies

An allergy is an immunological reaction to a substance. It may be serious and even life threatening if severe enough to cause anaphylactic shock.

Except in the case of some novel multimedia displays, offering smell or taste, contact allergies are the only ones that are relevant in ICT. They are caused by allergens that enter the body via the skin. These allergens are particularly contained in scented products and other chemicals. Sources include latex, some metals and some plastics.

6 Human Centred Design process

6.1 ISO 13407 definition

According to ISO/IEC 13407 [68], the incorporation of a human-centred approach is characterized by:

a) the active involvement of users and clear understanding of user and task requirements;

b) an appropriate allocation of functions between users and technology;

c) the iteration of design solutions;

d) multidisciplinary design.

User involvement is essential in order to understand and define the context of use, the tasks, and how users are likely to work with the future product or system. The users and developers should interact throughout the design process. The nature of user involvement varies depending on the design activities that are being undertaken. Also the type of the product has an effect. When designing custom-made products, the actual users can be directly linked to the design process. When designing consumer products, you can involve appropriate representatives of the planned user groups in the design process.

The aim of the technology is to assist the user to carry out selected tasks. The design should identify all the tasks to be carried out and define which parts of the tasks are taken care of by technology and which parts are the user's responsibilities. Decisions cannot just be based on letting the technology do what it is capable of doing and allocating the remaining functions to the user. The human functions should form a meaningful set of tasks.

In iterative design, feedback from the users is a critical source of information. You cannot define exact user requirements at the beginning of a design process. On the one hand, the designers do not have a clear idea of what the users might want to have. On the other hand, the users do not have a clear idea what the technology could make possible. The current context of use is only the starting point of the design. The planned new system may change the context of use and then again the new context of use may change the user requirements for the technology. The design process shall support this iteration by visualizing the design decisions and evaluating them with the users in the planned context of use. As the result of the evaluation, both the context of use and the design may be refined.

Human-Centred Design requires a variety of skills. Depending on the nature of the system to be developed, the multi-disciplinary team may include end-users, management, application field experts, system designers, marketing experts, visual designers, human factors experts and trainers. An individual team member may represent different skill areas and viewpoints. The minimum team consists of the designer and the user.

The Human-Centred Design procedures can be applied to any system component the user may have to interact with. This includes hardware and software components, as well as user manuals.

6.2 Why Human-Centred Design?

There are many good reasons to adopt a Human-Centred Design approach to ICT equipment. One important reason is the legal regulation on the minimum safety and health requirements for work with display screen equipment. (EU Directive 90/270 [138]).

Usability engineering has proved that the application of the principles of Human-Centred Design has high payoffs (INUSE project document: User Centred Design, 1996).

- Reduced production costs: the overall development times and costs can be reduced by avoiding over design and reducing the number of changes required late in design.
- Reduced support costs: systems that are easier to use require less training, less user support and less subsequent maintenance.
- Reduced costs in use: systems better matched to user needs improve productivity and the quality of actions and decisions. Easier to use systems reduce stress and enable workers to handle a wider variety of tasks. Difficult to use systems reduces health and well being, motivation and may increase staff turnover and absenteeism. Difficult to use systems are time consuming to use, and are not exploited to full advantage, as the user may be discouraged from using advanced features. In some circumstances, they may never be used. An ineffective system may be a major financial liability for the user organization.
- Improved product quality: Human-Centred Design results in products that have a higher quality of use and are more competitive in a market that is demanding easier to use systems.

All these benefits are obtained taking into account the total life-cycle costs of the product, not only those of the development, but also the set-up phase and the maintenance phase. The initial costs of Human-Centred Design activities are compensated by all the benefits that are produced at the end. In spite of being important benefits however, they are seldom expressed in economic terms.

ISO/IEC 13407 [68] emphasizes the ergonomic, economic and social benefits in the rationale for adopting a Human-Centred Design process. Making systems more usable makes them meet user and organizational needs better. The systems:

a) are easier to understand and use, thus reducing training and support costs;

b) improve user satisfaction and reduce discomfort and stress;

c) improve the productivity of users and the operational efficiency of organizations; and

d) improved product quality appeals to the users and can provide a competitive advantage.

6.3 The Design process

In a design process that adopts a Human-Centred Design approach, the following activities should take place:

1) defining the context of use;

2) specifying user and organizational requirements;

3) producing prototypes; and

4) evaluating the designs.

ISO 9241-11 [60] gives further information on how to specify and measure the usability of products and the factors which have an effect on usability.

6.3.1 Defining the context of use

Context of use includes the following factors.

6.3.1.1 Description of users

The 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. For more information about user groups (see clause 5).

6.3.1.2 Description of tasks

By completing a thorough task analysis covering each of the user groups the ICT product or service will impact, the designers will obtain a detailed description of the product's requirements from the users' perspective. There are four ways in which a task analysis can make a user centred impact within a design process:

1) By affecting the designers' understanding of the users' task requirements.

The process of collating and analysing user and task data usually takes the terminal development team into close contact with current users of similar products and their marketing colleagues. There is a subtle but very significant difference between designing a product with its essential functionality and designing for the experience of using that product. Collating user/task information gives designers the opportunity of learning about that experience at first hand and of seeing their work through another pair of eyes.

2) By indicating a framework for the design of the user interface based on the structure and logical grouping of users' tasks and sub-tasks.

The grouping of tasks and sub-tasks helps the user to breakdown complex tasks into more manageable logically related groups. The relationships of task frequency, task importance, operational sequence, task similarity, etc., can all be applied to the way control keys are organized, or the way menu items are linked and structured hierarchically, or the way the display screen is laid out.

3) By establishing user performance criteria to specific key tasks which can be used to evaluate the product concepts and prototypes during the development.

The application of user performance criteria to specific key tasks that have been defined, leads directly to the production of a Usability Specification for the terminal being designed. Where, for example, it could be specified that:

- 95 % of a representative sample of users can achieve task A successfully at the first attempt, within X seconds; and
- 80 % of a representative sample of users can achieve task B successfully at the first attempt, within Y seconds; and
- 95 % of the same sample of users can subjectively rate the terminal on task A and or B, as good as or better than a similar sample rated a competitive product, on a similar task or set of tasks.

The existence of a usability specification of this sort can act as a strong focal point for all aspects of the design by setting clear objectives by which the design solutions can be tested. The earlier in the design process such a specification is made, the earlier prototype solutions can be tested and the easier design changes can be implemented.

4) By providing formal methods for the elicitation and assessment of user and task requirements, e.g. User/Task Requirements Specification, Functionality Matrix.

A Functionality Matrix [107] can be used to cross reference the user and task requirements defined during the task analysis, with the prospective terminals planned functionality. The concept is that, to meet the users' requirements, there should be an element within the terminals functionality which can be simply matched against each stated requirement.

Table 3: Simplified example of HUFIT's Functionality Matrix [107]

HUFIT - Functionality Matrix		Terminal Functionality						
User and Task Requirements		A	B	C	D	E	F	etc.
	1							
	2							
	3							
	4							
	5							
	6							
	7, etc.							

By looking along the rows of the matrix the specified requirements can be checked to see that they are all being accommodated. Additional functionality may then be required to cover any missing elements. Similarly, by looking along the columns of the matrix, the functionality can be checked to see if any unnecessary provision is being made, that is, not being balanced by a user or task requirement. By introducing a five point scale to assess each cell of the matrix, a rough comparison can be made between columns or rows when design trade-off decisions might be necessary.

For further information on task analysis see [119].

6.3.1.3 Description of equipment

Relevant characteristics of the equipment need to be described. The description of the hardware, software and materials may be in terms of a set of products, one or more of which may be the focus of usability specification or evaluation, or it maybe in terms of a set of attributes or performance characteristics of the hardware, software and other materials.

6.3.1.4 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, organizational structure and attitudes).

6.3.2 Specifying user and organizational requirements

ISO13407 [68] states that the following aspects should be considered in order to identify relevant user and organizational requirements:

a) Required performance of the new system against operational and financial objectives.

b) Relevant statutory or legislative requirements, including safety and health.

c) Co-operation and communication between users and other relevant parties.

d) The users' jobs (including the allocation of tasks, users' well-being, and motivation).

e) Task performance.

f) Work design and organization.

g) Management of change, including training and personnel to be involved.

h) Feasibility of operation and maintenance.

i) The human-computer interface and workstation design.

The allocation of function between tasks performed by the human personnel and tasks performed by the technology should be specified. These requirements should be specified in a form that can be subsequently assessed at the stages of user testing and evaluation.

6.3.3 Producing prototypes

Prototypes can save money by allowing designers to test out features of their products or services before full-scale systems are built. Prototypes can be used at a number of stages in the design process. Prototypes can range from models, mock-ups or full simulations. Producing prototypes allows designers to communicate more effectively with potential users and obtain their feedback. This may reduce the costs of reworking of the total design.

Prototypes used in the early stages of design can be used to test out initial ideas or features of a product.

They can vary from computer simulations or paper based schemes to full scale working prototypes. Features of the hardware can be simulated in such materials as wood or foam. They can be used to visualize design decisions in the software requirements phase in order to collect feedback and new ideas from the users. Full-scale prototypes of for example telephones can be simulated on computers using visualization techniques. When used in association with touch screens sample users can be led through trials as if they were using real equipment.

Scenarios or storyboards are useful in conjunction with the prototypes to represent a sequence or flow of user actions required to achieve a specific task. There are usually many different ways to achieve the goal, and then different users may follow different steps while interacting with the system or service.

Building the scenarios for each task ensures that all users follow the same process, and that measures taken are comparable (e.g. time and errors measures, and subjective data).

6.3.4 Evaluating the designs

6.3.4.1 General

Evaluation, in human factors terms, is a process for gathering information about how users will perceive and use a product or system.

It is recommended that evaluation:

- is done early in the design stage to compare product concepts, user interface prototypes and draft user guidance materials against predetermined usability criteria to avoid costly mistakes;
- includes evaluation against usability criteria as part of the design decision making;
- ensures all trials are conducted with a representative sample of users, including people with special needs. Ensure that the representative sample does not include any persons with overt connections with the development under review;
- at the prototype stage compares preferred design and design alternatives, for rate of errors, speed of performance, time to learn and subjective preferences against the predetermined usability criteria;
- results in a modification of the design to optimize the performance of the target user group on the product or system.

Evaluation is an essential element of human-centred design. By involving potential users in the design process to test out parts of the system and prototypes it is possible to highlight areas of difficulties and to improve the design details.

Expert evaluation as well as laboratory trials should always precede the field trials. In the laboratory trials the main usability problems can be identified and they can be solved before the field trials. In this way, in the field trials you can concentrate on collecting feedback that only can be got in the field, e.g. the usability and utility of the system in real and continuous use.

Very often, usability techniques are only considered at the end of the development of a product, which is a mistake, since potentially costly mistakes can be avoided if usability is considered in all steps of the development process.

Usability can be evaluated by either an analytical checklist or by usability testing.

6.3.4.2 The Analytical Checklist Approach

A usability checklist is based on accepted design rules and standards, which represent a set of requirements for the usability components identified. An example checklist prepared for ordinary telephone terminals has been published by ETSI (ETR 051 [11]).

An evaluation method was devised in January 1995, as a supplement to ETR 051 [11], to assist the evaluator when dealing with issues relevant to people with special needs.

The evaluation method consists of usability assessments of 56 components/facilities of conventional telephones. The method provides guidance on the pertinent questions to ask; what technique(s) is (are) appropriate for data collection, and what is the range of acceptable responses. Although the method is evaluative, it is not designed to generate a single or summative value statement.

The method is designed for both early and late evaluation. In the former case, a design document can be inspected and assessed against the acceptable range for each usability component/facility, and appropriate recommendations can be made. Late evaluation requires an existing product or a high fidelity prototype.

It is most useful for pre-release usability assurance and for comparing competing products against a common benchmark. In the case of early evaluation, the most commonly used technique would be a checklist. In contrast, all forms of late evaluations will require a mix of empirical or objective assessments (e.g. experimental techniques) and more traditional subjective assessments using questionnaires. These techniques are well-known see clause 6.3.4.3.

The evaluation method concerns different groups of disabled users. Annex A provides a pre-questionnaire and checklists for each group of disabled users to make it possible to use the evaluation method for any single group of disabled people, without having to consult all the questions. It also contains suggestions for presenting the results.

See also clause 5 for full details about disabled users and their handicaps in relation to ICT products and services.

6.3.4.2.1 The usability components/facilities

The usability components/facilities are mainly organized according to the "Usability Component Model" used in ETR 051 [11]. This scheme for organization has been developed to enable the easy identification of important characteristics for the design of usable telephones.

The usability components/facilities to be assessed are:

1.1	**Physical interface - anthropometric usability components**
1.1.1	Shape and size of the handset
1.1.2	Shape of the earpiece
1.1.3	Space for the fingers on the handset
1.1.4	Key spacing between each key
1.1.5	Size of the keys
1.1.6	Curvature of the top of the keys
1.1.7	Material of the top of the keys
1.2	**Physical interface - motoric usability components**
1.2.1	Length of the cord of the handset
1.2.2	Fastening of the cord of the handset
1.2.3	Position of the fastening of the cord
1.2.4	Weight of the telephone
1.2.5	Portability of the telephone
1.2.6	Weight of the handset
1.2.7	Balance of the handset
1.2.8	Pressure needed to activate the keys
1.2.9	Pressure direction of the keys
1.2.10	Height/recession of the keys with regard to the surface of the keypad
1.2.11	Operation of the volume control
1.2.12	Position of the control for adjusting the volume
1.2.13	Method for adjusting the volume of the ringing tone
1.2.14	Position of the control for adjusting the ringing tone
1.2.15	Tilt of the keypad

1.3	**Physical interface - perceptual usability components**
1.3.1	Incorrect position of the handset
1.3.2	Size of the characters on the numeric keys
1.3.3	Contrast between the characters and the background on the numeric keys
1.3.4	Size of the characters on the supplementary keys
1.3.5	Contrast between the characters and the background on the supplementary keys
1.3.6	Contrast between the keys and the background
1.4	**User input/output - motoric usability components**
1.4.1	Activation by simultaneously pressing two or more keys
1.5	**User input/output - perceptual usability components**
1.5.1	Multiple indications of adjustings and choices
1.5.2	Controls, keys and adjustment settings requirements
1.5.2.1	Activation of adjusting controls and special keys by mistake
1.5.2.2	Haptic feedback from pressing the keys
1.5.2.3	Auditory feedback from pressing the keys
1.5.2.4	Operation of the volume control
1.5.3	Tones and indications requirements
1.5.3.1	Volume
1.5.3.2	Sidetone
1.5.3.3	Adjustment of output volume
1.5.3.4	Volume of the ringing tone
1.5.3.5	Different tones of the ringing tone
1.5.4	Screen display requirements
1.5.4.1	Size of the characters on the display
1.5.4.2	Contrast between the characters and the background of the display
1.6	**User input/output - cognitive usability components**
1.6.1	Layout of the keys
1.6.2	Tactile marking of the number 5 numeric key
1.6.3	Separation of the key groups
1.6.4	Space for symbols or pictures at/on the quick dialling keys
1.6.5	Labelling of the control for adjusting the volume
1.6.6	Labelling of the control for adjusting the ringing tone

These facilities do not apply to ETR 051 [11] as this does not contain facilities.

2.1	**Conventional facilities**
2.1.1	Sturdiness
2.1.2	Non-skid
2.1.3	Quick dialling
2.1.4	Repeat call
2.1.5	Hands free operation
2.1.6	Display
2.1.7	Directions for use
2.2	**Facilities especially for disabled users**
2.2.1	Possibility for a handset holder
2.2.2	Possibility for a keyguard
2.2.3	Built-in inductive coupling
2.2.4	Possibility for connection of an inductive coupler and/or audio amplifier

6.3.4.2.2 Groups of disabled users

The evaluation method concerns the following group of disabled people and they can also take part in the assessment of the telephones (except for people with low voice output):

Visually impaired people:
- people with low visual acuity;
- people with restricted visual field (e.g. "tunnel vision");
- people with obstructed vision (e.g. cataracts).

Blind people:	- people blind from birth;
	- people with acquired blindness.
People with	
reduced mobility and strength:	- people with muscular dystrophy;
(they need to be able	- people with arthritis.
to lift a handset)	
People with	
unco-ordinated movements:	- people with cerebral palsy;
	- people with multiple sclerosis.
People who are hard of hearing:	- people who normally use hearing aids;
	- people who will not use hearing aids.
People with	
learning difficulties:	- experts on the problems that people with severe learning difficulties have.
People with low voice output:	- people who use a voice amplifier for speaking;
	- people who speak with the oesophagus;
	- people who suffer from multiple sclerosis;
	- people who suffer from muscular dystrophy.

6.3.4.2.3 The subjective assessments

Subjective assessments involving disabled users are carried out either to complement objective measurements, or when objective measurements are not possible, or when the objective measurements are difficult to interpret.

Only users affected by the relevant item are involved. It is important that the group of users is representative with respect to age and gender. Also, the environment where the assessments are carried out need to be the same during the whole assessment procedure.

The method describes for each item which groups need to be involved and what questions they may be asked. In addition questionnaires for the user tests are enclosed in annex A.

The users are asked one or two questions about the relevant item and are then asked to rate their answers as "very bad", "bad", "acceptable", "good" or "very good".

6.3.4.2.4 The objective measurements

Measurements should only be carried out by professionals following the recommendations given in the relevant clauses of this document. In many cases the criteria for evaluation are described by numbers, but in some cases sufficient knowledge about exact numbers does not exist, therefore the criteria are described by text only.

6.3.4.2.5 Analysis of the results

The assessments from the questionnaires that users have filled out are collected, each feature of each telephone is analyzed, and conclusions are drawn, after which a final evaluation of the telephone can be made.

The results may be presented in many ways. Examples of presentation are given in annex C.

6.3.4.2.6 Using the method

Described below are some generic steps which users of the method are advised to follow:

a) specify the purpose of the evaluation (e.g. to make comparisons, to evaluate a design);

b) define your Evaluation Group (e.g. who are target users, describe their defining characteristic);

c) relate the Evaluation Group to the most appropriate usability components/facilities. This will help in the selection of only the most critical components for that particular target group;

d) based on the selected components and the purpose of the evaluation, determine the most appropriate data collection or technique(s) (e.g. questionnaires, expert review, experimentation). In most cases, more than one technique should be considered in order to provide both an objective and a subjective assessment;

e) carry out the evaluation study;

f) analyse the data using descriptive and/or inferential statistics as required;

g) draw conclusions and make recommendations which are relevant to the selected target group of users.

6.3.4.3 The Usability Testing Approach

Usability tests can measure both user performance (time, errors, learn-ability, etc.) and user preference (satisfaction, acceptability, aesthetic appeal, etc.). The evaluation can be related to absolute criteria (e.g. time to complete a task, percentage and type of errors per task, or specified ranking on a standard satisfaction inventory) or alternatively, it can be comparative (users perform better and prefer the new prototype to the old system, or people make less errors on product A than on product B). Usability tests require a sample of users to perform a sample of tasks on the product or system, and for a variety of measures to be taken and analysed. Obtaining reliable data from experiments involving people is not a simple task, without due care and attention to correct procedures the experimenter/data collector can significantly affect the results.

ITU-T and ETSI have both published guidance for the usability evaluation of telecommunication systems and services (ITU-T Recommendation F.901 [83] and EG 201 472 [4]).

The following table summaries the properties of evaluation methods that have been reviewed in EG 201 472 [4] which aims to help evaluators compare and choose the most appropriate method for their requirements at a particular stage of evaluation and should be consulted for further information.

The table is divided into two different parts: the first part describes testing and evaluation methods, and the second part includes data collection and measurement techniques. This means that you can undertake one of the methods in the former category with any (although not always!) of the data collection methods in the later category. For instance, you can plan experiments gathering data by means of audio-video recording and questionnaires at the same time. But, for example, questionnaires are usually not used at the same time as observation.

Of course, the usability expert is always free to choose a method according to some other specific needs, however, we have tried to provide details of the most common techniques, and also their most likely applications.

Table 4: Testing and evaluation methods

Method Name	Design cycle Stage	Users Needed	Main Advantage	Main Disadvantage
Experiments	Components (hardware or software) design. Establishing generic principles for system design, basic HF research.	Depends on complexity. At least 10 for design cell	It allows to test design hypotheses or competing alternatives in an optimal way.	Complex techniques involved, which requires expert knowledge for maximum benefit. Usually made in the usability laboratory, and not in the real use environment.
Field Observations	Final testing. Task analysis.	3 or more	It is made in real use environment: provides first-hand feedback on the user's interactions in the context of the real task, and it is flexible to circumstances.	Very costly. Difficult to analyse, and to know the reasons for behaviour. Different observers may differ in interpretations
Heuristic evaluation	Early design, "inner cycle" of iterative design	None (it is made by experts)	Finds out individual usability problems. Can address expert user issues.	Does not involve real users, so does not find "surprises" relating to their needs.
Focus groups	Task analysis, user requirements	6-9 per group	Spontaneous reactions and group dynamics. Allows to find out opinions or factors to be incorporated in other methods (e.g. surveys)	Hard to analyse. Low validity.
Input logging	Final testing, follow-up studies	At least 20	Finds highly used or unused features. Can run continuously, and may be felt non-intrusive. Data gathering is automatic, and a permanent record of the interaction can be kept.	Analysis programs needed for huge mass of data. Data is at a very fine level, requiring time-consuming data consolidation and reduction. Violation of users' privacy.
Surveys	Follow-up studies, User feedback. User requirements.	Hundreds	Tracks changes in user requirements. Analysis of user's opinion for the working system in its real environment.	Sampling procedures and field tests organization require a lot of work, thus costly.

Table 5: Data collection and measurement techniques

Technique	Method in which it is used	Main Advantage	Main Disadvantage
Questionnaires	Surveys. Experiments. Structured interviews.	Easily elaborated and compared, once a validated instrument is developed. Written interchange inherently more "formal" and less natural than a spoken interchange May be self-completed by users, and thus easy and cheap to repeat. Usually appropriate to find out subjective user preferences and attitudes.	Pilot work needed to validate the instrument can be costly and complex. May require prompting to users for stimulating completion. Less effective communication: questions and answers may be interpreted differently or not be well understood. Contradictions may be overlooked or require second round of questions to check.
Interviews	User requirements. Task analysis	Flexible, in-depth attitude, experience probing and spontaneous information. Effective communication: ability to explain questions better and to interpret answers better. Contradictions may be pointed out and explained right away.	time consuming. Hard to analyse and compare. Open answers data must be consolidated and structured for comparison. Requires considerable manpower. Reactions may be influenced by interviewer.
Performance measures (e.g. reaction time, error rates)	Performance evaluation Experiments	Objective measures. Results easy to compare. They can be also taken by experts (e.g. mistakes) and include expert judgments	Does not find subjective constructs (opinion, attitudes, satisfaction).
Thinking aloud	Experiments. Interviews.	Points out cognitive processes implied in the use of the system. It highlights users' misconceptions and conceptual models.	Unnatural for users. Hard for expert users to verbalize. Information is difficult to analyse.
Audio-video recording	Observation Experiments	Records all behaviours and can be kept for analysis in the future. Wealth of data also on "body language" reactions Possibility of multiple analysis by different observers increasing reliability of results	Ethical and legal requirements (see clause 9). Behaviour has to be categorized. Very costly and lengthy (10 hours to analyse satisfactorily 1 hour of videotape)

6.4 Human-Centred design - Summary

The usability activities in the design process can be described as:

1) Define initial user requirements;

2) Visualize design decisions in the software requirements phase:

   - use case descriptions;
   - screen views, user interface prototypes;
   - collect feedback and new ideas from the users,

3) Prototype during the design phase and evaluate with the users;

4) Organize field trials in the end, but it is recommended not to plan field trials without having laboratory tests with the users first. In the laboratory trials the main usability problems can be identified and they can be solved before the field trials. In the field trials you can get feedback of the usability of the system in real and continuous use.

- The above mentioned activities should be integrated with other system development activities, e.g. analysis, design, testing.
- The plan should identify the persons or organizations that are responsible for the Human-Centred Design activities and the range of skills and viewpoints that they provide.
- The plan should define the procedures for analysis of the results of the evaluation and feedback of the results to the design. The plan should also define how to document the iterative design.
- There should be milestones for the Human-Centred Design activities.
- The project time scale should allow for the feedback and for the possible design changes. It is especially important to assure that there are evaluation activities during the early phases of the design.
- It is essential that the users and the designers participate together in most activities. Second hand information is never the same as actually meeting the users and seeing how they cope with your system.

7 General design issues

7.1 General principles

7.1.1 Introduction

Interface design principles are the generic rules and concepts that underlie the development of all applications.

Much work has been done in the fields of psychology and human computer interaction studying peoples' use of ICT products and services, in an attempt to understand what features make systems easier to use. This has enabled researchers to derive some general design principles that if followed should decrease the likelihood of users experiencing problems. For example, Shneiderman [130] describes eight golden rules of dialogue design: strive for consistency; enable frequent users to use shortcuts; offer informative feedback; design dialogues to yield closure; offer simple error handling; permit easy reversal of actions; support internal locus of control; reduce short term memory load.

Obviously, these principles need to be interpreted in the light of the particular design context, with reference to the information available about the intended ICT product or service users, tasks that the service will support and the operating environment.

This clause contains more specific design guidelines covering general design issues; dialogue styles; user support and security issues.

The following clauses contain more details on specific guidelines and recommendations related to product and service input and output components; hardware issues and service specific issues.

7.1.2 Adaptability

(Personalization, Configurability, Customization)

This is the facility to allow a terminal or service to be adapted to the specific needs or preferences of the user.

Cross references:

Adjustability, Assistive technology, Electronic input, Multimedia/multimodal, Feedback.

Recommendations:

- Allow users to install personal environment/customization/adaptation settings with one command from any location in the system, either from an internal/external drive, or from the Internet.
- Support the addition of assistive technology devices within the design. This can overcome the problem of miniaturization that is common in for example mobile devices.
- Allow the output from the device to be accessed before the presentation level so that it can be adapted to the users' specific needs.
- Allow configuration of the system to the most appropriate media for the users' special needs, both for input to and output from the system. The user interface should be adjustable to individual needs.
- Store personal user information for adapting the system for example on a smart card.
- Allow public access terminals to be adapted to all users. The terminal needs to be able to adapt to the physical requirements, the auditory requirements, the visual requirements, the dexterity requirements and the cognitive requirements of the users.
- Use automatic adaptability features with care. This should be under user control with an over-ride facility.

Additional comments

There is a wide understanding that different groups of users have special needs that should be taken into account by designers of mass-market products. To assist in catering for such needs, special equipment adaptations can be provided. These special devices exist to assist disabled people when using ICT products and services.

Examples of special adaptations for the visually impaired are: Large displays; Tactile indicators to indicate phone states; Speech output to confirm digits pressed.

Examples of special adaptations for the hearing impaired are: Flashing lights on the phone indicate incoming calls. Inductive couplers which improve the clarity of incoming speech for hearing aid users. Incoming speech amplifiers with variable volume control. Text phone based on an electronic keyboard and screen.

Examples of special adaptations for the voice impaired are: Conversation phones which amplify outgoing speech. Textphones, and devices which can speak recorded phrases (including emergency messages) by pressing buttons on a keypad. Speech synthesizers linked to a telephone.

Examples of special adaptations for the physically impaired are: Devices for holding the phone handset or resting the handset on the shoulder; Headsets for permitting conversation without needing to hold a handset; Speech input devices for dialling and receiving handsfree phone calls.

7.1.3 Adjustability

(Repetitive Strain Injury (RSI), Swivel and Tilt, Settings)

This is the facility to position and re-position a module or a complete terminal and to alter the settings to meet the specific personal requirements of the user.

Cross references:

Adaptability; Casework; Visual Displays; Flexibility; Portable and mobile equipment.

Recommendations:

- Consideration should be given to the construction of all single unit terminals, to facilitate adjustment of the terminal to optimize the orientation of the elements critical to the user (e.g. swivelling the display to avoid reflections)

- If the terminal integrates a visual display terminal and keyboard, the keyboard should be separate from the display unit and the keyboard and display unit flexible enough to allow a range of working arrangements [2]. The display unit should allow the following adjustments:
  - Screen tilt: -5º to +20º (from the vertical).
  - Screen height 110mm (minimum).
- The screen should also rotate as far as possible in either direction.
- If the keyboard is also adjustable, at least one position within the range of adjustment should meet the height requirement of 30 mm on the "C" row.
- When an item is being adjusted, enable the item to remain stable while the adjustment is locked. If possible the whole procedure should be possible one handed.
- Give consideration to the construction of the terminal for the replacement or parallel operation of control and display areas, to maximize the opportunity for people with special needs to use alternative input and output technologies to the standard fit.
- When terminals or terminal modules are adjustable, provide adequate hand positioning points with suitable friction surfaces to assist in making the adjustments.
- Allow the user to alter the settings such as volume, brightness and contrast so as to meet their personal preferences and to cater for changes in the environment.
- Public access terminals should accessible to all users including those in wheel chairs. The terminal needs to be both accessible for height and reach limitations. There should be sufficient room around the terminal, clear ground space of at least 760 mm deep by 1 220 mm wide.
- The device should not impose undue restrictions on the position of the user during extended use (e.g. use extendable receiver cords or portable videophone displays).

Additional comments:

It is a physiological requirement that people adjust their posture to relieve stresses on the body. Therefore it is essential that equipment designs should not constrain people to work in fixed or cramped postures, especially when the equipment has to be used over extended periods. This applies equally to the end-users and maintainers of the equipment.

More information can be found in [52].

7.1.4 Colour

(Hue)

Is the sensation produced on the eye by rays of decomposed light. It can either be direct as the colour on a display screen or reflected as on paper or material.

Cross references:

Casework colour; Keys; Displays.

Recommendations:

- Avoid using colours from the opposite ends of the spectrum. In particular red and blue/cyan should not be used to differentiate two items of information since the user will have difficulty in focusing these colours at the same time.
- Use no more than five colours when coding information.
- Adhere to existing colour conventions, e.g. red for danger/heat/stop, blue for cold etc. If meanings are arbitrarily used provide users with a table showing the colour associations.

- Avoid shades of blue, green and violet for conveying information - yellowing of the cornea with age interferes with the passage of blue light and can cause confusions between these shades.
- Use colours to structure the display and group categories of data.
- Contrast ratio should be maximized when selecting colours for background and foreground elements. Black text on a white background provides the highest contrast ratio and optimizes visual processing for text. Real contrast for other colours will depend on the presentation device used.
- Use a casework colour that contrasts with the controls.
- Avoid using very dark or very bright colours, keep the difference in average luminance between different visual task areas within a ratio of 10:1 [53].
- Use matt rather than gloss finishes to products in order to minimize glare.
- It is important that the contrast between character and background on the keys is high enough for visually impaired people to easily read the character. White on black or dark blue background is the best. Poor combinations are white/a light or pale colour, black/a dark colour, red/green or blue/yellow.
- It is important that the contrast between the keys and the background is high so that visually impaired people can distinguish the keys from the background. White on black is optimum. Poor combinations are white/a light or pale colour, black/a dark colour.

Additional comments:

Colour is important in effective display and hardware design because it makes the screen layout attractive; it may reduce user's interpretation errors; it emphasizes logical organization of the information; and is very efficient at drawing the user's attention to a given part of the screen. However, colour is difficult to use correctly. Colour can be a powerful medium for coding but should be used carefully. Many users will be unable to distinguish certain colour combinations. See clause 5 for details of colour disabilities in the population. The environment also effects human colour perception e.g. lighting conditions may change the colours we see to less effective ones in display terms.

Tables 6 and 7 give recommendations for colour combinations for printed material and displays.

Table 6: Suitable colour combinations for characters/symbols and the background for printed materials

Background	Colour of character/symbol							
	Black	White	Magenta	Cyan	Yellow	Green	Red	Blue
Black		+	+	-	+	-	+	-
White	+		+	+	-	+	+	+
Magenta	+	+		-	+	-	-	+
Cyan	-	+	-		+	-	-	+
Yellow	+		+	+		+	+	+
Green	-	+	-	-	+		-	-
Red	+	+	-	-	+	-		+
Blue	-	+	+	+	+	-	+	

Table 7: Suitable colour combinations for characters/symbols and the background for luminous displays (e.g. monitors)

Background	Colour of character/symbol							
	Black	White	Magenta	Cyan	Yellow	Green	Red	Blue
Black		+	+	+	+	+	-	-
White	+		+	-	-	-	+	+
Magenta	+	+		+	+	+	-	-
Cyan	+	-	+		-	-	+	+
Yellow	+	-	+	-		-	+	+
Green	+	-	+	-	-		-	+
Red	-	+	-	+	+	-		-
Blue	-	+	-	+	+	+	-	

7.1.5 Consistency and Standardization

(Styleguides, Stereotypes)

Consistency within the way a terminal operates allows the users to improve their skills and predict the effects of their actions.

Standardization provides for compatibility between systems which allow the user to transfer learning from the conventional telephone service, other terminal equipment and the proprietary software of other terminals. Standardization also provides manufacturers and service providers with a recognized benchmark for the appropriate technology to assist in both procurement and approvals.

Cross references:

Call Handling; Dialogue Styles; Flexibility; National Variations; General Design Issues.

Recommendations:

- There should be consistency across the whole user interface.
- Consistency of language should be applied so that the terms or labels used on the display, keyboard or control panel and any documentation are the same e.g. A key labelled CANCEL (or DELETE, or CLEAR, etc.) may be used to undo the last action. Whichever the choice, always use the same word (in this example CANCEL) whenever it is referred to throughout the dialogue and the supporting documentation. Avoid introducing synonyms, such as clear, undo, erase, etc.
- Consistency of effect should be applied so that the user perceives an action as having the same outcome regardless of mode or level within the system e.g.
  A simple way of switching a feature on and off is to press the feature key. The user may predict that this simple strategy applies to all feature keys and will make errors if sometimes two presses of one key leads to a different feature, or that one feature has to be cancelled with the cancel key.
- Apply a consistent syntax and logic to procedures and sequences so that frequent users of the system can develop their skill and speed, e.g.
  LOG ON can be consistently "User-Name, Password, Enter";
  HELP can be consistently available via the function key "F1";
  COMMANDS can be written "Verb, Separator, Noun 1, Separator, Noun 2", etc.
- Structure the visual display layout so that the user can predict where to find required information e.g.
  Top Line - Screen title, application and file names.
  Second Line - Pull down menu bar.
  Bottom Line - Status information and low-level messages.
- User control procedures for basic voice call set-up, incoming call and call terminate should be available to users in a form which conforms with the basic telephone.
- User control procedures for non-voice, and voice plus, systems (e.g. videophones, voice/data, multimedia) should conform as far as possible to user's available experience with conventional telephone systems.
- Whenever appropriate, reference should be made to internationally recognized standards and guidelines.
- Where a telephone application is run from a multi-purpose terminal, reference should be made to appropriate proprietary software standards and style guides, to present a consistent look and feel to the interface.
- Ensure the electrical interfaces between peripherals and user control procedures are standardized to allow people with special needs to be able to connect modified control or output devices. i.e. provide a standardized assistive technology interface.
- Protocols for communication between smart card, transponder and reader should be standardized so that the users can use their own personal equipment as an interface when communicating with the system.
- Interoperability between smart card readers and different types of terminals (e.g. television, telephone and PC) should be provided.

- The connection between terminals and personal user interfaces/equipment (e.g. headphones) should be standardized.

Additional comments:

Most people have a well-developed skill in detecting patterns and developing hypotheses and rules about how things behave. Consistency within the design exploits this human capability and allows the users to improve their performance and minimize errors. Inconsistencies which break the overall pattern are a source of error which can lead to frustration, loss of confidence and rejection of the system.

Terminal designers should also be aware that there can be a trade-off between consistency and other user interface principles, like customization, flexibility, etc. For example, one consistency rule could suggest that a menu always has the same default item highlighted; whereas a contrary consistency or flexibility rule might suggest the highlight is always on the most recently selected item, as that may be the most likely next selection. The existence of such trade-offs makes the requirement for a thorough understanding of the user's tasks much more important, the provision of easy to modify software prudent and the need of usability trials essential.

Matching user experience and expectations can significantly improve learning times and reduce error rates. Where incompatibilities occur, these should be examined since they are likely to be a major cause of user error. Where possible, the system should detect or compensate for these errors by offering some degree of flexibility. The marketing strategy of deliberate non-compatibility is not in the user's interest and could inhibit the overall take-up of the ICT product or service if users find that they are unable to communicate with others.

7.1.6 Error Management

(Accidental operation, Error Handling, Error messages, Mistakes; Undo)

Making errors is a part of the natural learning process and also the result of breakdowns in skilled performance. Users will make mistakes and errors. To be helpful, the user interface and system design needs to ensure the impact of user errors is minimized and where possible recoverable.

Cross references:

Feedback; Help; User Support; User prompting; General Design Issues; Security.

Recommendations:

- Error messages should be displayed immediately after the user entry in which the error is detected.
- Allow the system to be configured by the user to allow longer than normal timeouts. This would allow an elderly or disabled user to input data at their own rate.
- Use error messages which do not blame the user, and which prompt the user on the correct action or choices.
- When exiting or recovering from an error, put the user back where the error was committed, particularly if they were part way through a procedure.
- The system should be designed to be error tolerant, protect from serious consequences and allow easy recovery.
- Provide simple error recovery, for example, delete last key stroke to correct minor keying errors.
- Minimize the number of keystrokes in order to reduce keying errors.
- Provide visual or auditory feedback to allow users the opportunity to review entries.
- It should be possible for users to review and correct speech input entries.
- With complex systems allow for at least one level of undo last command, a user will feel that they can try things without damaging the system or the information if this is available.
- With complex systems allow the user a quick escape route back to a recognizable point such as an opening menu, or current active work area.

- Design the system to protect the user from the consequences of errors or forgetfulness e.g. Make it difficult for a user to accidentally delete the contents of a personal telephone directory; Remind the user of a call left on hold.

- Provide context sensitive error messages or help which will allow the user to recover from, or overcome, the source of the error e.g. "the number you have dialled is temporarily unavailable, please try again later".

Additional comments:

The normal breakdown of human behaviour is sometimes quoted as one in one hundred, which is greatly in excess of the accepted engineering breakdown tolerances that may be as low as one in one million operations. Design ought to allow for, and minimize, the impact of human errors and encourage rapid recovery.

One of the main differences between skilled behaviour and novice behaviour is not so much in the number of mistakes made, but in the amount of time the novice spends trying to recover from mistakes. A novice may reject a system as too difficult if they are unable to recover from their first few minor errors.

7.1.7 Feedback

(Indications)

A response from the system to the user acknowledging that an action, or activity is taking place, or has failed.

Cross references:

Acoustic Signals; Optical Signals; Response Times; Speech Output; General Design Issues; Error Management.

Recommendations:

- Feedback should be continuous during the entire operation of the service.

- Feedback should always be given in response to all user actions. Feedback needs to be considered at two levels:

    1) on the controls correct or incorrect activation, e.g. tactile feedback to a key press, pointer movement to a mouse movement, etc.

    2) on the terminal's, network's or system's response to the control input, e.g. the display of a character, menu or dialogue box, the sounding of an acoustic signal, etc.

- Feedback may be positive, e.g. progress statements or "action complete"; or negative, e.g. error messages. In general people are thought to learn better from positive feedback.

- Feedback is important to let the user know the system/terminal status. It is essential as an aid to learning and should always be immediate, but especially so in the case of errors and faults.

- Feedback should always be consistent and tested to ensure conformity to user stereotypes.

- In general, essential feedback should not be restricted to one medium (visual, auditory, tactile). Duplication across different media should be available to support people with special needs, e.g. network activity, such as call progress, has been signalled by audible tones, but they may also be augmented by lamps or display messages in text or pictogram form. Spoken messages may be used as an extension of audible tones.

- It should be possible for users to configure the system so that feedback is always given in a medium and timing appropriate to their needs.

- Provide feedback as users perform tasks to make it as immediate as possible.

- In Direct Manipulation Interfaces, when a user initiates an action it is mandatory that the system provides some indicator, visual or auditory, or preferably both, that the application has received the user's input and is operating on it.

- For speech input systems it is particularly important to give feedback on all input, due to the high error rate.

- It is mandatory to warn people before they initiate a task that will cause irretrievable data loss. For instance, when trying to erase a file (or a message in a voice mail service), display a message such as "If you erase this file, you will not be able to recover it. Do you want to go on with the operation (Y/N)?".
- When the system is processing a task, clearly inform the user by means of a different cursor, e.g. an egg timer or watch (this depends on the particular system), or simply by displaying a message "Please wait".
- When the operation is going to be lengthy (more than 15 seconds), such as a retrieval task, or a complex search in a database, provide feedback on how long the operation will take, or visual feedback that the process is continuing. An example of this is by means of a thermometer dialogue box, in which a bar moves as the task is being performed.
- When task performance requires data exchange and/or interaction with other users, allow the user to obtain status information concerning other people currently using the system.
- When task performance is affected by operational load (e.g. a number of on-line users), allow the user to obtain status information indicating current system performance, expressed in terms of computer response time.

Additional comments:

Feedback is an essential element of good interface design practice. It raises confidence in using the equipment, helps users to overcome errors and reduces learning time.

However, feedback can make the system slower for experienced users, or for those who require a very fast operation. This depends on the terminal equipment and the media requirements.

7.1.8 Flexibility

(Configurability)

Flexibility within the dialogue design accommodates different methods for achieving the same objective, and allows the user to apply different methods as their skill and experience develops.

Cross references:

National Variations; General Design Issues.

Recommendations

- Applications should accommodate differing user expectations and preferences at the simplest level (e.g. dates, punctuation conventions, national characters) and consider alternative control sequences or procedures to adapt to users' previous experience or to improve compatibility with other systems e.g. the date could be accepted in any familiar form:

  24.02.1992

  24/2/1992

  24 February 1992

- Consider permitting alternative control or command sequences to protect users from unnecessary pseudo errors, or to improve compatibility with other similar systems, e g. with a credit card payphone, permit the sequence of inserting the card before or after lifting the handset.
- Where a system may be used by skilled users, offer short cuts, more powerful command sequences, or codes that allow for quicker or more efficient operation e g. allowing a user to enter a short command rather than wait for a menu to be displayed visually or presented as speech output.
- Rational trade-off between complexity and increasing number of options should be carried out before the design specification is finished. Early design testing can help to indicate the best option to meet all these often conflicting requirements.
- The system should adapt to all possible users' expectations and stereotypes, or more precisely, previous knowledge on the operation of similar systems.

- Allow systems to be driven by both command languages and simple graphical user interfaces. This allows commands and procedures to be introduced by both written expressions or signalling with an e.g. pointing. The first possibility is important since there will be some people (blind people, experienced programmers) that will need or like this form of interaction with the computer. The second will be welcomed by those people who like the visual aspect of the interface and the ease of interaction.

Additional comments:

Flexibility within the design helps to protect novice users from frustrating minor errors that can arise as a result of breaking minor design rules.

Novice users may, however, be confused if too many choices are offered too early when they have no knowledge of how to choose between a number of options. Early design testing can help to indicate the point of balance between too much and too little flexibility.

Establish acceptable default values that can be easily personalized or returned to the default value as preferred e.g. page sizes, colour codes, or address labels.

Allow for easy personalization by people with special needs, by means of allowing settings to be altered by use of, for example, smart cards.

7.1.9 Response Times

(System Response, Timeouts)

Response time is the time taken for the system to respond to the users' inputs or commands.

Cross references:

Call Handling; Feedback; General Design Issues.

Recommendations:

- In principle, response times, from control activation to displayed result, should be as short as possible.
- Response times should match the speed and flow of human thought processes. Table 8 shows recommended response times.
- Unpredictable and variable response times are not acceptable (maximum variation ±10 %). In practice, users will accept small delays to maximize response time consistency. For example, terminal generated responses times should try to be consistent with those of the network, for similar user features.
- Where long delays are the result of task complexity or network constraints, immediate acknowledgement should be given together with an indication of how long the delay will last with an option to abort if the delay is unacceptable. In general, delays likely to be longer than 1 or 2 seconds should be supported by feedback.
- Consider whether tasks that necessarily take a long time, such as a file transfer or printing, may be carried out automatically as a background operation while the user performs other tasks.
- Ensure timeouts at any part of the dialogue do not affect people who may be slower than normal in entering control responses to dialogue requirements, particularly if there are amounts of data to be assimilated/comprehended. Follow the principle of the user being in control at all times. Ensure that the dialogue is patient and forgiving to user delays, without being condescending.
- Ensure timeouts do not inadvertently cause loss of data, particularly if the user has paid for it as part of a communication.
- In general, ask the user to confirm timeouts before disconnecting or losing a dialogue. Possible exceptions include situations where the current displayed information is security sensitive, or personal; even then consider the option of screen savers with passwords, etc.

Additional comments:

It has been found that as systems improve and users gain more experience, faster response times may normally be expected. This should be balanced against the finding that some response times may be felt by the user as too fast, forcing the operational pace and causing stress. Configure systems to have response times and timeouts set by the user so that for example an elderly or disabled user can input data and interact with the system at their own rate.

Table 8: Recommended response times

User activity/task	Time	Telecommunications examples
Reaction to key actuation	0,1s	Audible or tactile confirmation of successful key actuation. LED signal as a status check. Displaying an entered character on a visual display. Switching on a loudspeaker, microphone. Switching through a connection.
Display of short and simple guidance information that can be taken at a glance	0,5 s	User prompts. Error messages. Reception of a system's ready status, e.g. dial tone on lifting handset. Information on single or two line displays, e.g. display texts for telephone applications. Paging through a list or menu on a line display. Paging through a telephone directory or notepad. Displaying document headings when paging through a document file. Calling up a menu, displaying the following menu.
Display of large amount of complex information that needs to be read	1,0 s	Opening a document in an activated program. Displaying the next page in the document. Displaying a document section selected by means of scroll bars. Calling up a complex operating field or dialogue box. Terminating a program.
Simple inquiries	2,0 s	Activating a service or program with a function key, menu item or icon Ringing tone and busy tone after dialling. Status interrogation, e.g. services on an ISDN feature telephone. Reaction after insertion of a chip card. Making up a page. Manipulating graphics. Calling up a specific page in a long document.
Complex inquiries	5,0 s	Identification at a terminal. Opening a document, including activation of associated processing program. Making up an entire document. Interrogating a database.
Program loading and execution	up to 15,0 s	Resuming a defined work status. Loading long programs. Executing complex programs. Automatic layout processing performed on long documents (more than 10 pages), e.g. dictionary-based syntax checks, teletex to telex format conversion, word searches, search and replace operations.

7.2 Dialogue styles

7.2.1 General

(User Interface Style)

Dialogue style refers to the overall character of the interaction between the user and the system used to achieve a specific goal. It includes such considerations as who has the initiative, how much support the system gives to the user and how much power the user has over the system.

A good dialogue style should be suitable for the task, self-descriptive, controllable, should conform with user expectations, be error tolerant, be suitable for individualization and should be suitable for learning [59].

Cross references:

Auditory Menus; Command Language Style; Control Key Dialogues; Error Management, Graphical User Interface; Menu Dialogues; Phone Based Interface; Usability.

Recommendations:

- Make the dialogue appropriate to the task complexity and the user's level of skill.
- Use self-descriptive procedures whereby the user can immediately perceive what to do.
- Simplify interaction by reducing the number of commands to be remembered and the number of keystrokes to be entered.
- Provide feedback immediately as confirmation of input.
- Provide error handling so that users can correct data input errors and reverse actions requested in error. If appropriate, provide error detection and offer informative error messages indicating what to do next.
- Provide flexibility to allow for differences in user expectations and short cuts for skilled users, to improve compatibility with other systems and to allow for national variants.
- Maintain compatibility with user's expectations and their experience with other systems.
- Offer redundancy in input and output where the user's attention may be diverted to other tasks, and to accommodate people with special needs.
- Undertake prototype and evaluation of design decisions so as to optimize the dialogue design.
- Use hierarchical menu structure to guide users through more complex tasks;
- Consider auditory dialogues to support users where input and output devices are limited;
- For skilled users of more complex tasks provide short cuts and more powerful command entries;
- Consider mixed dialogues including form filling, graphic, object manipulation and animation to support users controlling more complex tasks with multi-function or multimedia terminals.

Additional comments:

A summary of the advantages and disadvantages of different dialogue styles is shown in table 9.

Table 9: Dialogue style: summary of advantages and disadvantages

Dialogue Style	Advantages	Disadvantages
Menu	improved learning reduces key strokes reduces memory load structured decisions error recovery	length of hierarchy slow for frequent users requires auditory or visual display consumes display space or loads user memory requires system responses in real-time
Command language	powerful interface economical in screen space conciseness may assist disabled users	inappropriate for naïve user difficult to learn loads user memory generally requires training
Phone based interface (12 key entry)	flexible, requires absolute minimum terminal universal device	lacks user prompts requires memorization or documentation poor error handling multiple key strokes limited feedback available
Graphical User Interface	visualization of task easy to learn easy to retain low memory load errors can be avoided encourages exploration user satisfaction	more difficult to program requires graphical display requires pointing device requires real-time system responses
Direct manipulation	Easy to learn Immediate feedback available intuitive interaction	requires graphical display requires pointing device requires real-time system responses
Control key dialogue (function or soft-keys)	acts as prompt reduces key strokes easy to learn direct control	increases number of keys increased size of device soft-keys require display
Form fill-in	familiar layout natural to user acts as prompt easy to validate	requires graphical display
Natural language	natural to user	requires much computing power typed input can be verbose requires knowledge of syntax and context
Voice	input does not require keyboard output does not require display	recognition may not be accurate

Further information can be found in ISO 9241-10 [59], Shneiderman [130] and Preece, Rogers and Sharp [126].

7.2.2 Menu Dialogues

(Menus)

A menu presents the user with a list of choices from which a selection can be made. The result may be a second or third list of choices that builds up in a hierarchical structure. Each single list comprises a menu. Menus may take many forms: auditory menus, icon menus, pop-up/pull-down menus. Menu hierarchies may be sequential (single menus one after another), pull-down (vertical menus are opened from a horizontal menu bar), cascading (a second menu opens adjacent to a selected item in a primary menu), etc.

Cross references:

Auditory Menus; Dialogue Styles; Graphical User Interface.

Recommendations:

- Use menus to aid novice, and casual users, e.g. to provide initial access to language variants at terminal installation, but allow shortcuts such as type ahead for skilled operators.
- The main menu should be available and it should always be possible to return to it easily and quickly [120].

- Shortcuts should be provided for expert users, e.g. pressing the Command key plus the initial letter of the command instead of using the menu option. They should be provided for the most frequently used or most critical items. When shortcuts are available, they have to be visible to the user.
- Give the menu a title that clearly and unambiguously indicates the contents and give the menu options informative names which relate to the users task and are distinctive from the menu labels. Make sure that menu items do not overlap in their meaning. Where appropriate, labels should be congruent, i.e., Open/Close, Import/Export. The labels should be single words without numbers.
- Group the options in a way that is meaningful to the user, in groups that cover all possibilities. If conventional ordering for options is possible (e.g. days of the week, numeric values, physical properties), the most frequently used options should be placed first. If no logical order or no frequency order exists, and users are likely to know the names of the desired options, options should be placed in alphabetical order
- Allow the user to choose a menu item by point and select using cursor keys or mouse, by numeric entry, or by initial letter. Each menu item should be large enough to allow pointer selection.
- Show all the options provided, use low-contrast or other techniques to indicate options not currently available.
- Use cascading menus sparingly. Avoid using cascading menus for frequent, repetitive commands. Be aware that cascading menus can add complexity to the menu interface by requiring the user to navigate further through the menu structure to get to a particular choice. Cascading menus also require more co-ordination to handle the changes in direction necessary to navigate through them.
- Limit the number of options to less than 10. If more options are required, arrange them into meaningful groups that can be accessed as a next level menu. Lengthy menus can take a long time to scan, thus slowing down the interaction.
- Limit the hierarchy of menus to 3 levels. If more levels are required, provide navigational cues to the current level and navigational aids to assist backtracking, and/or returning to a main menu.
- When a selection is made by the user, immediate feedback should be provided (e.g. message, highlight the option).
- Avoid automatic scrolling for menus; if they have to be used, test for comprehension to ensure the display rate is optimal.
- A pop-up menu should only contain commands that apply to the selected object or objects and its context, rather than commands grouped by function.
- The visual presentation should enhance the menu structure, i.e. enhance group separation [108].
- In a sequence of screens, menus should always be displayed in the same location.
- Navigational cues should be provided to help users learn the menu structure, orient and move within it. Methods for providing such cues include: distinctive titles, numbering schemes, graphics techniques and simultaneous display of menu panels and menu maps. Give the user indications about their current position in the menu structure
- It is preferable to build a menu structure with more items in the beginning and at the end than in the middle: 8×2×2×8 will produce better results than 2×8×8×2. The structure should take into account the time it will take to select one of the last items in the hierarchy.
- The user should be able to step back up the menu structure in a single action, and either go back one step at a time or directly to the top. If the menu is large, provide a map of its levels

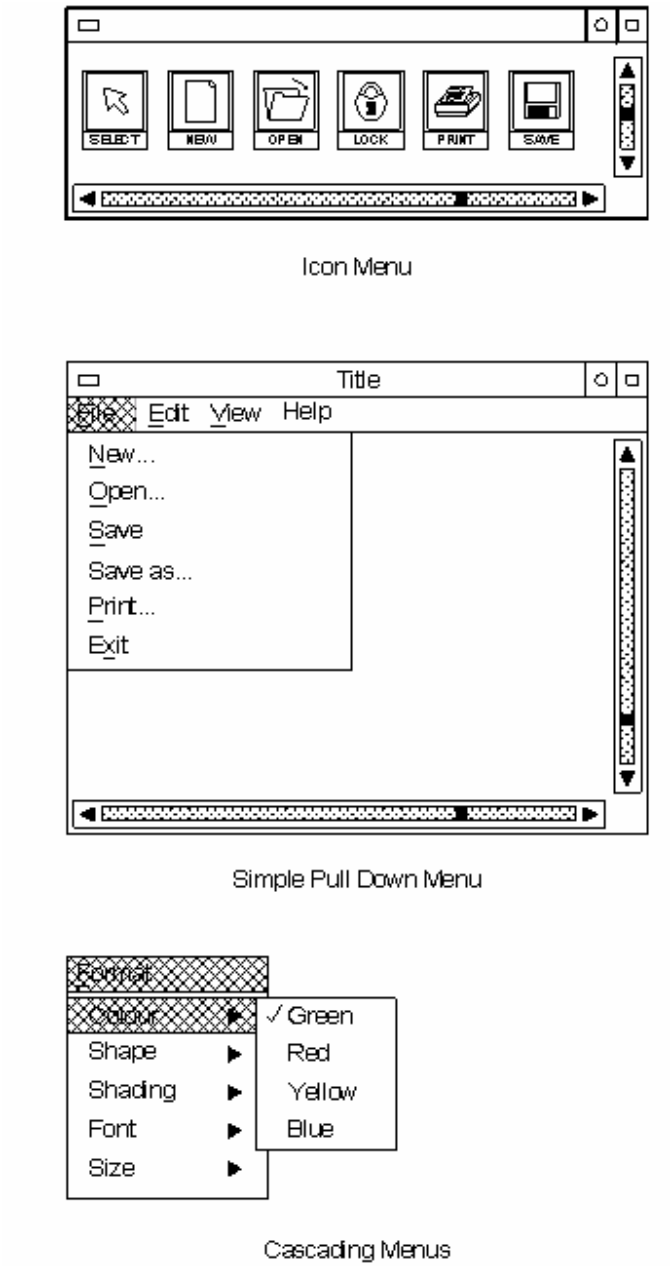


Figure 7: Example menus

Additional comments:

Menus are a valuable aid to novice and casual users since they reduce the need to know and remember. The titles and menu options should relate closely to the user's expectations and job requirements. The acceptability of these names should be assessed, with a representative sample of users.

Further information can be found in ISO 9241-14 [62].

7.2.3 Command Language Style

(Code Schemes, Command Strings, Stimulus Protocols)

A Command Language style requires the user to initiate and control procedures by entering a series of alphanumeric characters, to create command strings (groups of command language words). The software then executes the command, and should provide feedback on its execution.

Typically command languages require very precise inputs, and provide minimum user prompts. This dialogue style is therefore now rarely used on its own except for skilled and regular users. However, for users who have difficulty inputting to a system (e.g. those with physical impairments), the conciseness of the commands and the possibility of using voice input may offer advantages.

Cross references:

Control Key Dialogues; Dialogue Styles, Phone-based Interfaces; Supplementary Services.

Recommendations:

- Command language styles are more appropriate for skilled and expert users, and preferably as a duplicate method of interaction.
- Develop command names and mnemonics that are meaningful within the task, user experience or application.
- Limit the use of numeric codes, using single digit access for the most frequently used commands or features.
- Improve memorability of numeric codes by arranging meaningful groups beginning with the same initial digit, for example, all call diversion codes could start with 5, and all mailbox entries begin with 6, followed by one more digit to allow up to 10 options, or (only if essential) two digits to allow for up to 100 options.
- Offer user guidance in the form of on-line help, on-product graphics, prompt cards and reference documentation.

Additional comments:

Command languages require the user to remember the commands and features. For highly skilled users this dialogue style is fast and powerful. Novice and casual users are at a disadvantage and need alternative support to develop a level of skill. Studies show that even users with a reasonable level of skill are usually only able to remember a small set of frequently used command names and numbers.

A user should not be expected to be an expert in all aspects of a complex user interface. In practice they may prefer to swap between dialogue styles depending on their familiarity with the task and the procedures necessary at any point in the interaction.

Further information can be found in ISO 9241-15 [63] on the design of command languages.

7.2.4 Phone based interface

(Telephone keypad)

The minimal interface over which to conduct a dialogue with a telecommunications system is a simple telephone without any form of display. In this field a telephone provides a universal means of communication. Data can be input with a 12 button keypad using DTMF signalling and responses can be received in speech form. This form of dialogue is most commonly met when gaining access to a call centre through a call steering system, where a simple question and answer dialogue is intended to route the caller to an appropriate attendant.

Cross references:

Telephone keypad, Auditory menus, Speech output.

Recommendations:

- Provide a confidence tone when a key is depressed.
- Provide a display or a loudspeaking facility on a one-piece telephone as it is not normally possible to listen to speech responses from the network when using the keypad for signalling.
- Restrict the length of auditory menus to reduce memory load.
- Provide a means of access to a human operator.
- Provide a recovery route from error.

Additional comments:

It is not possible to input data from a keypad providing loop disconnect signalling.

Alphanumeric input requires multiple key presses and is only feasible for messaging where "store and forward" signalling can be used.

7.2.5 Graphical User Interface (GUI)

(GUI, Object Manipulation Dialogues, Screen Graphics, WIMP, Window Systems)

Graphical User Interface refers to a class of operating systems/software that provide visual images (icons etc.) instead of words for use in command dialogues. Object manipulation dialogues use visual images which can be selected and controlled by pointing devices. The functional elements of the dialogue are the windows, icons, menu and pointers (WIMP).

Cross references:

Dialogue styles; Menu Dialogues; Standardization.

Recommendations:

- Develop a meaningful visualization or concrete metaphor of the user's tasks.
- Use readily identifiable visual elements and icons in preference to abstract images.
- Give immediate feedback of results of actions to ensure user perception of direct control of on screen objects
  - e.g. when selecting and dragging an object it should appear to move and stop simultaneously with the movements of the mouse.
- Any destructive actions should only result from an explicit action e.g. deleting the contents of a stored message should be the result of selecting the message, activating a delete command, possibly with confirmation.
- Allow easy reversal of actions e.g. provide undo or cancel last action.
- Use a graphic device such as highlight to clearly distinguish the active window.
- Use an object-action command style where the object is selected prior to being operated on.
- Develop Help information.
- Offer keyboard based shortcuts for frequently used menu items and to aid skilled usage.
- Use proprietary style guides to ensure consistency and compatibility with other applications.

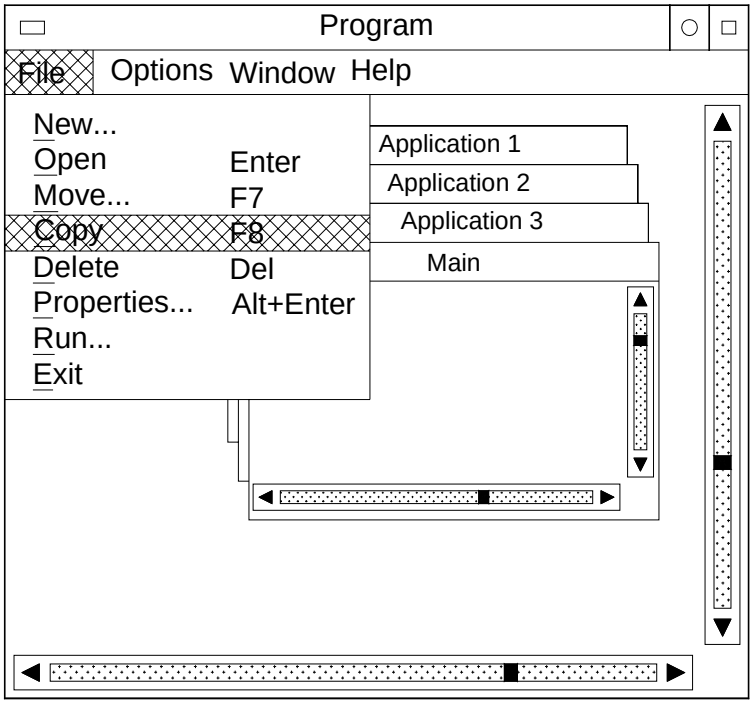


Figure 8: Example Graphical User Interface (GUI)

Additional comments:

The benefits of a GUI to the user are that the dialogue is easier to learn, as options are either on-screen or easily identified from menus, and command string entry is minimized. Subjective response to the visual imagery and animation is very positive, especially from people with either no or limited computer experience. However, classic graphic user interfaces create problems for users with visual impairments and older users with poor hand-eye coordination. Multimodality of both input and output can overcome many of these problems.

Further information can be found in ISO 9241-16 [64], Helander (1997) [116] and Shneiderman [130].

7.2.6 Interface metaphors

Graphical User Interface

An interface metaphor presents a representation of some object (e.g. a recorder control panel) with which the user is familiar and from which the function, behaviour and organization structure of the system can be predicted. In theory, learning should be automatic if the user is familiar with the device or system represented.

The screen presents a virtual world which contains an intuitive metaphor to guide interaction [131].

Cross references:

Dialogue styles, Graphical User Interface, Icons.

Recommendations:

- Carefully analyse the domain which the metaphor is intended to represent to ensure that the user's model is correctly represented in iconic form
- The interactive objects in the metaphor should be represented as realistic icons.
- Define the interface functions to have behaviour consistent with the represented object.
- Use common metaphors where they exist (e.g. a desktop).

Additional comments:

Metaphor is closely related to analogical memory and problem solving by analogy [131].

7.2.7 Direct manipulation

Icons, WYSIWYG

A dialogue technique by which the user directly acts on objects on the screen, e.g. by pointing at them, moving them and/or changing their physical characteristics via the use of an input device. A good example of direct manipulation is dragging a document icon on to a printer icon to have it printed. In direct manipulation interfaces, the dialogue is generally related to objects (the entities manipulated), attributes (properties of those objects) and user manipulations over those objects.

There are a number of features of direct manipulation systems which are common, for example the spatial relationships among objects reflect real life; objects can be above, under, or partially obscured by others. They move from one position to another smoothly without jerky movements of the cursor, thus providing the feeling of continuity, of real existence. This continuity is reinforced by the principle of "What You See Is What You Get" (WYSIWYG), i.e. printing reproduces the image on the screen. Modification of objects and attributes are rapid. The system's focus of attention is reflected by the cursor position; its status by the cursor appearance and behaviour.

In summary, a direct manipulation system:

- Provides continuous presentation of the object of interest.
- Relies on physical actions.
- Provides rapid, incremental and reversible operations whose impact on the objects are immediately visible.
- Makes heavy use of metaphors from real life to support the sense of reality.

Cross references:

Dialogue styles, Graphical User Interface, Metaphor, Icons.

Recommendations:

- Provide immediate feedback, interactivity requires that the system immediately interprets any user action, and any change in the system is reflected at the interface.
- Design the interface consistently within the same service, and if possible, beyond, to help provide a feeling of permanence, continuity and reality.
- Define the set of interface objects to have a consistent behaviour and appearance. Each object should represent only one function or action. Each object should be identified by putting its name beneath the icon. Where appropriate, allow for icons to be customized to indicate, for example, the contents of a folder.
- Wherever possible, design multimodal objects, to allow users with different sensory capabilities to perceive them in their preferred modality.
- Objects must have perceptual similarities; design the objects so that users can distinguish between what is selectable, and what is not e.g. all selectable objects could share the same shape or appear with handles when the cursor is clicked on them.
- In certain situations, when extra support is needed, each selectable item could be highlighted as soon as the cursor moves over it.
- Choose a metaphor suitable to the task e.g. a book metaphor for online documentation, a handset for a modem connection.
- Depending on the objects, the user should be able to move them back and forth, resize, scale, zoom, rotate or choose another representation of the data, for example, in a different modality, or to consume less space.
- The design should provide the user with easy manipulation of object attributes such as size, shape, colour, presentation.
- The design should provide single and multiple selection of objects, and insertion of objects.

Additional comments:

General information about direct manipulation can be found in Helander [116], Preece, Rogers and Sharp [126] and Shneiderman [130].

The advantages of direct manipulation include:

- The system is easy to learn and easy to retain as it uses knowledge from the real world, hence it is suitable for novice users.
- It reduces task complexity by visualization and manipulation of concrete objects.
- It encourages exploration.

The disadvantages of direct manipulation include:

- It is time consuming for repetitive tasks, e.g. to delete all files with a given extension.
- It currently depends heavily on the pointing device for accuracy and good hand-eye coordination of the user. Alternatives need to be explored to widen the user groups who can use direct manipulation by exploring multimodal input devices and techniques.
- Representations may look (or sound or feel) obvious, but may not always be so to use.

7.2.8 Control key dialogues

(Programmable Keys, Soft-keys)

Control key dialogues are interactions which are based on dedicated or programmable function keys, the latter being known as "soft keys". The feature or facility assigned to a function key may be fixed by the hardware design (e.g. Handsfree key), determined by the dedicated software and the current position in the dialogue (as in the keys on many automatic banking machines) or determined by the application software currently running on the terminal (e.g. PC Function keys).

Cross references:

Dialogue Style; Function Keys; Keyboards; Labels.

Recommendations:

- Use dedicated control keys to support casual and novice users.
- Select meaningful labels and avoid abbreviations.
- Ensure labels on keys are clearly legible: use a sans serif font, as large a point size as possible, good contrast between key and text colours.
- Group keys by task function, task sequence, frequency of use or importance (See Function Keys).
- Provide a help mode: users should be able discover the function of each key in a simple manner.
- Use soft key dialogues to reduce the numbers of function keys, when the functions available depend on the current state of the dialogue, or to enable a number of menu choices to be offered on a small display.
- Give feedback, which may be tactile, auditory or visual to confirm that the corresponding function has been activated. The feedback should optionally appear in more than one sensory modality.
- When soft-keys are used ensure there is a close one-to-one spatial relationship between each key and its displayed label. The best relationship is where the key and displayed label occupy the same space, e.g. transparent membrane overlay.
- Use clear, obvious mappings, e.g. three keys underneath three labels as shown in figure 9 Avoid ambiguous mappings, e.g. 2 rows of 4 labels and 2 rows of 4 keys underneath display, (the user is confused about the control/display relationship, proximity vs. layout map).

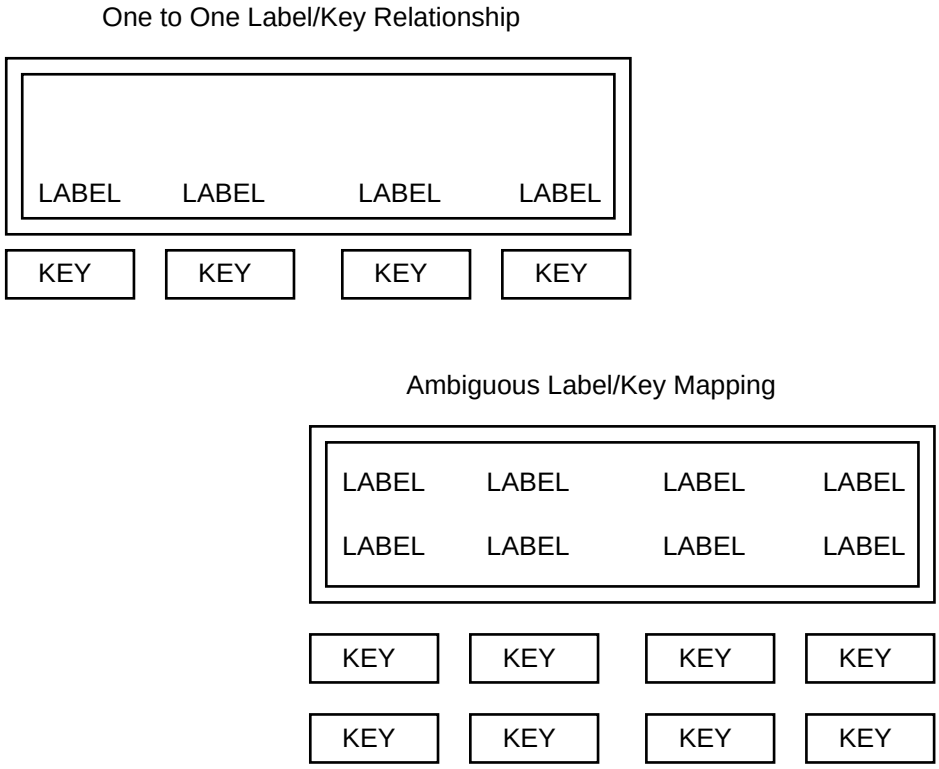


Figure 9: Example of soft key arrangements

- If the number of soft-keys is greater than 5 in any row or column, consider grouping the keys (and labels) into 2 or more groups (in the same row or column) to help the user see which label goes with each key.
- In devices with multiple soft-keys, keep the position constant for specific functions, i.e. functions like "OK", "Cancel", "Navigate up" should always be placed on the same soft-key.
- Provide full word labels (or symbols). If abbreviation is necessary, use a consistent rule for creating all the abbreviations and provide a printed key in the user documentation.
- Ensure that the text labels or symbols associated with the soft-keys are represented in a legible form in sufficiently large fonts. Soft-key labels should be presented in the user's language.
- Ensure a minimum separation of one character space (horizontal) or one row (vertical) between adjacent soft key labels on Character displays.
- When soft-keys access menus, ensure the menu hierarchy is shallow, not more than three levels (preferred), unless an audit trail or some other technique is available to help the user to navigate through the system.
- Keep the number of items in a soft key menu equal to the number of keys, avoid having more menu items at the same level.
- Provide a facility for the user to return quickly to the top level (or another anchor point) from any point in a soft key menu hierarchy.

Additional comments:

Dedicated control keys give users a clear visual reminder of the features, but too many can become confusing.

There is some evidence that a soft key dialogue has a higher usability than a fixed function key dialogue. However, it also depends on other factors within the overall dialogue design, e.g. quality of prompts and feedback, comprehension of key labels, complexity of dialogue etc. Simple analysis demonstrates the savings in terms of numbers of keystrokes, and the reduction on memory load when a user is only presented with valid choices.

7.2.9 Query language dialogues

(Question and answer style)

A dialogue style (also known as a question and answer style) which presents the user with a question, possibly in the form of a checklist or questionnaire, with a space for them to make a simple, generally yes/no, reply.

Cross references:

Dialogue styles; Graphical User Interfaces; Interface Metaphors; Form fill in dialogue Style.

Recommendations:

- Use only for naïve or novice users unlikely to make frequent use of the system.
- Ask only one question at a time.
- If a previous answer is needed later in the dialogue, re-display it [131].
- Keep the sequence of questions compatible with any user model.

Additional comments:

These dialogues are easy to use because the prompts should give complete instructions to inform the user what to do by listing the valid responses [131].

Though easy to use, these dialogues are tedious for an experienced user and slow to operate because each step has to be answered each time.

They are easy to program, as replies can be validated by simple conditional statements against a look up table [131].

7.2.10 Form fill-in Dialogues

A form fill-in dialogue is a special type of question and answer dialogue which requires the user to enter or modify fields on a "form", analogous to a paper form (see Interface Metaphors), presented by the system. The system then updates a database associated with it. A form fill-in dialogue is attractive to users, as the full complement of information is visible, prompting users to the information required and giving them a feeling of being in control of the interaction.

Cross references:

Dialogue Styles; Graphical User Interfaces; Interface Metaphors; Query Language Dialogues.

Recommendations:

- A form fill-in dialogue is suitable for a wide variety of users: experienced and inexperienced, frequent and infrequent. Very inexperienced users may find a Question and Answer dialogue easier to use (see Question and Answer dialogue).
- A form fill-in dialogue is suitable in situations where considerable amounts of data entry are required.
- Use logical grouping and sequencing of fields. Related fields should be adjacent and aligned with a blank space for separation between groups. The sequencing should reflect common patterns (e.g. city followed by region followed by country).
- Use an aesthetically pleasing and clear layout. A uniform distribution of fields is preferred to crowding one part of the display and leaving other parts blank.
- Use alignment to create a feeling of order and comprehensibility. This allows the frequent user to concentrate on the entry fields and ignore the labels.
- Indicate the maximum length of data entry fields, provide feedback (both visual and auditory) if user tries to exceed this maximum.
- Mandatory and optional fields should be clearly distinguished. Where possible, place mandatory fields first.

- For fields where information is required in a particular format, indicate the format required, either in the field or next to the field (see figure 10).

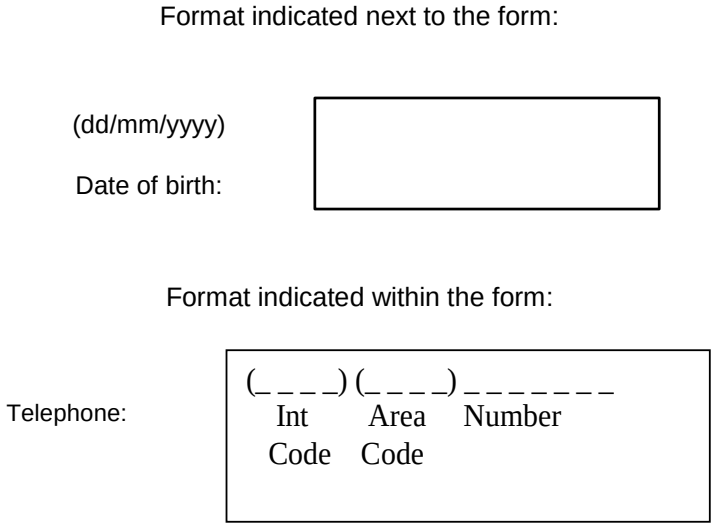


Figure 10: Form formats

- Times: even though the 24 hours clock is convenient and unambiguous, many people find it confusing and prefer the AM/PM designation. Make the required format clear to the user.
- Dates: if possible, accept several input styles (e.g. 01/04/03, 01-04-2003, 1 April 2003) (a confirmation message can be used to resolve ambiguities). Otherwise give a clear indication of the required format (see figure 10). Explicit examples may also help users.
- Use clear and meaningful titles for fields. Identify the topic and avoid computer or other technical terminology or jargon, unless appropriate to the target user group.
- Use consist terminology and abbreviations.
- Default values should be displayed if possible. This saves time for the users and gives further indication of what input is required. It should be clear how to change the default values, even to a novice user.
- Users should never have to enter measurement units (e.g. km, kg). These should be presented to the right of the input field.

7.2.11 Natural language dialogues

A natural language dialogue allows the user to make inputs into the system using unconstrained statements either by typing them or speaking them. This requires the system to cope with the vagueness, ambiguity and ungrammatical constructions associated with natural language. This problem has been a topic for artificial intelligence and has proved difficult to overcome. All current natural language systems are in fact only limited subsets of a language and operate by the system recognizing keywords in the user's inputs.

Cross references:

Dialogue styles, Voice dialogues.

Recommendations:

- Make it clear to the user whether natural language input is or is not acceptable.
- It may be appropriate to mix menu selection with natural language dialogue so that the user can navigate easily to a sub-topic and then pose a question on that particular topic.
- Provide example natural language inputs to the user. This will give them a clear set of structures to follow if they wish. Very often it is possible to use a few simple structures as templates for other queries.

Additional comments:

Advantages of natural language dialogue include:

- Suitable for novice users i.e. those with little or no computer experience and those who have difficulties with conventional input devices, particularly the mouse.
- Suitable for infrequent users and those will little time for training (e.g. senior managers or users of a general public information system).
- Suitable in situations where there is a well defined range of topics.

Disadvantages of natural language dialogue include:

- Ideally natural language systems would allow the user to speak their inputs into the computer system. However, such voice input systems are still not perfect for continuous speech and so this requires users to speak slowly and carefully, or enter inputs by typing them into the system. Such inputs can be long winded and error prone.
- Natural language systems may lead the user to have unrealistic expectations of the system, and to think that they can make inputs outside of its domain of knowledge. This can result in user frustration.
- Even remaining within the domain of the system's knowledge, the user may construct inputs that are vague, ambiguous or not completely understood by the system. This can result in a lengthy clarification process with the user.

7.2.12 Voice dialogues

A voice dialogue describes the interaction with a system when either the input or the output takes the form of spoken voice. Speech entry in particular is potentially a great opportunity for reducing the burden of data input. Speech output can be of great benefit to disabled persons, particularly those with impaired vision.

Cross references:

Auditory menus, Command language style, Multimedia presentation, Multimodal interaction, Speech input, Speech output.

Recommendations:

- Use speech input, particularly where other input facilities are limited e.g. to a 12 button keypad.
- Use speech input where the demands of the primary task results in inability to use other input techniques, e.g. command entry whilst hands are fully occupied.
- Use a small vocabulary of preferably standardized words, to assist recognition and minimize user memory load. (A set of spoken commands to control the most common functions of ICT products and services can be found in ES 202 076 [7]).
- Use longer rather than short monosyllabic words to assist in recognition. Avoid single character/digit words.
- Select speech input vocabulary words to minimize possible recognition confusions (speech recognition and auditory confusions are similar).
- Provide user prompts appropriate to the dialogue (see figure 10, see also clause 7.2.13).

Table 10: Voice data entry modes for interactive systems [116]

Speech Dialogue Type	Type of Prompt
Command words	No prompting - User takes initiative
Direct entry	e.g. "Input all information"
Query language	e.g. "What day are you travelling on"
Menu choice	e.g. "On a Weekday, a Saturday, or a Sunday
Yes/No choice	e.g. "Travelling in the afternoon? Say Yes or No"
Grunt confirmation	e.g. "If you are travelling in the afternoon, make a noise now"

- Provide recognition feedback after each input.
- Use speech output in addition to visual output, or when there is no visual display available. It has an advantage where the user needs to be free to attend to other tasks such as watching a visual display or driving, or is unable to read because it is too dark, or the user is visually impaired.
- For maximum intelligibility of speech output recorded natural speech is preferable to concatenated speech, with synthetic speech ranked third.
- Minimize the load on human memory by allowing users to hear the message repeated, and to enter commands or data immediately and not to have to remember and wait to the end of the message.
- Respect limits of the human working memory and the echoic store (approximatively 3-4 elements) when designing menus.

Additional comments:

Speech input can be most appropriate as an alternative for control key dialogues where a spoken command replaces a specific key operation.

At present, speech recognition systems have limited ability to deal with continuous speech and so are too error-prone for use with natural language dialogues.

7.2.13 User Prompting

(System messages, User Guidance)

Prompts are system initiated messages or dialogues requesting the user to perform a particular action, (e.g. "Please choose the language"), to introduce some data (e.g. "Please introduce your password"), or simply indicating that the system is ready to receive user's inputs or commands.

Cross references:

Error Messages, Help, User Support.

Recommendations:

- Inexperienced users will require a greater degree of prompting than experienced users. For experienced users, prompting might be provided as an optional aid.
- It is recommended that systems provide a graded level of prompting, i.e. if the user does nothing then further prompts are given until action on the users part takes place.
- Prompts should indicate the nature of the input required from the user, e.g. "Please answer yes or no".
- Prompts for data or command entry should be displayed in a standard location next to the entry field.
- Prompts should provide cues for the type of data to be entered by formatting data entry fields consistently and distinctively.
- Users should have the option that prompts are presented both visually and aurally simultaneously.
- When prompts are presented both visually and aurally, the contents should be exactly the same, to avoid any kind of interference. Alternatively, make sure that the spoken section relates clearly to that displayed, possibly by highlighting the current line or phrase on screen as it is being read out.
- Allow the user to interrupt auditory prompts, particularly those which require a long presentation time and have a fixed presentation rate. This allows faster operation when the user has achieved adequate performance.
- Providing prompts in different media aids access by people with special needs.

- Provide prompting for the required formats and acceptable values for data entries. For example:

'Specify the vehicle type: _?
(c = Car, t = Truck, b = Bus)'

- If an element of a command entry is not recognized, or logically inappropriate, prompt the user to correct that element rather than requiring re-entry of the entire command.
- A faulty command can be retained in the command entry area of the display, with the cursor automatically positioned at the incorrect item, plus an error message describing the problem.
- Provide data loss prompts as a confirmation action to warn users explicitly of any possible data loss. For example:

'Confirm deletion of entire file: SCREEN.IMG (Y/N)?'

- Speak directly to users. Choose wording for user prompting in the active voice, rather than the passive voice since sentences in the active voice are easier to understand. For example use "Press ENTER to continue" rather than "The user should press ENTER to continue".
- Use an active verb structure and address the user, e.g. "Connect the battery to the terminals", is better than "The battery should be connected to the terminals".
- Use positive statements: e.g. "Begin speaking after the tone" is better than "Do not speak until after the tone".
- When prompting the user towards a sequence of steps, follow that same sequence in the wording of a prompt message. For example: "Enter log-on sequence before running programs", and not "Before running programs, enter log-on sequence".
- When users log on to a system, display appropriate prompts automatically at the user's terminal. If possible, do not require the user to take any special action to obtain a log-on display, other than turning on the terminal.
- If a user tries to log into a system and it is denied because of system unavailability, display an advisory message to tell the user what the system status is and when the system will become available. Avoid "as soon as possible" messages. Make an estimate of system availability, and update the estimate later if that becomes necessary.
- Display prompts for data or command entry in a standard location, next to the command entry area at the bottom of the display. As an alternative, prompts might be provided in a window overlay added to a working display at the user's request.

Additional comments:

Advantages:

- Prompting the user is very important for inexperienced or novice users of any system or service, guiding the user to achieve their task goal with the system.
- Prompting in advance of data or control entry will help reduce errors, particularly for inexperienced users. Prompting might be provided as an optional feature for skilled users.

Disadvantages:

- Prompts can decrease system performance. This depends on the terminal's capabilities and the media used for the prompts.
- Prompting may not be needed by skilled users and indeed may hinder rather than help their performance in situations where display output is slow (as with Teletype displays).

7.3 Assistive technology

(Accessibility)

A term covering the technology used by any device used by a disabled person to prevent, compensate, relieve or neutralize any resultant handicap. For the purposes of this document, the ability to interface to an ICT device is also assumed.

Cross references:

Design for All, multimedia presentation, input components, output components.

Recommendations:

Where a Design for All solution to equipment design is not reasonably achievable, one possible solution is to provide a technical interface to permit the use of a so called "assistive device". This fills the gap between the needs of the user interface of the device and the abilities of the user [42]. Some form of assistive technology is required by a user of ICT technology whenever the person's disability is such that they cannot operate the technology safely and efficiently.

There is currently a shortage of standards for these interfaces but where they exist, they should be implemented. Assistive technology is thus used to modify the method of inputting information to or receiving information from a piece of mainstream technology. Standards exist for the inductive coupling of telephones to hearing aids [31], for the electrical coupling of telephones to hearing aids [38] and for an additional equipment interface to ISDN terminals [37].

The increasing use of the Design for All philosophy should mean that the majority of disabled people will not require assistive technology but will be able to use mainstream technology successfully.

It is important at the design stage to ensure that the necessary hardware and software hooks are provided to permit the later connection of assistive devices.

7.4 Multimedia presentation and Multimodal interaction

7.4.1 Multimedia terminals

Multimedia terminals have the ability to transmit and receive combinations of media having fundamentally different properties, e.g. text and video, or audio, graphics and video, simultaneously. This is in addition to the ability to communicate separately in each media. As a comparison, a telephone is an example of a monomedia terminal and a videophone is perhaps the first commercial example of a multimedia terminal, able to communicate in audio and visual media simultaneously.

Cross references:

Addresses; Call Handling; Data Transmission; Videophones.

Recommendations:

- Ensure call set-up, incoming call and call termination procedures meet user expectations, and are fully supported by prompting and feedback indications. Use the general rules and generic procedures shown in Call Handling, when new procedures have to be developed.
- Keep addresses simple and consistent. Minimize the number of operations necessary to address any particular terminal or media. Consider a unique address for the user, irrespective of the range of media involved in a call.
- Consider facilities to enable a multimedia communication to degrade gracefully, i.e. service by service, when problems arise. Where audio is one of the media within a communication, it may be preferable to the users to lose the audio link last.
- Keep call termination as simple as possible, preferably a single action/operation. At the same time, ensure any transmitted data is not inadvertently lost; enable the user to decide whether received data can be discarded or not.

- Provide simple procedures to enable users to select different media both before and during a call. Ensure there is an opportunity for consistency between the default media selected for both outgoing and incoming calls. Inconsistency between default media for incoming and outgoing calls is not recommended, except for experienced users.

- Ensure synchronization between different media objects within a communication meets user expectations. For example, maintain lip synchronization between audio and visual media within ±50 ms, or between a pointer and an image showing the pointer in a shared viewing application, perhaps < 100 ms.

- Ensure the user is kept informed of changes in call charges invoked because of changes to the media to be transmitted/received. In general, users should have an indication of the charges for different media both before and during a call.

- Foster the user's perception of equally sharing the communication space within a multimedia call. Avoid dialogue structures that force an artificial hierarchy on the communicating parties, i.e. chairman vs. the rest.

Additional comments:

Multimedia Terminals enabling the concurrent transmission and reception of audio, visual, text and other data, are still in the research and development stage. Further information can be found in [5].

7.4.2 Multimodality

The provision of more than one modality provides alternative and redundant means of inputting or presenting information. Multimodal interfaces can achieve more natural and effective human-computer interaction by integrating a variety of signals by which humans usually convey information. Many of the needs of people with sensory and cognitive disabilities can be met with mainstream products if output information is provided in a range of different modalities [5].

Cross references:

Icons, Tactile indications, Acoustic input, Acoustic output.

Recommendations:

- Where possible, allow users to select from a range of presentation modalities.

- Ensure that the information presented to the different sensory channels is congruent [5].

- Use multimodality if the information channel is overloaded.

- Consider multimodality to overcome adverse environment constraints.

- Note that some modalities, e.g. sound, may affect nearby users.

Additional comments:

In the interest of Design for All, designers should always consider the possibilities of multimodality of both input and ouput. The needs of blind and dyslexic people can be met if text and graphic information is also provided in speech form and the needs of hearing impaired people can be met if speech and sound information is also provided in text [5].

More detailed information can be found in [5].

7.4.3 Nonspeech sounds

(Auditory icons, Earcons)

Can be either real world sounds (auditory icons) or brief abstract or musical motifs (earcon), used either as unimodal information source or as part of a multimodal icon.

Cross references:

Acoustic Signals; Auditory Displays, Auditory icons, Earcons.

Recommendations:

- ensure that any sounds used are reproducible within the bandwidth relevant to the system.
- ensure the sound is presented at a similar volume to acoustic signals, and that the dynamic range is limited to prevent apparent silences and sudden loud bursts.

Additional comments:

Be sensitive to the potential user's listening habits, avoid musical extremes, acoustically harsh electronically reproduced sounds.

7.5 Labels and abbreviations

(Legends, Icons)

Single alpha or numeric characters, text string or symbol used to indicate the function or feature available from a control or display.

Cross references:

Casework; Visual Displays; Control Key Dialogues; Help Mechanisms - Text; Keyboards; Keys; Symbols; Icons; User Support.

Recommendations:

- Use full words that accurately describe the control or display's function. Avoid abbreviations, unless usability testing confirms they are acceptable.
- Use alphanumeric labels or legends to identify controls, displays and other functional elements of the product or terminal.
- Abbreviations can be used if they are familiar to the user group, however, icons can be more language independent.
- Use symbols, icons and pictograms to overcome language difficulties when identifying controls or displays, connectors and sockets, or to give guidance (see Symbols and National Variations).
- Use established graphical symbols for common functions.
- Ensure printed material is clear and legible and easily understood by the users. Keep printed text upright and on horizontal lines. Avoid vertical, curved or inverted text.
- When using small displays ensure that there is adequate space on the display for the labelling of soft keys.
- Dark text on a light background is preferred with a brightness contrast of 70 % to 80 %.
- Embossing the casework is not recommended as the lack of contrast makes it difficult to read the text. However it can be useful as additional information for people with poor sight.
- Put the label or legend on the control or display, or in close proximity. Ensure there is no ambiguity about which label relates to which control/display.
- Ensure safety labels are prominently displayed and durable for the expected life of the equipment.
- When user-editable labels are available, provide paper inserts for users to designate their own descriptions.
- Where standards exist, ensure they are adhered to, for example labelling of letter groups on keypads etc.
- For multifunction buttons utilizing the shift mechanism, make clear the association between the control button, SHIFT and the labels on the multifunction buttons by the use of a coding technique. Colour is useful for this but should only be used in conjunction with an icon and/or label.

- In order to help blind and visually impaired people and people with learning difficulties, it is important that the control for adjusting the volume is clearly labelled, so that it is easy to find and to understand the use of the control.
- In order to help blind and visually impaired people and people with learning difficulties, it is important that the control for adjusting the ringing tone is clearly labelled so that it is easy to find and to understand the use of the control. The labelling should be easy to understand, see and feel.
- Unique information symbol language for location signs of terminals should be used to minimize confusability.
- Ensure characters on keys are legible for people with reduced vision, in terms of size and contrast. More information on key labelling can be found in clause 8.2.

Additional comments:

Where a product is complex, users, particularly the elderly, may have difficulty remembering specific sequences of operations and a small reminder card on the product can be very helpful.

7.6 National Variations

(Language Differences, Alphabet differences)

Within the European Union there are differences of language, and social and cultural conventions which need to be accommodated. There are also differences in alphabets that need to be considered and provided for where possible.

Cross references:

Acoustic output, Icons; Symbols.

Recommendations:

- Allow users to select their preferred European language. During system development store system messages in separate text files so that they are easier to find and translate.
- Where input is required using a 12 button keypad, permit the use of the alphanumeric and other common characters assigned by ES/HF-00026 (see Bibliography).
- A set of spoken commands in a number of European languages can be found in ES 202 076 [7].
- Allow flexible data formats for the following:
  - thousands separators: 1000, 1,000, 1.000, 1 000, 1'000.
  - decimal point: 1.5, 1,5.
  - currency symbols € 5, £ 5.
  - date: 25,12,1992, 25/12/1992, 25-12-1992, 25:12:1992, 25th December 1992.
  - time 21:30, 21.30, 9:30 pm.
  - time zone: GMT, CET.
  - telephone numbers: 12 3456, 12-3456, 12:3456, (12) 3456, [12] 3456, and for international numbers +44 12 3456.
- Minimize national variations within icons and symbols; select icons and symbols from agreed international standards or "industry standards". If none are available, use text or evaluate the acceptability of new or local symbols to other nationalities and cultures. Use EG 201 379 [3] on the evaluation of icons and symbols and the ISO/IEC 11581 standard for their design [67].
- Where possible use internationally recognized icons or symbols instead of words.
- Where possible allow language translation of the displays and instructions.

- Standardized signs with accompanied text (in national language) indicating the nature of a public terminal should be displayed in sufficient size and placed in close context with a terminal.

Additional comments:

Systems and services may be used throughout Europe where language and cultural differences occur, and by visitors from other countries. The terminals should have the widest possible acceptance by the pan-European market.

7.7 Security

(Protection, Privacy)

A system and service needs to be secure from unauthorized use. The user should be assured that the transaction cannot be intercepted by others.

Cross references:

Safety; Input Devices.

Recommendations

- For passwords and other secure entries, display feedback of the entry with abstract, meaningless, characters, such as "*" or "x", showing only the number of characters introduced, not the actual characters themselves.
- Virus checkers should not make a system or service more difficult to use. If a virus is found it should be clear to the user what to do to recover from the situation.
- Privacy should be ensured for public access terminals.
- Public terminals should minimize the risk of interception of private information.
- Public access terminals should ensure the privacy of PIN codes, bank account details and electronic card codes.
- Public access terminals should provide a warning if the user leaves the smart card, money, ticket etc in the machine.
- Devices in a mobile environment should not allow eavesdropping, i.e. being unintentionally overheard.
- Prevent unauthorized use of mobile terminals.
- Ensure against unauthorized data access of mobile terminals.
- Ensure against unauthorized access to information stored on a fax machine for later transmission.
- When assistive devices are being used e.g. loud speakers or large print, the privacy of the information should be ensured.
- Reduce the danger of eavesdropping by the provision of headsets instead of speakers.
- When smartcards are being used for transmission of confidential information the service should ensure security of transmission between transponders and readers, possibly by encryption techniques.

Additional comments:

Any security measures used should not make the system or service more difficult to use.

There are many different methods of user identification available. Biometric information (e.g. fingerprints, iris recognition, voice authentication) may be more secure than PIN entry. Further information can be found in clause 8.9, Biometric input.

7.8 User Support

7.8.1 General

(Prompting, Training, Tutorials, User Guidance)

User support is used as a global term to describe all forms of information offered to assist in the proper and efficient operation of the ICT product or service. This may include information given as part of the dialogue or requested as help, on product graphics and labels, handbooks and user guides. The objectives of user support is to promote efficient system use (i.e. quick and accurate use of full capabilities), minimize memory load on the user and hence minimize the time required to learn to use the system. It should also have the flexibility to support users of different skill and ability levels.

Cross references:

User prompting, Error messages, Help, Help Mechanisms; Human; Auditory; Text; Multimedia; Built-in, Tutorial Systems.

Recommendations

- Guidance should be readily distinguishable from other displayed information.
- Directions for use should be simple and easily comprehensible. They should be available in different media to suit the user needs or preferences.
- System initiated guidance should not remain on screen beyond a certain useful time, whereas user initiated guidance should be under user control allowing the user to dismiss it when required.
- Provide user guidance appropriate to the user requirements and task complexity.
- Provide the user with specific information relative to the task context rather than generic messages.
- User guidance should not disrupt the user's task and the continuation of the dialogue with the system, but distinctive messages or coding techniques should be consistently used to alert users to conditions that require special attention.
- Provide clear and specific information to guide the user through the operational sequence, including how to recover from errors.
- Support the user's memory by offering choices, for example, as menus, or prompts to show what telecommunication features and services are available, or what jobs can be done.
- Include task sensitive messages that help the user proceed correctly, indicating the commands or syntax, or permitted range of values.
- Develop task sensitive on-line help and paper based handbooks or guides.
- Consider the need for the user guidance to help develop or revise existing user models or expectations.
- Ensure that the guidance given is accurate and up-to-date.
- Use familiar wording and short simple sentences.
- Ensure help is available in the local language and translations are clearly written.
- Validate user guidance with sample users and be prepared to modify and improve the information given.
- When user guidance requirements may change, which is often the case, provide some means for users (or a system administrator) to make necessary changes to user guidance functions.
- There should be a manual alternative to electronically provided support services. Manual services (i.e. a person at an information desk) should not be more expensive for the users.

Additional comments:

User support should be available at four levels of operation, where appropriate:

- Task level: the user should be informed about the goals of the system or service in general and for any particular task.
- Semantic level: this should explain to the user what objects and operations are available in the system to perform the task.
- Syntax level: this level provides information on the syntax of available commands.
- Physical interaction level: this provides assistance on the physical input, e.g. mouse click, function keys, how to use a light pen.

Preparation of user guidance should not be the sole and separate responsibility of technical writers who were not involved in the design process. Interface designers and users should participate as well.

All users benefit from clear and easy to understand user guidance. Those most in need of support will be the least skilled of the intended user group, although even skilled users need support when using unfamiliar equipment or when attempting unfamiliar tasks.

In general, it is most effective to tell the user "what to do"; users are aware of what they are trying to achieve and only need to know how to follow the correct procedure. This applies particularly to the simpler systems and to novice users. The main content of the user guidance should be directed towards the questions that the user will ask and the tasks in hand.

Where a system is specifically designed to encourage the user to explore the system, as for instance in object-oriented dialogue styles, it may be necessary to give more general guidance on the capabilities of the system.

Similarly, with a complex system where the user may be expected to develop a level of familiarity and confidence in the system, it can be valuable to develop a concept of how the system works so that he or she is able to predict what to do and what the result will be.

No matter how complex the system is, the user guidance needs to build confidence in individual stages that are easy to understand, using everyday language.

7.8.2 Help

7.8.2.1 General

(Tutorials, User Guidance, User Support)

Help systems are used to aid users to successfully perform tasks. Help can be offered so that the user is informed about the purpose of a function key, or command. Context sensitive help may be given to guide the user through an unfamiliar sequence, or recover from an error.

Cross references:

Error Management; User Prompting; General Design Issues, Help Mechanisms- Human; Built-in; Text; Auditory; Multimedia; Dialogue design.

Recommendations:

- Multi-modal help should be provided where possible.
- For simple systems with limited display capabilities consider providing help using speech output.
- Provide information about features and network services available.
- For more complex systems, provide help that is sensitive to the context and to the users' task requirements.
- Write the help information in short simple sentences and include what to do next and how to return to the main task.

- Use help information to identify features and controls.
- Provide flexibility when searching for a help feature.
- Allow skilled users the option of switching off help prompts if they are not required.
- Provide the availability of extended help modes.
- For complex help, for example, with a Graphic User Interface, provide cues to navigation within the help material with clear titles, e.g. page forward and back; and consider an audit trail so that the user can trace back to previous screens and see where they came from. Recovery back to the beginning should be obvious if a user gets lost in the help system.
- Use an evaluative design process to test out the level of support needed by first time and inexperienced users and examine how to improve the effectiveness of the help information being developed.
- The cost of accessing the help should be made clear to the user prior to the access.

Additional comments:

Build systems to be intuitive so that they are easy to use, if not then help is essential. Sometimes the user may simply want to know the effect of a particular function key, or the range of features available. Most often users require help in order to complete a specific task, and in order to recover from errors.

Flexibility within the help information can allow users to gain information at different levels. As the users' skills for frequent operations increases, so they will become less reliant on the prompts and help information, however, the guidance may continue to be needed for more advanced features, and features used infrequently. Help is probably best developed as part of the dialogue design process.

Help should be provided in a number of different formats e.g. Human, On-line, Text, Auditory, Multimedia to take account of users' different abilities.

For further information see [108].

7.8.2.2 Help Mechanisms - Auditory

(User Guidance, Voice Messages)

Auditory help consists of stored or synthetic voice messages that give explanations about the purpose and the use of the product or service.

Cross references:

Help Mechanisms- Human; Built-in; Text; Multimedia; Help.

Recommendations:

- Keep spoken messages or synthetic speech short and simple.
- Do not use abbreviations in an audio situation.
- Minimum quality levels are required. Particularly with voice messages, the messages should be recorded by a professional speaker.
- When using synthetic speech to provide messages, ensure that those messages are short and simple.
- Use auditory help in those services in which voice is the main medium (e.g. conversational services).
- If the messages presented aurally are to be presented together with written information, the content of both media should be the same, or easily related to the text. Providing information by an additional redundant media can help some people with disabilities. There should be an option for the user to select the most appropriate media.
- If the auditory help is to be used in Graphic User Interfaces, information on the location of procedures or interface components on screen should be clearly provided.

- Consider synthetic speech output for user guidance messages in environments with low ambient noise, when a user's attention may not be directed toward a visual display or when providing a visual display is impractical.
- Auditory signals such as synthetic speech are useful for notifying a user of important information when his/her attention is focused somewhere other than a visual display, such as when a touch-typist transcribes data from a paper form.
- Speech output might also help a user who accesses a computer from a remote location by telephone.
- Remember that people other than the user might hear those spoken messages. Speech output may prove distracting to other people trying to work nearby. Also, the user of a system may not wish others to hear his/her messages, as might be the case if spoken messages are provided for an automated banking application.
- Synthetic speech is not useful if many messages are given at one time, or for conveying a lengthy list of menu options.
- When messages are spoken, the user has to remember each message. If many different messages are given one after another, then a user would probably not remember them all, and might only remember one or two.
- In general, users will understand complex messages better when they see them displayed than when they hear them.
- If synthetic speech is used to provide warnings as well as other forms of user guidance, ensure that spoken warnings are easily distinguishable from routine messages.

Additional comments:

Advantages of Auditory help:

- Aurally presented instructions can be more effective than visually presented instructions when subjects are engaged in highly attention-demanding tasks.
- There is evidence suggesting the superiority of aural over visual messages when subjects performed simultaneous motor or information processing tasks.
- In general, basic and applied research studies which focus on task performance suggest that information presented aurally persists longer in short-term memory and is less vulnerable to interference than visually presented information.
- It is a flexible and relatively cheap way to provide help in some systems, especially with audio as the main medium (e.g. telephony services).

Disadvantages of Auditory help:

- Not very good in a noisy environment.
- It has very poor ability to indicate graphical information in modern Graphical User Interfaces.
- It may not suit users of Graphical User Interfaces.
- If presented simultaneously with other different verbal or written information, it can interfere and increase user's memory load.
- The user does not have control over the rate at which information is presented, and unlike the reader of a text, cannot check back over earlier sections for review.
- The material is presented serially and it is difficult to locate the position in a list.

7.8.2.3 Help Mechanisms - Human

(Help lines, Operators, User Guidance, Relay Services)

Human operator help consists of procedures in which guidance is directly provided by a person, thus answering questions asked by the user directly. Multimedia systems may provide a video window which opens in the interface screen and the user receives live help from a human operator instead of a pre-recorded video sequence.

Human operators can also be used in relay centres to help people with special needs. For example, a human can provide the link between a deaf and a blind person by translating the conversation into text.

Cross references:

Help Mechanisms- Built-in; Text; Auditory; Multimedia; Help.

Recommendations:

- If the operator is to take control of your system, then the user should be informed of this.
- If the human operator help is not available, provide some form of backup or a facility for the user to record their problem so that it can be dealt with later.
- Specialist directory enquiry and service help facilities should be provided for people with special needs.
- Information should be given to the user as to how long he can expect to be waiting in a queue before connection to a human operator.

Additional comments:

Advantages of Human Operator help:

- It is the most attractive way to provide information to the user, since there is real human contact.
- It has proved to be very effective in providing guidance and training on user interfaces, particularly if the operator can take control or run a copy of the interface and can explain the correct procedures to the user directly on it.
- It is highly flexible, allowing the operator can adapt to all users' needs.
- Human operators are essential for relay centre services provided for the disabled.

Disadvantages of Human Operator help:

- The cost may be high, not only due to the cost of having the operator available, but also due to the cost of maintaining an interactive line between user's and operator's points.
- Human contact may extend the time required for the operation.

7.8.2.4 Help Mechanisms - Multimedia

(Multimodal presentation, Voice+images+video)

Multimedia help consists of guidance messages which combine different media (voice + images + video). It can be made with pre-recorded video sequences or with animation procedures. Very few investigations have been made on this topic. In one example of this type of help, when the user requests help, a video window opens showing images of the screen the user is currently interacting with. A person is superimposed onto the screen, giving explanations and pointing to various elements.

Cross references:

Help Mechanisms- Human, Built-in; Text; Auditory, Help, Symbols, Multimedia/Multimodal.

Recommendations:

- Pre-recorded video help has proved to be an effective and relatively simple way of providing human contact for help. With it, a person shows the procedures in the interface by being superimposed upon it.
- If a copy of the interface screen is shown in the help message, make it clear to the user that it is a copy and that he or she cannot interact with it.
- Show not only the required procedures for the operation of the interface, but also the consequences of every action.

- It should be clear how to turn off the help and to delete any unwanted files.
- A user should have control over the rate of presentation of the information and be able to check back over earlier sections.

Additional comments:

Advantages of Multimedia help:

- Use of video or animation has unique potential for presenting dynamic events.
- It has proved to be very effective means to provide guidance and training for user interfaces if a copy of the interface is shown in the sequence, since the location of the components can be clearly shown.
- Visual media may be attractive to a wider range of users than simply textual interfaces e.g. people with poor reading skills.

Disadvantages of Multimedia help:

- It requires a definitive interface or application specification and so is not very flexible.
- The cost is very high, involving the use of complex techniques if it is to be made with minimum quality (either for producing video or animation). The requirements on the terminal are also high.

For further information see [108].

7.8.2.5 Help Mechanisms - Built in

(Training, Tutorials, User Guidance)

Built in help systems are part of ICT products and services. Their ultimate goal is to provide assistance to users for performing tasks and to help to progressively increase user's abilities handling the system or service. Built in help systems provide additional information about possible commands, functions or operations of system interface. The objective is to improve both current and long-term performance with the interface. Theoretically, support information will reduce the amount of learning, memory and cognitive processing required for the computer-based task resulting in a decrease in user time and errors.

Cross references:

Help Mechanisms- Human; Text; Auditory; Multimedia; Help.

Recommendations:

- In some applications, it may prove helpful to allow individual users to reword and/or add their own notes to on-line guidance material, just as they might annotate paper documentation.
- A "message board" appearing at log-in may suffice to notify users of current changes. More extensive measures may be needed, including corresponding changes to user guidance information, e.g. prompts, error messages, help displays, etc.
- Built-in help is an integral part of user interface design, and should be designed and tested at the same time as the other user interface procedures.
- Whatever methods are used to highlight critical items in the data display, adopt similar methods to highlight the display of critical user guidance information.
- Allow several methods for formulating help requests and use standard or commonly accepted methods for requesting help in the system.
- Provide an adjustable level of help detail to accommodate the information needs of a wide range of users.
- The help information should be presented in such a way that the user can immediately try out any advice received.
- Help should be non intrusive. The user should be allowed to turn it off.

- Help should be presented in an area peripheral to the task area or in a separate non overlapping window to avoid interfering with the visibility of the user's task area. It should never cover the entire task display.
- The help presentation may include a listing of on-line help topics from which the user can choose.
- Make sure that the task remains visible while help is being sought.
- Phrasing is important, so the result of an action should be stated before describing how to execute the action. e.g. "to clear the screen, press RETURN" instead of "press RETURN to clear the screen".
- Guidance should be worded as a positive statement, using familiar vocabulary, short, simple sentences and neutral tones.
- Guidance should be provided implicitly through the dialogue, prompts and messages but may also be presented on explicit request from the user for more detailed information.
- A built in help system should not be the electronic version of the written manual.
- Provide concrete help text (not the same as in the hard-copy manual), and examples.
- Describe what can be done in task-oriented terms (interface actions and objects) for improved skill learning.
- Describe procedures step by step to help to solve specific problems.
- Provide context sensitive help. This means that the system is able to recognize or even preview the user's problem before it appears, and to provide assistance about that particular problem in its context.
- Monitor user actions to provide context sensitive help or to actively diagnose user problems.
- Help systems which provide an improved performance time (in terms of times and errors for the task) have been found to be those in which subjects initiated and selected help material.
- Allow users to interrupt the help at any time and return to the task.
- If help messages are initiated automatically by the system, or they have a fixed presentation time (e.g. audio or video sequence), they should finish automatically and return to the normal terminal operation.

Additional comments:

Built-in help is neither the remedy for a poor interface design nor the electronic version of hard-copy written documentation.

Advantages of providing Built-in help:

- Both online help or interactive training are requisites of modern interfaces or systems since all applications are becoming increasingly complex.
- Help messages may simplify the user-interface by meeting the needs of the infrequent user and may also facilitate the operation of less frequently used features.
- The user does not need hard-copy manuals, which take up workspace and possibly divert the user's attention from the video display and computer-based task. Manuals may not be available when they are needed, or users may not know what documents are available, which ones are relevant, or how to procure them. Even users who possess the appropriate documentation will not necessarily have it with them when it is needed.
- Built-in help documents can be modified relatively easily. Besides, if they are designed with electronic indexes and cross-references (hypertext), they can enhance the user's capability to retrieve documentation quickly.
- New technologies, especially multimedia, e.g. animation or video, may aid users in understanding the interface structure. This may help users learn and remember computer-based procedures.
- Using Built-in help about selection rules is very useful when there are different, alternative methods of operation, and when the user does not know the reasons which make one method preferable over another.

Disadvantages of providing built in help:

- Built in help can be useful for experienced users who already know the operation of the application or interface, and for those who wish to learn new functions. However it can be completely ineffective for novices, who will require detailed information about how to operate the system in specific tasks. Such users will find tutorial systems more suitable.
- Many users cannot read multiple pages on-screen and need to print the document. It should be possible to print any help offered in a legible format which is under the user control.
- Usually built in help does not reduce the time taken for resolving a problem.
- Many systems incorporate multi-media into the applications (sound, high-quality images and real-time video), however, user help has remained mainly text-based, usually with long descriptions as an electronic version of hard-copy manuals.
- If built-in assistance is presented in a windows interface, introducing a help window may actually increase the cognitive load on the user, since the user may not be able to see all the necessary information and may have to execute additional procedures to manipulate these windows on the display.

7.8.2.6 Help Mechanisms - Text

(Customer Documentation, Handbooks, Manuals, User Guides, Cartoon style "balloons")

Textual help consists of messages where the medium is written information. These messages can be presented in various forms to the user: by means of cards, paper instructions, a handbook or manual, in a separate window with electronic indexing procedures, or by way of cartoon-style "balloons" appearing on the screen and pointing to specific interface components or as labels to icons.

Paper based documentation in the form of handbooks and user guides continue to be a valuable resource for providing user guidance that can be used at the same time as operating the equipment or taken away and read separately.

Cross references:

Help Mechanisms- Human; Built-in; Auditory; Multimedia; Help.

Recommendations:

- Written help, in the form of cards or hard-copy manuals, is desirable but should not be regarded as sufficient for ICT products and services. Users now expect some form of online help.
- Provide electronic indexes, hypertext links and cross-references, to maximize the user's capability to retrieve documentation quickly.
- Use abbreviations carefully when presenting help messages visually.
- Develop written instructions in parallel with the system development, taking account of the user requirements, the tasks to be done and the complexity of the tasks.
- Instructions have to be complete, accurate and up to date.
- Consider the need to include the following contents: name of the product and manufacturer; table of contents; safety information; installation or assembly; diagram or picture of components, or parts; operating instructions; routine maintenance; index.
- Organize the instructions by user defined tasks, and build up confidence by starting with one that is simple, or frequently occurring, or likely to be done first.
- Consider alternatives to narrative text: illustrations; flow-charts; tables; lists.
- Write instruction procedures as lists of short sentences that can be followed as a sequence of steps.
- Use short simple sentences, typically between 15 and 25 words long, with a maximum of 30 words.
- Use familiar words, avoiding jargon and abbreviations.

- Develop a consistent page layout for handbooks to enhance readability and visual.
- Test the instructions for technical accuracy by simulating tasks on the product, and test for understanding and usability with people using them to operate the system. Be prepared to edit or change the instructions to improve understanding.
- When instructions are translated it is advisable to use a translator whose first language is the one into which the translation is made, and to repeat the validation in the other language.
- Provide text in a larger point size for the visually impaired.

Additional comments:

User guides and handbooks are going to be used most frequently in the early stages of operating the system or product. At this stage the user may initially want to know "what" the system can do to help them in their work.

All user guidance materials, handbooks, user guides and prompt cards should be tested to ensure they are usable by the target population; not just in terms of legibility, comprehension and presentation, but more importantly also on the content. The aim should be to answer questions like: "Can a sample of users take the product and the handbook, correctly install it and complete a simple task successfully, without reference to external help, within a reasonable time?".

Advantages of Textual help:

- It is very easy to modify textual help as the interface or application changes.
- It can be designed to meet the needs of different types of users.
- It is relatively inexpensive to produce.
- The user has control over the rate of presentation and can easily check back earlier sections for review. (This is particularly true of paper-based help. Electronic help should also support a similar level of flexibility).
- Paper-based documentation can be consulted without interrupting the current state of the interaction on screen.

Disadvantages of Textual help:

- If presented in separate hard-copy cards or manuals, the user may have to leave the terminal to consult the paper information.
- Written information imposes high cognitive load on the user.

7.8.3 Tutorial Systems

(Training, User Guidance)

Tutorial Systems give training to users and provide the required knowledge about available procedures to inexperienced users. They normally provide initial knowledge about how to operate with a system.

They consist of instructional dialogues that train users to increase knowledge of the computer-based task and facilitate long-term performance. Tutorial systems provide general instructions and practice in interface procedures. To achieve this aim, they provide simple tasks with which users can practice.

Cross references:

Help Mechanisms- Human; Built-in; Text; Auditory; Help.

Recommendations:

- Provide training on the goals that the system can achieve, to indicate to novice users what can be done with the system.
- Present step-by-step interface procedures to assist the user with specific problems.
- Provide procedural demonstrations of interface procedures so that users can quickly learn simple operations.

- Provide detailed knowledge of interface procedures that inexperienced users can actively learn and that more skilled users can combine with other procedural knowledge to improve long-term performance and understanding of the interface.

- Provide users with an understanding of representative tasks to increase their knowledge of when to apply specific interface skills.

Three methods of training and guidance are described by:

- Telling the user what to do (verbal methods), either by means of written manuals or their electronic implementations, and also by means of spoken material. These methods impose high memory requirements, which can be limiting for elderly, untrained or inexperienced people, as well as problems for adequately translating the required actions to words.

- Showing what to do (demonstration or guidance), providing not only the required procedures but also the results of the actions. This method generally produces a more uniform performance with very different types of users, due to fewer memory requirements and the provision of visual cues, and can more effectively draw attention to the relevant elements to achieve a specific goal.

- Having the user practise under controlled conditions, which can adapt the training to users needs very closely, but is limited to the availability of the required resources needed for its implementation.

Additional comments:

Advantages of providing a tutorial system:

- A basic knowledge of interface functions is a critical component for initial learning by subjects.

- They decrease the cognitive load of users who are learning a new interface task by providing an explicit procedure for users to follow.

- It is an important issue in the design of broadband services especially when they are intended for its use by the general public and for the first few moments of interaction for all kinds of users.

- They can reduce the need for hard-copy manuals, which take up workspace and possibly divert the user's attention from the video display and computer-based task.

- New multimedia technologies, as animation or video, may aid users in understanding the interface structure. This may help users learn and remember computer-based procedures.

Disadvantages of providing a tutorial system:

- As it takes time and effort to use a tutorial system it requires commitment on behalf of the user.

8 Input components - Design Guidelines

8.1 General

The recommendations in this chapter relate to those parts of an ICT product which allow the user to carry out the procedures or dialogues associated with a particular operation or function. The input devices covered include keys and keyboards, pointing devices, discrete and continuous controls, software controls and indications, acoustic, visual, biological and electronic input devices. The recommendations given in this clause are of a general nature applying to most input devices.

Recommendations:

- When choosing a specific input technology, designers should be aware of the typical failure rates for the technologies under consideration and, equally, the likely human error rates in using that technology within the range of tasks expected.

- When choosing a particular input technology, designers should be aware of the limitations particular technologies present to people with special needs. Users need to be able to locate the ICT product and the particular controls and indications - even if they are blind; they need to be able to understand how the input device is operated (e.g. pressed, lifted, or turned) - even if they are intellectually challenged; they need to be able to perform manipulations on the input devices - even if they have one hand only or no hand at all. For example, keyboards may require dexterity in both hands, light pens and touch screens force the user to lift the whole arm, etc. In general, for people with special needs:

  - Minimize the force required to operate controls.
  - Avoid simultaneous manipulations, e.g. pushing and rotating.
  - Avoid making the user hold a control in a specific position for periods of time.
  - Avoid controls which limit or restrict the handedness or grip of the user.
  - Offer alternative input modalities for visually-impaired users when employing pointing and continuous input devices.

Additional comments:

In the individual entries listed in the cross references, recommendations are included that:

- Refer to agreed international standards, and to information given on draft international standards where these are relevant.
- Give guidance on Human Factors design for individual input technologies, based on good practice and recorded studies.
- Highlight design requirements for elderly and disabled users and requirements for maximizing safe operation.

8.2 Tactile input: Keys and keyboards

8.2.1 General

In the following clauses, recommendations are given for the design of keys, keyboards, and keypads. Design-for-all recommendations that apply to all types of keyboards and keypads are given in clause 8.2.4."

8.2.2 Keyboards

8.2.2.1 General

(Keypads)

An input control panel containing a number of keys or pushbuttons. The keys are usually arranged to conform to a standard layout, e.g. digits 0-9 and alphabet keys in ISO/IEC 9995 [66]. Alternatively, a number of function keys may be arranged singly, in groups, or in column/row matrix.

Cross references:

Alphanumeric Keyboards; Control Key Dialogues; Cursor keys, Function Keys; Keys; Pushbuttons; Soft keys, Switches; Telephone Keypads.

Recommendations:

- The recommended tilt/slope depends on the type of keyboard/keypad (e.g. between 5° and 12° for alphanumeric keyboards, ISO 9241-4 [54]). If the tilt/slope is adjustable, the keyboard should be stable in all possible positions.

  For people with reduced movement capability it may be a problem if the keypad is too tilted or horizontal, or if the front of the keypad is too high, because this makes it difficult to rest the hand on the keypad or the table while pressing keys.

- ES 201 381 [9] requires the tactile marking of individual keys (e.g. the number "5" on telephone keypads and the letters "F" and "J" on alphanumeric keyboards) in order to increase the usability of keyboards and keypads for visually-impaired people.

- Further recommendations are offered in detail in each of the cross referenced guidelines.

Additional comments:

The optimum design of keys and keyboards is essential to minimize user errors (e.g. miskeying and double keying) and to speed data entry as well as reducing the likelihood of RSI (Repetitive Strain Injury). Slow keying times and high error rates can increase operation costs, without necessarily increasing revenue. At the same time, they reduce the users' acceptance of the system and their perception of quality.

Keyboards may comprise:

- The standard keypad as found on telephones, used for entering discrete data items, and operated by a single finger. The 10 or 12 numeric keys, principally used for entering telephony addresses, and for signalling to the connected network or terminal.

- The combined alphabetic and numeric keyboard (e.g. computer keyboards) with one key per character or digit, with or without shift keys to access alternative characters or symbols; and usually operated with both hands.

8.2.2.2 Alphanumeric Keyboards

(Alphabetic Layouts, QWERTY/QWERTZ/AZERTY Keyboards, Repetitive Strain Injury)

An alphanumeric keyboard contains keys bearing letters of the alphabet as well as numbers (and possibly function keys), usually in separate blocks. They commonly have shift keys to access alternative characters or symbols.

Cross references:

Control Key Dialogues; Keyboards; Keys; Pushbuttons; Switches; Telephone Keypads.

Recommendations:

- General recommendations on the design of alphanumeric keyboards can be found in ISO/IEC 9995 [66] and ISO 9241-4 [54].

- The preferred horizontal and vertical distance between two adjacent keys (key centre to centre) for professional level alphanumeric data entry is 19mm ± 1mm, vertically and horizontally irrespective of key cap style [66].

- The space between the key groups should be clearly larger than the space between the keys within a group, and the keys of the various key groups have clearly different shapes, sizes, textures and/or colours.

- If the key groups are separated by a clearly defined space, by different shapes or by different textures of the keys in the various key groups, it is easier for blind people or people with visual impairment to identify the various key groups.

- The preferred arrangement of letters, digits and symbols is the accepted "QWERTY" layout [66], with national variations (see figure 11).

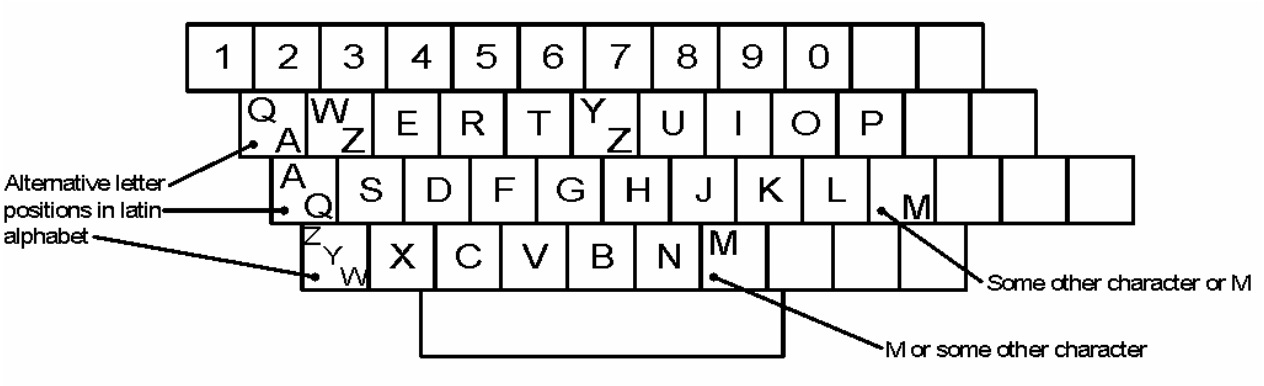


Figure 11: ISO/IEC recommended arrangement of letters

- The preferred keyboard height at the home row (A, S, D, F, etc.) is 30 mm or less with a recommended maximum of 35 mm (ISO 9241-4 [54]).
- The preferred keyboard slope is 5° to 12° (or 0° to 15° as limits of the accepted range) (ISO 9241-4 [54]).
- Where the alphanumeric keyboard is part of display screen equipment that is to be used for a significant part of the working day, the design needs to meet Health and Safety regulations under the European Council Directive /EEC [139].
- For VDU workstations, ensure the keyboard is separable from the screen unit by at least 300 mm (ECMA-110, ECMA-126). This may be desirable, but is not mandatory, for portable terminals or compact systems for specific applications.
- In a compact keyboard with small horizontal and vertical key distances, "QWERTY" layouts may perform better than Alphabetic layouts.
- Alphabetic layouts are only recommended if space precludes the 4 × 10 key matrix necessary for a "QWERTY" layout, where the increase in key size for a 5 × 6 versus a 4 × 10 layout can be traded with the benefit of "QWERTY" over alphabetic.
- Use keys with 1,5 mm to 6 mm travel for alphanumeric keyboards, if membrane keyboards have to be used, be aware that data entry performance may be reduced (increased keying times and errors) (ISO 9241-4 [54]).
- Use keys with 0,25 N to 1,5 N force for alphanumeric keyboards, be aware that "snap-action" tactile feedback may slow professional typists, use "ramp/continuous force" keys for main keyboard and "snap-action" for function keys (ISO 9241-4 [54]).
- Make use of enlarged keycaps for critical functions, e.g. space, enter, tab, backspace, and the shift keys (shift, alt and control), avoid the use of keycaps which include a standard size finger pad on top of the main key body.
- ES 201 381 [9] requires the tactile marking the letters "F" and "J" on the home row of alphanumeric keyboards in order to increase the usability of keyboards and keypads for visually impaired people.
- There should be an option that allows the user to only need to press one key at a time. For instance, a control key and a numeric key can be pressed consecutively, as opposed to simultaneously. People with reduced movement capability, people with uncoordinated movements, people who have only one hand, and people who use a headstick or mouthstick will have a problem if they have to press more than one key at the same time.
- For further Design-for-All requirements on the design of keyboards and keypads see clause 8.2.4.

Additional comments:

As a matter of good design practice, the electrical and terminal interface characteristics of detachable keyboards should conform to recognized standards. This is one way to maximize the opportunity to offer alternative keyboards and other input devices for users with special needs.

8.2.2.3 Telephone Keypads

(Alphabetic Layouts, Keying Logics, Keypads, Mnemonic Dialling, Rotary Dial)

The keypad on a telephone terminal used to enter the digits 0-9, plus * and #, for access to terminal or network functions. The digits may be sent to line in the form of loop disconnect signalling, where each momentary loop disconnection represents a single element of a digit or may be in the form of DTMF (Dual Tone Multi Frequency) signalling, where each digit is represented by a pair of tones sent to line.

Cross references:

Alphanumeric Keyboards; Keyboards; Keys, Pushbuttons.

Recommendations:

- The recommended minimum keypad includes the 12 keys, 0 - 9, * and #. The preferred arrangement for telephone numeric keypads is 12 keys in a 3 column by 4 row layout.
- The digits 1, 2 and 3 should be assigned to the top row (ITU-T Recommendation E.161 [76]) as shown in figure 12. This is especially important for people who are blind or visually impaired.

1	2	3
4	5	6
7	8	9
*	0	#

Figure 12: ITU-T Recommended numeric layout

- The preferred keypad angle for desktop telephone terminals is dependent upon the height of the keypad from the desk (see figure 13). For keypads with the home row (4, 5 and 6) greater than 85 mm above the desk, the recommended angle is 25° ± 10° from the horizontal. For keypads with the home row at 30 mm or less, the recommended keypad slope is 5° to 12° (or 0° to 15° as limits of the accepted range) (ISO 9241-4 [54]).

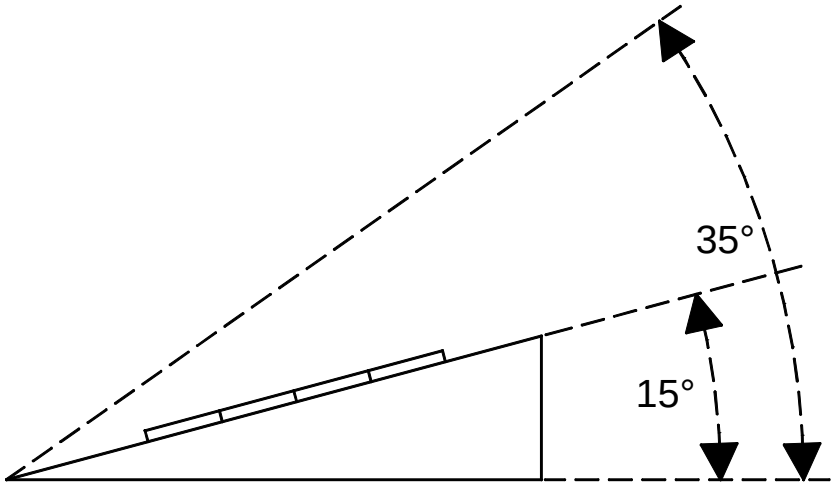


Figure 13: Keypad angles - preferred range

- ITU-T Recommendation E.161 [76] specifies the layout of alphabetic letters associated with the numeric keys (no provision is made for specific national characters).

1	ABC 2	DEF 3
GHI 4	JKL 5	MNO 6
PQRS 7	TUV 8	WXYZ 9
*	0	#

Figure 14: Layout for alphabetic characters on keypads

- If alphabetic data entry is required, a full alphabetic or alphanumeric keyboard should be provided.
- ES 201 381 [9] requires the tactile marking of the number "5" key on telephone keypads in order to increase the usability of keyboards and keypads for visually impaired people.

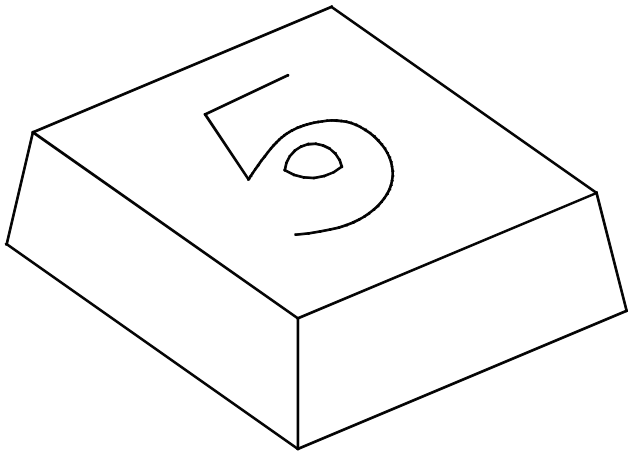


Figure 15: Tactile marking on key 5

- For further Design-for-All requirements on the design of keyboards and keypads see clause 8.2.4.

Additional comments:

In exceptional circumstances, where space precludes the use of an alphabetic keyboard and the alphabetic data entry requirements are limited, it may be acceptable to use a multiple keying logic ("multitapping") to enter alphabetic and numeric data via the standard 12 key keypad, e.g. press key "2" once for A, twice for B, three times for C (assuming the keypad is in alpha mode).

The designer should be aware that all multiple keying logics may result in significant increases in keying time and greater incidence and variation in errors. The ITU-T mapping assigns up to four characters to the digits 1-9. This may be supported by rapid scrolling through the possible characters if the key is held down.

In many mobile products such as cellular telephones, predictive methods are being employed that require the user to touch each respective numeric key only once while the predictive software selects a word from a list as in many cases the intended entry is unambiguous.

Whatever keying logic is selected, single or multiple (shift function or chord), performance will improve if visual feedback is given of the character selected. However, while the user should never be expected to key data "blind", keypads should always be designed such that they are fully usable by visually impaired people as well (see also clause 8.2.4).

8.2.3 Remote controls

(Keypads, Controls)

A remote control allows the cordless control of the functions of a device from within a certain distance.

Cross references:

Alphanumeric Keyboards; Keyboards; Keys, Pushbuttons.

Recommendations:

- If the remote control includes a number key block, the arrangement of the number keys should comply with ISO 9241-4 [54].
- The keys should be grouped according to the functionality they address (number keys, volume control, stream control (Play, Pause, Stop, etc.)).These function groups should be arranged spatially apart and the keys of the key groups should be distinguishable in terms of form, colour and shape.
- Feedback should be provided on the action of the control.

Additional comments:

Replacement remote controls should be available even after the provision of the product they are used with has been discontinued.

8.2.4 Keys

8.2.4.1 General

(Buttons)

Discrete input selection devices used to enter single pulse inputs.

Cross references:

Alphanumeric Keyboards; Keyboards; Pushbuttons; Telephone Keypads.

Recommendations:

- Provide keys with flat or concave (dished) sculptured key caps, which accept a good proportion of the finger pad. If the top of the keys has a convex curvature, people with reduced movement capability or uncoordinated movements and people who use a mouthstick or headstick may have problems operating the keys as the fingers/stick will easily slip off the keys. Also the material the key is made of is important (see figure 16).

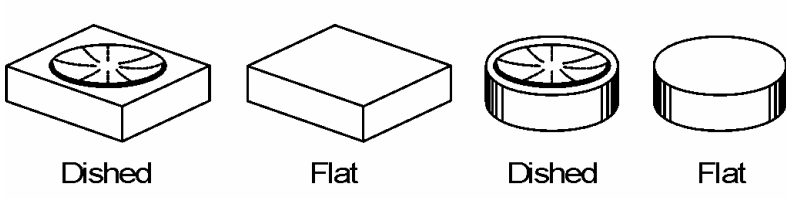


Figure 16: Example flat and dished keycaps

- The key size should be at least > 60 mm^2 and preferably > 110 mm^2. Maximum size of the keys is limited by the size of the keypad. It is important that the size of keys is sufficient for people with uncoordinated movements to be able to hit the right keys. For visually-impaired people the keys need to be sufficiently large so that there is room for characters of sufficient size.

- For people with reduced movement capability or uncoordinated movements it may be an advantage if the key is flush with the surface of the keypad so that it is possible to rest the hands on the keypad when the keys are pressed. Keys placed under the surface of the keypad or keys with a more deeply dished top may be of help for people with reduced movement capability and for users of a headstick or mouthstick. For blind people and people with reduced vision it is an advantage when the keys are raised because they then can feel where the keys are.

- Recommended material for the top of the keys is rubber or matt plastic [54]. If they are made of glossy plastic, people with reduced movement capability or uncoordinated movements and people who use mouthstick or headstick may have problems operating the keys as the fingers/stick will easily slip off the keys. For visually impaired people glossy keys may create a glare so that they cannot see the character on the key.

- Provide conventional ramp or snap-action force/travel keys (travel 1,5 mm to 6 mm, force 0,5 N to 1,5 N [54], in preference to membrane (zero travel) keys or touch panel.

- If membrane keys are essential, bubble membranes with minimal travel are more acceptable than flat ones. The pressure needed to activate the keys is important for people with various kinds of disability. People with reduced muscular strength may have a problem if too much pressure is needed, and people with uncoordinated movements may have a problem if too little pressure is needed as, in this case, the keys are easier to activate by mistake.

- The key movement direction should be completely vertical. Keys should be activated no matter where they are pressed. The keys should not get jammed. If the direction of the key pressure is unsteady so that the pressure is not completely vertical, people with reduced movement capability or people with uncoordinated movements and people who use a headstick or mouthstick may have difficulties in activating the keys as, in those cases, the fingers or the stick may slip off the key without having activated it.

- The key cap inscriptions should be readable at the perceived viewing distance. The minimum size of the characters should be 16 pt or 4 mm, or, from 6 mm to preferably > 9 mm for better legibility by visually-impaired users. The maximum size of the characters is limited by the size of the keys.

- It is important that the contrast between character and background on the numeric keys is high enough for visually impaired people to easily read the character. Key cap inscriptions should have a minimum contrast ratio of 1:3. Good colour combinations to achieve this are white on a black background and white on a dark blue background. Not recommended are: white on a light or pale colour, black on a dark colour, red on green, blue on yellow.

- Keys should be designed and arranged in such a way to avoid activation by mistake. Blind people, visually impaired people, people with reduced movement capability and people with uncoordinated movements will have an increased probability of activating keys and other controls by mistake.

- Numeric and alphabetic keys that may be used for professional data entry should correctly detect each key activation in correct order by N-key rollover (where N=3 or more with a burst rate minimum of 50 characters per second over 3 seconds).

- Numeric and alphabetic keys that auto repeat, should provide a fixed rate (15 ± 5 characters per second) after an initial delay between 500 ms and 750 ms after the key is actuated.

- Ensure feedback is provided on each key's actuation and the resultant dialogue action. For key actuation provide tactile ("snap-action" force travel curve or distinct stop to key travel) or auditory (click) feedback. For resultant action provide auditory or visual feedback as appropriate (e.g. DTMF tones and/or display digit).

- For people with reduced movement capability it is important to have a distinct haptic or auditory feedback from the keys. Otherwise they will often press the keys harder than necessary in order to activate them. For blind and visually impaired people, feedback is important so that they can feel or hear when the key is activated.

- For people with reduced kinaesthetic senses, e.g. due to diabetes, who cannot feel when the keys are activated, it is important that the keys give a distinct auditory feedback when they are activated (also in the earpiece of a telephone handset). For people who are blind or visually impaired, a distinct auditory feedback is important so that they can hear when the keys have been activated.

- Well-spaced keys reduce the chances for pressing the wrong keys. This is especially important for:
  - people with uncoordinated movements because wide spacing prevents them from pressing several keys at the same time;
  - people with visual impairments because they can distinguish keys more easily if there is more space between them; and
  - blind people who can more easily feel each key.
- It is recommended to provide a keyguard. It will be an advantage for people with reduced movement capability to have the keys recessed so they can rest their hands on the keypad when they press the keys. Recessed keys are also useful for people with uncoordinated movements and for people who use a headstick or mouthstick. Keys may be recessed by means of a keyguard.

Additional comments:

LCD touch overlays can match conventional keys for data entry time and errors, if spacing is equivalent to conventional dimensions and feedback is given to signal the keys actuation (clicks and DTMF tone).

Snap-action keys give good tactile feedback when operating function and numeric keys. If the task requirements are for professional data entry, then "snap-action" feedback may prevent users from reaching maximum burst rates, and "ramp or continuous force" keys may be preferred.

8.2.4.2 Cursor Keys

(Arrow Keys)

The simplest pointing device, with four keys representing the standard directions of up, down, left, right; usually used to control screen based cursors or pointers.

Cross references:

Function Keys; Joysticks (Hand/Finger); Keyboards; Keys; Light Pens; Mouse; Pointing Devices; Pushbuttons.

Recommendations:

- Provide cursor keys as basic cursor controls to supplement any other chosen device used with the system, unless space specifically precludes it.
- Choose a layout of keys which complements the users' expectations for the relative positions of the four directional keys, i.e. up above down, left to left of right. Use the standard inverted T or cruciform layouts. (See figure 17) [66].

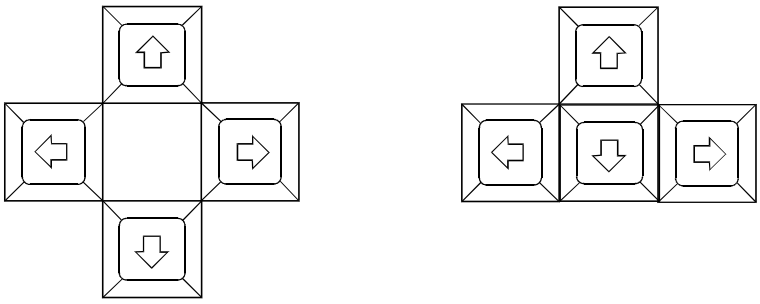


Figure 17: Preferred cursor key arrangements

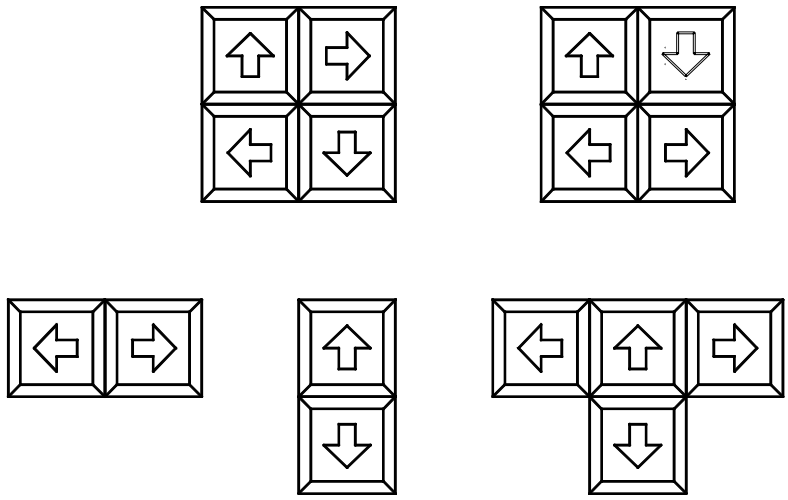


Figure 18: Cursor key arrangements to be avoided

- Label the keys with arrow symbols which clearly indicate the direction of operation (ISO/IEC 9995 [66], defines the symbols).
- Use the same minimum dimensions for the cursor keys as for the rest of the keys on the keyboard (see Alphanumeric Keyboards).
- The basic four cursor keys may be supported with two more keys, frequently labelled Home (move cursor to top left position of document, data-block or screen) and End (move cursor to bottom right position of document, data-block or screen) [66].
- Use only to move pointers or cursors across a regular grid. Avoid using for full two dimensional movements.
- Do not use for drawing on the screen, except perhaps for rectilinear objects.

Additional comments:

See also clause 8.2.2.2.

8.2.4.3 Function Keys

(Programmable Keys, Soft-keys)

Keys dedicated to the direct selection of commands and features. The named function or feature may be assigned by the hardware design or may by programmed by the user. Where the function of the key is indicated by a visual display, according to the current dialogue state, these are termed soft-keys.

Cross references:

Control Key Dialogues; Dialogue Style; Keys; Keyboards.

Recommendations:

- Use named function keys to give rapid implementation of simple actions, and for frequently used features within more complex procedures.
- Arrange function keys into groups that reflect the logic of the task such as sequential operation, importance, frequency of use, and function.
- Separate or use colour coding to reduce risk of keying errors that might have irreversible effects such as terminating a call while still transmitting data.
- Avoid multiple functions on a single function key.
- Where shifted functions are unavoidable, limit the number of shifted levels to two.

- Give feedback, which may be tactile, audible or visual to confirm that key has activated.
- Use soft-key dialogue to give guidance and to minimize numbers of function keys.
- For Design-for-All requirements on the design of function keys see clause 8.2.4.

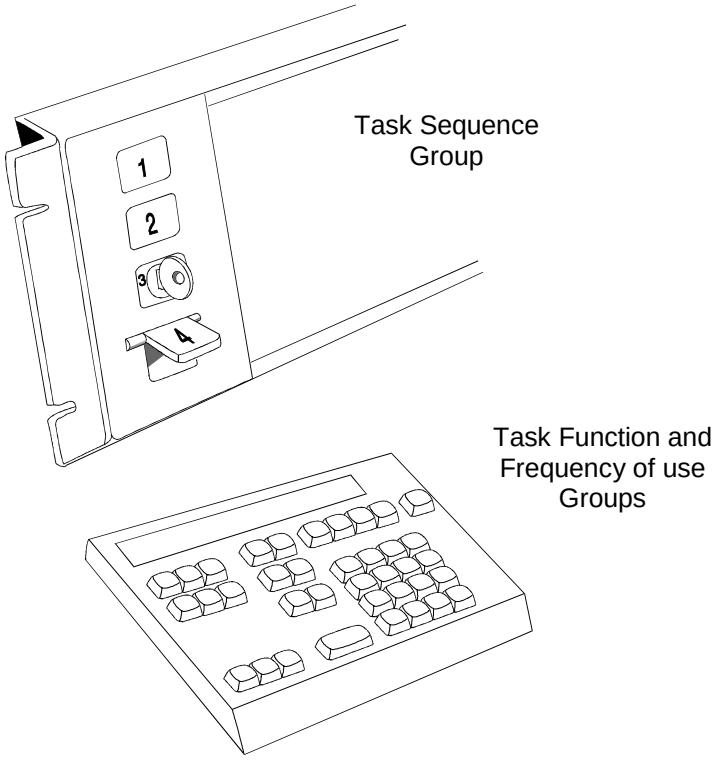


Figure 19: Example function key layouts

Additional comments:

Dedicated function keys are usually quick and easy for novice users to operate since they provide a permanent reminder of the features available.

More information on soft keys may be found in clause 7.2.7.

8.3 Tactile input: Pointing devices

8.3.1 General

(Cursor Controls, Controls, User Stereotypes, Assistive devices)

Input devices, which allow emulation of the pointing action of the user on a visual display. All these devices can drive a cursor either to position it over a screen element to enable the dialogue to proceed using that element, or to draw a figure/character on the screen.

Cross references:

Cursor Keys; Data Glove; Eye/Head Movement; Foot Mouse; Graphics Tablet; Joysticks; Light Pens; Mouse; Roller balls; Stylus; Touch Screens.

Recommendations:

- When choosing a preferred pointer device for a particular terminal, consider the users' tasks, and refer to table 16.

- Consider the advantages of enabling a variety of pointing devices to be used, so as to make the terminal accessible to people with special needs, and provide other users with more flexibility.
- For every pointing device, consider the need for feedback of user actions. Preferably, this feedback should be multimodal (visual, auditory, tactile).
- Allow the user to execute pointing functions from the keyboard [144].
- The operation of a pointing device should not require two simultaneous hand movements [144].
- The force needed to operate the pointing device should be between 0,3 and 0,6 Newton. Preferably, the required force should be adjustable [144].

Additional comments:

Tables 16(a) and 16(b) present a comparison of different pointing devices. See also ISO 9241-9 [58] for requirements of non-keyboard input devices.

Cursor keys, joysticks and eye/head trackers can also be used as pointing devices. They are all included in tables 16(a) and (b).

Some persons with reduced hand functions, such as reduced strength, small movements, or shaky hands etc., may encounter difficulties in handling pointing devices, such as mice, joysticks, track balls, touch pads, touch screens, etc. [144].

Table 16(a): Comparison of pointing devices

	Pointing/ Indicating	Selecting e.g. menu items	Selection No. of choices	Tracking	Tracing/ free-hand drawings	Dragging Objects	Speed of positioning
Mouse	Good	Extra keys - Good	Up to 3	Fair	Fair	Good	Good - Fair
Foot Mouse	Fair	Fair	?	Fair	No	Fair	Fair
Stylus	Good	Good	1 at a time	?	Good - Fair	Good -Fair	Good
Light Pen	Good	Good	1 at a time	Fair	Fair	Fair	Good
Roller Ball	Good	Extra Keys	1 or 2	Good	Poor	Good	Good
Data Glove	Good	Good	?	Fair	?	Good	?
Graphics Tablet	Good	Extra Key- Good	Many	Fair	Good	Fair	Good
Touchpad	Fair	Fair	1 at a time	Fair - Good	Poor	poor	Fair
Touch Screen	Good	Good	1 at a time	Poor	Fair - Poor	Fair - Poor	Good
Cursor Keys	Fair	Extra Key	2 (Enter or Cancel)	Fair	No	Poor	Fair - Slow
Joystick	Good	Extra Key	1 or 2	Good	Poor	Fair	Good
Eye/head movement	Good	Fair	?	Good	Poor	Fair -Poor	?

Table 16(b): Comparison of pointing devices

	Positioning Accuracy	Space Require-ments	Eye/Hand Co-ordination	Unobstructed view of display	Parallax Problems	Low Cost	Free to position in workplace
Mouse	Good -Fair	Fair	No	Yes	No	Yes	Yes
Foot Mouse	Poor	Small	N/A	Yes	No	Yes	Yes
Stylus	Good	Small - None	Yes	No	Maybe	No	No
Light pen	Good	Small	Yes	No	Maybe	Yes	Yes
Roller Ball	Good	Small	No	Yes	No	Fair	No
Data Glove	?	Special	Yes	Yes	No	No	Yes
Graphics Tablet	Good	Large	No	Yes	No	Fair	No
Touchpad	Fair	Fair	Fair	Yes	No	Yes	Yes
Touch Screen	Fair	None	Yes	No	Possible	Fair	No
Cursor Keys	Good	Small	No	Yes	No	Yes	No
Joystick	Fair	Small	No	Yes	No	Fair	No
Eye/Head Movement	?	Special	N/A	Yes	No	No	No

8.3.2 Mouse

The mouse has become the most common point-and-select device. It consists of a small contoured "box" that fits under the palm or fingers. Movement of the mouse over a flat surface is reflected in co-ordinated movement of the cursor. It is usually provided with one or more buttons for activating screen elements at the current cursor position. Movement of the mouse is detected either mechanically or optically. Mechanical mice can be used on any surface, whereas optical mice can only be used in combination with a special pad.

Cross references:

Footmouse; Pointing Devices, Roller Balls; Graphics Tablet; Joysticks, Hand/Finger; Cursor keys.

Recommendations:

- Use a mouse with a rounded peak close to the centre of the top surface to give palm support, with buttons on the front and top surface rather than just on top. Ensure the buttons are stiff enough to support resting fingers without activation and provide good tactile and auditory feedback when activated.
- Provide a good textured surface for gripping particularly at the side. Ensure the mouse is stable (not rocking) and glides smoothly over the work surface, and provides a good platform for key operation (does not move on key presses).
- The shape should be suitable for both right-handed and left-handed users [108]. Note that mice specifically designed for left-handed people are available on the market.
- Use a single button to select one of a group of displayed alternatives or use different buttons to select different responses to a single attribute or function.
- The buttons should provide sufficient haptic and auditory feedback of the click when operated [108].
- When two or more buttons are provided, allow the change of the selector button for right-handed and left-handed use [108].
- For right-handed users, the right mouse button is more difficult to use than the other buttons. Hence, the right mouse button should not be used as a default setting for frequently use functions [116].
- The mouse cable should be kept off the mouse pad with the help of a cable lead. This should prevent the mouse from being blocked [108].

- It is recommended that the cable be introduced from the top front of the mouse via a flexible cable lead [108].
- If a cord interferes too much with the use of the device, consider a cordless mouse [116].
- The mouse pad should be designed so that minimal movements and inadvertent movements of the hand are buffered [108].
- Provide sufficient space close to the display for hand arm movements to control the cursor, which may require a special mouse pad (optical mouse) or suitable level of friction on the workstation surface (friction ball mouse).
- Enable the user to customize mouse features, such as the speed of movement of the cursor, the distance moved by the cursor, and the double-click interval.
- Precision of targeting can be improved by means of software driven adjustment of the translation of the mouse's wheel to the requirements of precision of surface. This feature should particularly be used for people with reduced motor ability [108].

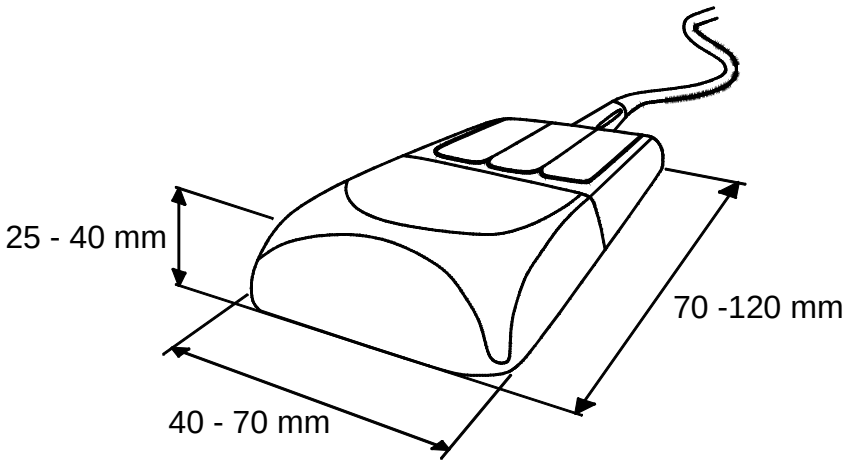


Figure 20: Example mouse

Additional Comments:

See [124] for a set of design criteria for a mouse directed towards reducing the user's exposure to risk factors for upper extremity musculoskeletal disorders.

Performance with mice is strongly dependent upon having experience with their use. If the system is to be used by inexperienced people, the user population's ability must be assessed [108], or another type of input device should be considered, e.g. a touch screen.

Avoid using a mouse for free hand drawing tasks. For these tasks, consider a graphics tablet.

Feedback should be provided in more than one modality. For example, adding tactile indication (a small pin that projects slightly above the left mouse button on approaching a target) and force feedback to the mouse increases the "effective" area of the target [104]. This may help users with limited motor skills to find the target more easily.

8.3.3 Foot Mouse

An input device where the foot is used to control a cursor. Typically consists of a metal pedal with a circular rubberized surface which pivots. Pressing the pedal at the top, bottom, left or right edge moves the cursor in the corresponding direction.

Cross references:

Pointing Devices; Roller Balls; Mouse; Joysticks, Hand/Finger; Cursor Keys.

Recommendations:

- Recommendations on the optimum dimensions, force travel characteristics etc. are not available from the literature.

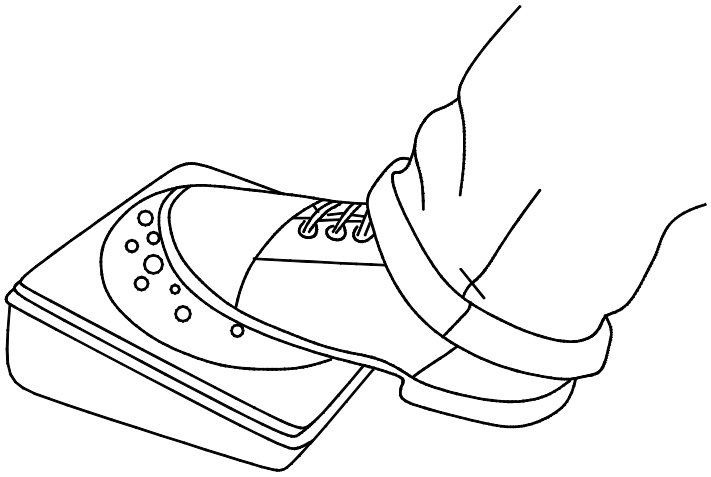


Figure 21: Example foot mouse (after Helander, 1988)

Additional comments:

The foot mouse takes about twice as much time to use as a hand-operated mouse [123].

Available for rapid course control of the cursor by holding the pedal down. Some fine control, single point movements are also possible. May be useful in some applications for people with special needs.

8.3.4 Stylus/Pen

(Gesture Interfaces)

An input device consisting of a transparent digitizing tablet (Graphics tablet) on top of a flat screen, to provide a note pad style device which uses a stylus as the single control device. Advances in software have enabled hand writing (for example, using Graffiti) and a number of pen marks or "gestures" (like carets, brackets, ticks, etc.) to be recognized successfully.

Cross references:

Pointing Devices; Touch Screens; Touchpad; Graphics Tablet; Lightpens.

Recommendations:

- The basic dimensions of the stylus should be 120 mm to 180 mm long, and 7 mm to 20 mm diameter, their mass should be between 10 g and 25 g, and a retaining clip or housing for the stylus (similar to the light pen) should be provided.
- The grasp surface of a stylus should be slip-resistant.
- The force requirements to activate the stylus on a tablet should not be greater than 1,5 N.

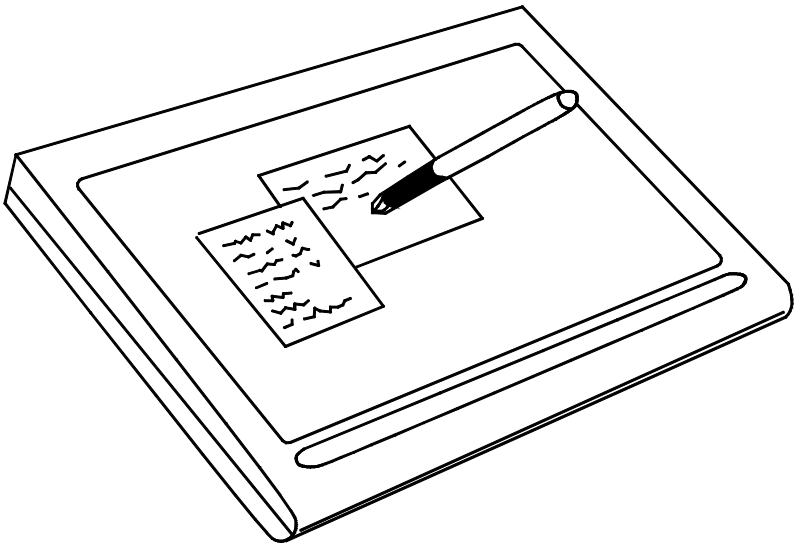


Figure 22: Example stylus/pen computer

- If handwriting recognition is offered, it should be easy to learn the required alphabet.
- An alternative of handwriting recognition in the form of a virtual keyboard should be offered.
- Input by stylus/pen generally requires the ability to accurately position it at the target, and is not very suitable for people with reduced motor skills. Also, since it is mainly used in combination with small, portable devices, the screens may not be legible for people with reduced vision.

Additional comments:

The stylus/pen computer makes use of an available range of "gestures" to control the dialogue. For example, a double tap may select a software object, a stroke through text or brackets around some text or data may mark the items for subsequent action like deletion, copying or moving. There are considerable advantages offered for editing or check style data entry tasks, particularly in environments that might preclude other solutions.

8.3.5 Light Pens

An input device usually used with CRTs, the light pen is used to point and select items displayed (in pointing mode) and to draw lines on the screen (in tracking mode). The pen detects the refreshing beam of the CRT and the timing of the signal gives the co-ordinates of the point touched. Resolution can be very high (typically approximately at 5 pixels, but can be as high as ¼ of a pixel on a screen with 1 000 × 1 000 resolution).

Cross references:

Graphics Tablet; Pointing Devices; Stylus/Pen; Touch Screens; Touchpad.

Recommendations:

- Consider the requirements of the task and the need to support the elbow and even the wrist if fine, accurate positioning is essential, may require the screen to be angled more to the horizontal than the vertical.
- Has the disadvantage of obscuring the screen at and below the point of touch and this may limit the degree of fine control. Has the strong advantage to point intuitively and to indicate or select with excellent hand eye co-ordination.

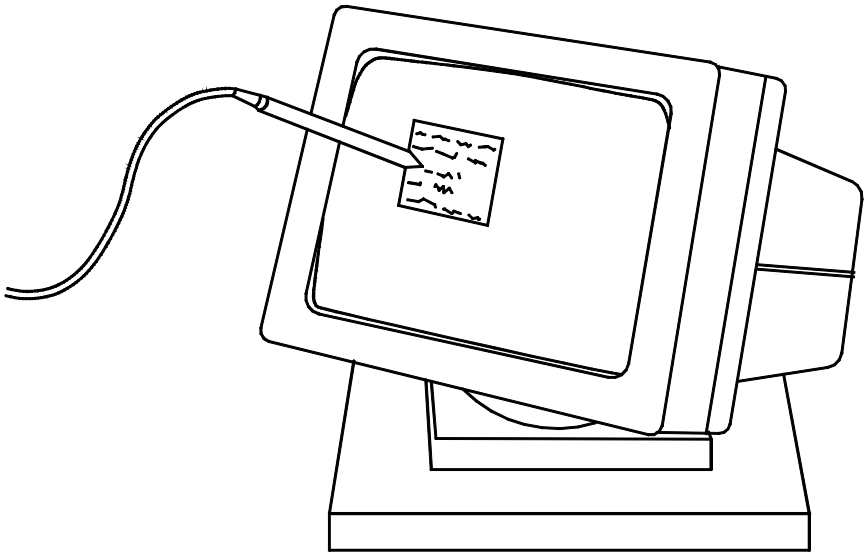


Figure 23: Example light pen

- Can be available for people with special needs as a head mounted or mouth controlled selector.
- Use a light pen within the following dimensions: 120 mm to 180 mm long, 7 mm to 20 mm diameter.
- Ensure the cable attached to the non-pointing end is not restricting the user's hand movements. Consider providing a holder of some form for when the pen is not required, and to assist in pen pick up.
- Provide feedback when the light pen is active on the screen and also when a selection is made.
- Make targets at the sides of the screen large enough to minimize the effects of incorrect placement, due to parallax problems [116].

Additional comments:

Because the light pen is used with a natural pointing gesture, this device is well suited for menu selection. Although a light pen may be used for drawing, it is not suitable for precise sketching. The constant rate of movement necessary in tracking mode creates additional difficulties in drawing tasks [116].

8.3.6 Roller Balls

(Tracker Balls)

An input device consisting of a small ball rotating freely in a fixed bed, with sensors to detect orthogonal movement which is digitized. It is usually fitted with 1 or 2 specific keys for co-ordinated control of point and select, etc. The control provides relative movement of a screen cursor in response to the direction the ball is rolled.

Cross references:

Footmouse; Joysticks; Mouse; Pointing Devices.

Recommendations:

- Provide adjustment of the display control ratio i.e. the speed of movement and distance the cursor moves in response to the speed and distance the ball moves. It is possible to adjust the roller ball in such a way that both gross movement speed (high gain) and fine positioning accuracy (low gain) are possible [116].
- Suitable for mobile devices or for equipments that have to be used in moving environments (on ships, planes etc.). Provide space for forearm and wrist support, to enable the ball to be rolled with the fingers. A switch may be necessary to disengage the ball when it is not being used.
- Avoid using for drawing tasks. Also, they are less suitable than mice for wide area selection tasks, where the cursor must be moved to distant points. Their usefulness is far more limited to pointing and selection tasks [108].

- If the roller ball can control the cursor beyond the current active screen area, provide indication on the edge of the area on the current direction of the cursor [102].

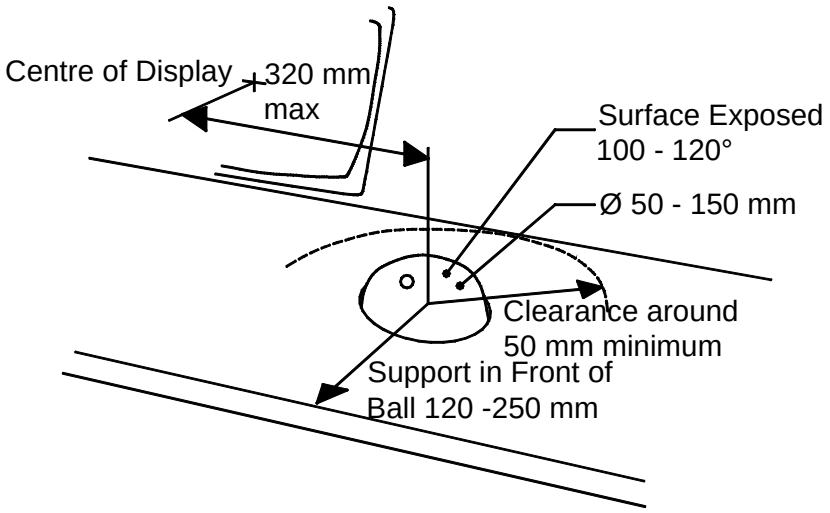


Figure 24: Example roller ball

- Use a ball within the following dimensions:
  - diameter 50 mm to 150 mm;
  - surface exposed 100° to 120°;
  - resistance for precision 0,3 N preferred (1,0 N maximum);
  - rolling force: 0,2 N to 1,5 N [58];
  - starting resistance: 0,2 N to 0,4 N [58];
  - resistance in moving environments 1,7 N maximum;
  - clearance around ball 50 mm minimum;
  - wrist arm support in front of ball 120 mm to 250 mm;
  - distance from centre line of relevant display 320 mm maximum;
  - recommended chord length of the exposed area at least 25 mm, exposed arc: 100° to 140° [58].
- Be aware that smaller roller balls may make precise control more difficult.
- Provide feedback in more than one modality (e.g. force feedback, auditory feedback).

Additional comments:

Unlike mice, roller balls cannot be run off the edge of the work surface [108].

Roller balls require minimum space and enable rapid movement of a cursor across a large screen. They also require minimum effort and may be used by people who tire easily, e.g. those with muscular dystrophy and multiple sclerosis.

Force feedback may be applied in a roller ball to help users positioning the roller ball at a target more quickly and with fewer errors. When entering a "force field"' that is created around a target, forces are exerted on the roller ball to assist entry of the cursor into the target or resist exit of the cursor from the target [111]. Force feedback may especially help users with reduced motor skills to find targets more easily.

8.3.7 Data Glove

(Gesture interfaces)

A device for pointing, gesturing and manipulating software objects by means of the user inserting a hand into a glove fitted with sensors to digitize manipulative movements in three dimensions.

Cross references:

Pointing Devices.

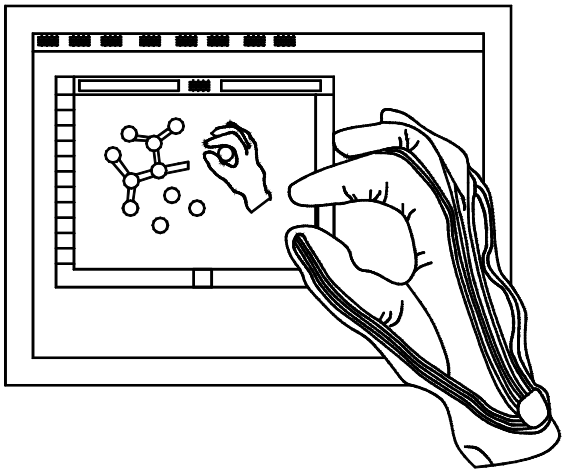


Figure 25: Example data glove (after Helander [116])

Recommendations:

- The data glove should provide tactile feedback to the user when a computer-generated image of the fingers "touches"' the surface of a displayed object. It allows users to interact with displayed objects as they do with real objects: they can be picked up, twisted, squeezed, thrown and set down [116].
- Further recommendations and ergonomic guidelines are not available at present.

Additional comments:

The use of Data Gloves is currently being explored in experiments dealing with virtual reality.

Data Gloves may be particularly interesting for Computer Assisted Design (CAD) applications, on multimedia terminals, since they offer three dimensional control.

Gestural input with the glove can have special applications such as input of American Sign Language or musical performance [130].

In tracking hand position, orientation, and movement of the hand, gesture-based input offers a natural and unobtrusive means for input of object designation and manipulation actions typically performed by the hand directly. Unfortunately, users require substantial training to master more than a half-dozen gestures.

8.3.8 Graphics Tablet

(Touch Tablets)

An input device consisting of a sensitive flat panel which can detect finger or stylus positions and movements. Usually it maintains a relative 1:1 relationship with an active area on the screen where the cursor tracks the current positions. It can be used for creating drawings and item selection.

Cross references:

Pointing Devices; Touch Screens; Touchpad; Stylus/Pen.

Recommendations:

- Use with a stylus or a puck for high resolutions and fine movement ability.

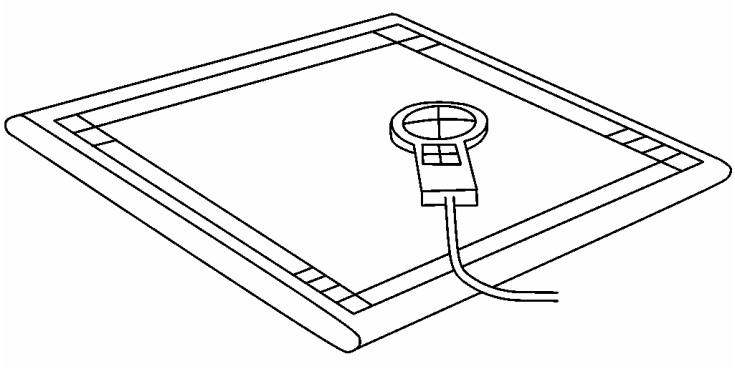


Figure 26: Example of graphics tablet

- Provide visual and auditory feedback to confirm item selections (a graphics tablet does not provide tactile feedback).
- Carefully control software for detecting item selection, to avoid "fall out", where the involuntary movements of the hand in releasing or lifting the stylus may relocate the cursor in a new active area. If small target areas have to be defined consider using a separate key press to confirm the selection. Avoid having to use two hands: one for lifting the finger off, and the other for pressing the key.
- Provide a display/control ratio for target acquisition tasks of between 0,8 and 1,0 for movement on the display relative to movement on the tablet.
- Consider the task requirements to define when the tablet is in absolute mode (1:1 positional relationship between the tablet and display active area) or relative mode (direction of movement from current position of cursor is 1:1 with the display - like the mouse). Absolute mode results in faster target acquisition rates and less error in tracking tasks. It may also be of benefit to visually impaired users, who can know exactly where they are positioned on the screen. Relative mode may be preferred in situations where the tablet is small compared to the display, since in this mode the amount of movement of the display cursor is not dictated by the tablet size [116].
- Select and adjust the tablet so that the pressure required does not fatigue the operator [116]. The maximum force required for input should not exceed 1,0 N [58].

Additional comments:

The choice of graphics tablet technology can impact the user's tasks, e.g. touch sensitive tablets may be prone to accidental touches by the resting hand etc.

Graphics or touch tablets are the best input devices for freehand drawings.

Graphics tablets can transmit information in more than two dimensions. For example, pressure-sensitive tablets have been developed that respond differentially to varying amounts of pressure.

Advantages of graphics tablets: the display and the tablet may be positioned separately, the user's hand does not cover part of the display, there are no parallax problems, drift in the display will not affect input, the user is not likely to experience fatigue. Disadvantages include: they do not allow direct eye-hand coordination, soreness and fatigue of the fingertip may be a problem over extended use periods.

8.3.9 Touchpad

(Touch tablets, LCD touch overlaysTouch Panels)

A surface which is sensitive to touch, and is available in different sizes. For an LCD touch overlay, the surface is transparent and regions of it can be configurable by software. It may be used on portable devices to replace the mouse.

Cross references:

Pointing Devices; Touch screens; Stylus/Pen; Graphics Tablets.

Recommendations:

- Follow standard recommendations on dimensions, clearance between keys, etc. to ensure that they can match the performance of conventional keyboards [108].
- Feedback (both visual and auditory) is most important [108].

Additional comments:

Touchpads offer high flexibility, and can be used as primary input device for personal computers, keeping compatibility with existing keypads. They provide the same functionality as other pointing devices, especially touch screens, but have the advantage of being more consistent with traditional keypads [108].

8.3.10 Touch Screens

(Gesture Interfaces, Touch Panels LCD touch overlays)

An input control device allowing the user to touch the screen at a position indicated by screen graphics to represent functions, actions or choices (as in a menu). The co-ordinates of the position are detected and stored as a digital input.

Cross references:

Pointing Devices; Stylus/Pen; Touchpad.

Recommendations:

- Various technologies exist for detecting finger or stylus contact with the screen. Some require specific overlays, others use a matrix of emitters and detectors along the sides of the screen. The conductive overlays provide the greatest resolution and typically the LED arrays the lowest.

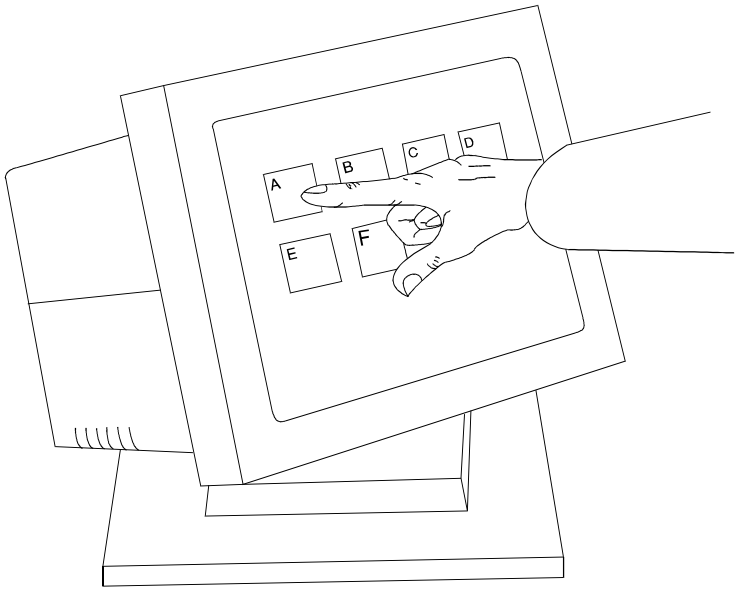


Figure 27: Example touch screen

- Capacitive screen overlays use the body's natural static to determine the position, so these are not suitable for clean room environments and users with prostheses.
- The low resolution technologies can suffer from some parallax problems, where the centre of pointing is not coincident with the displayed centre of pointing (cursor position).
- The major advantage is the direct hand eye co-ordination with the selected object, and being intuitive to people with minimal training and experience.
- Users should be informed as to whether they have to actually touch the screen (not necessary for LED screens), or on how much pressure is required (overlay screens).
- Provides for 1:1 absolute positioning, not good for tracking tasks.
- Requires simple software control to select from last touch position and to ignore finger "jitter" or "fall out" as the finger is removed.
- Use relative large finger sized targets for selectable items (seated users: target height 22 mm to 26 mm, target width 26 mm to 28 mm; standing users: target height 30 mm to 32 mm, target width 30 mm), or ensure there are no other selectable targets within a minimum 9 mm radius. An inactive space of a width of at least 5 mm should be provided around each target.
- May require the display to be angled towards the horizontal to provide arm/wrist support for accurate selection of smaller targets.
- Should be operable by use of a fingertip as well as a tool [144]. Pointing with fingers has the disadvantage that the arm and finger may block the screen. Also, the size of the user's finger tends to limit target resolution [116].
- Sufficient multi-modal feedback should be provided on selecting a target (visual, auditory).
- No memorization of commands is required, since all valid inputs are displayed on the screen [116].
- Touch screen devices are useful in situations where possible inputs are limited and well-defined, in situations where it is time consuming or dangerous to divert attention from the display, in high workload or high stress situations, and in situations where it is impractical to provide training in the use of the system [116].

Additional comments:

The constant touching of the screen with fingers causes a build up of grease and dust, so the screen itself needs to be easy to clean with few corners to trap the dirt. The overlay screens can become scratched and affect the clarity of the screen.

Touch screens can be very tiring to use where the arms are reaching forward without support, and it may be inadvisable to use this method of input for lengthy interaction. Mounting the screen more horizontally rather than vertically may reduce strain on arms and shoulders, but may create visual difficulties through increased reflections.

8.4 Tactile input: Switches

8.4.1 General

(Controls Discrete controls; Analogue Controls)

A control input device for signalling one or more discrete functions to the system. Discrete controls, or switches, are usually operated with a linear (toggle, rocker, slider switches, push buttons) or circular motion (rotary switches. Keys, a special case of switches, are treated separately as are key operated switches.

Cross references:

Key Operated Switches; Keys; Pushbuttons; Rocker Switches; Rotary Switches; Slider Switches; Toggle Switches.

Recommendations

- Take advantage of people's stereotypes for the directions of motion used for switching on, increasing the value or functions, etc.:
  - for linear switches - to the right, upwards or backwards,
  - for circular switches - to the right, clockwise.

Do not deviate from these well-established interpretations of directions without good reasons.

- Provide labels, legends and/or markings to:
  - identify the function of the switch,
  - identify the significance of switch settings, and
  - indicate the switch's current position.

For more information on minimum Design-for-All requirements for labelling see clause 8.2.4.

- For all discrete controls, the biomechanical load (effect on the musculo-skeletal system) should be minimized.
- Switches should be designed so that they can be operated without requiring undue deviations of the hand, fingers, arm, shoulder and head from their respective neutral positions [58].
- The switch should be sufficiently stable, such that its accuracy is not degraded during normal operation [58].
- It should be possible to operate the switch with either hand or mouthstick/headstick. If this cannot be achieved, alternative input devices (e.g. concavely-shaped keys) or an additional redundant input mechanism (e.g. voice activation) should be implemented.
- It should be possible to operate the switch with an impaired dexterity (e.g. a tremor). In addition, the switches should also be usable by people with restricted grip or significantly reduced muscle strength. If this cannot be achieved, an additional redundant input mechanism (e.g. voice activation) should be implemented.
- Switches should be grouped and labelled such that visually-impaired people can discern their functions.

Additional comments:

Table 11 provides a comparison of the different types of switches for different user task requirements. Recommendations for each type of switch are given below.

Table 11: Comparison of switches

	Slider	Rocker	Rotary	Toggle	Pushbutton	Key Operated
Number of discrete elements	2+	2	3-24	2	2	2-12
Control setting speed	quick-moderate	quick	moderate	quick	very quick	slow-moderate
Visual check of setting	easy	moderate	easy-moderate	easy	impossible unless latching	easy-moderate
Non-visual check of setting	moderate	moderate	easy-moderate	easy	impossible unless latching	easy-moderate
Simultaneous operation of several controls	easy-moderate	easy	moderate-poor	easy	easy	poor
Space requirements	small-medium	smallish	medium	smallish	small	Medium

8.4.2 Slider Switches

(Linear Switches)

A control input device for selecting discrete positions with a sliding action.

Cross references:

Pushbuttons; Rocker Switches; Rotary Switches; Slider controls; Switches; Toggle Switches.

Recommendations:

- Available for multiple position switches (two or more positions), not suitable for momentary switches.
- Use switches for finger tip pushing with an activation force of 1,5 N to 2 N and which travel more than 3 mm between switch positions. Larger sliders for finger/thumb gripping can have a higher activation force 2 N to 3 N and should travel further (5mm minimum) between switch positions.

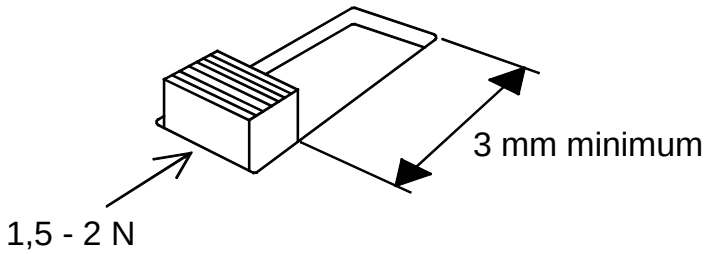


Figure 28: Example slider switch

- Use separate switches for separate groups of functions e.g. ringer selection (Off, Ring A, Ring B, etc.), keyboard signalling (digital, DTMF).
- Provide labels or legends for the switch and the switch positions. Ensure a good relationship between the switch position and its respective label.
- Provide a detent or indent to give tactile feedback when the switch has reached its new position, and to prevent accidental movement.
- For people with uncoordinated movements or reduced movement capability, it is important that the slider switch can be adjusted in a way which is easy to handle, e.g. the discrete positions must also be reachable by a person with a small tremor.
- Feedback on the effects of the chosen slider position is required for all users but in particular for blind and visually-impaired people.
- For more Design-for-All requirements for the design of switches see "Switches General" (see clause 8.4.1).

Additional comments:

None.

8.4.3 Rocker Switches

(Linear switches)

An input device where the keytop is used with a rocking motion to select one of two or at most three states.

Cross references:

Pushbuttons; Switches; Toggle Switches; Rotary switches; Slider switches.

Recommendations:

- Be aware that the current setting of a rocker switch can be ambiguous to discern. Consider supporting it with indicator light(s) or other display changes.
- Use rocker switches when a protruding toggle switch may be accidentally switched on or is a safety hazard.
- Be aware that rocker switches are acceptable for two position switches, they are not recommended for three or more positions. They can be used for momentary switches (if spring loaded), but keys or push buttons are more usual. In addition, momentary switches using a rocker switch are particularly difficult to perform using a headstick or mouthstick.
- Use rocker switches with the following dimensions:
  - rocker length 12 mm to 50 mm
  - rocker width 6 mm to 25 mm
  - displacement 30°
  - force 0,15 N to 1,0 N
  - separation 15 mm to 50 mm
  - height depressed 3 mm
- Feedback on the effects of the chosen rocker switch position is required for all users but in particular for blind and visually-impaired people.
- For more Design-for-All requirements for the design of switches, see clause 8.4.1.

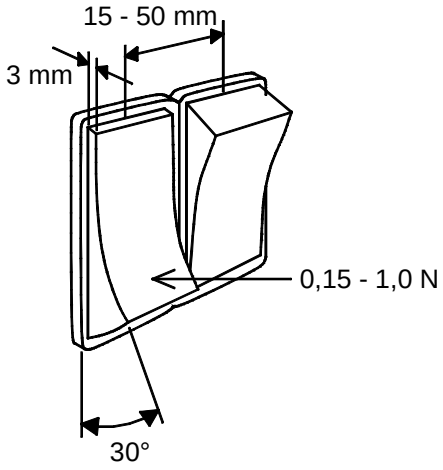


Figure 29: Example rocker switches

Additional comments:

None.

8.4.4 Rotary Switches

(Knobs)

A control input device where selection of discrete desired value is made in a rotary manner.

Cross references:

Key Operated Switches; Pushbuttons; Rocker switches; Slider switches; Switches; Toggle Switches.

Recommendations:

- Provide a pointed knob with clear indication of which element is the pointer.
- Use switches with the following dimensions:
  - length 25 mm minimum
  - depth 16 mm minimum
  - torque 0,1 Nm minimum
  - rotation between switch positions, 15° minimum, 90° maximum
    (30° preferred minimum rotation, especially if the user is unsighted or visually impaired)

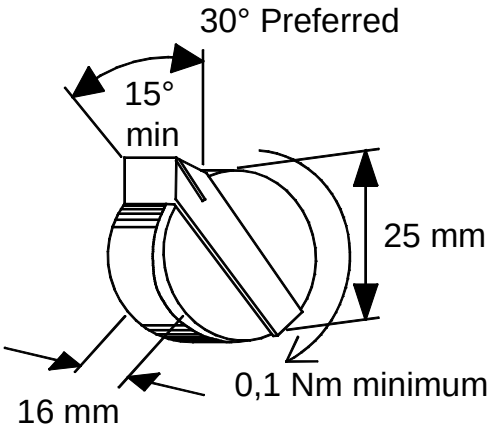


Figure 30: Example rotary switch

- Provide a detent or indent to give tactile feedback when the control is in the next switch position, provide a stop at both ends of the range.
- Use switch to move pointer to different functions or scale values. Do not use to move scale or functions past a fixed point.
- Avoid having switch positions directly opposite each other (180° apart).
- If banks of rotary switches are used for different functions, allow for consistency of orientation when all are at normal operating position, to simplify check reading.
- Make sure the knob pointer is close to the position markers to minimise parallax errors.
- Available for three or more position selections, not usually preferred for two position selection. (Two position switches can be effectively used in mimic panels to indicate flow lines open or closed, they can usually be turned either way to open or close the line).
- Provide a label or legend for the control and for each control position.
- Design the functionality in accordance with prevailing motion stereotypes (left for lower, less, and right for higher, more).
- For Design-for-All requirements for the design of switches see "Switches General" (see clause 8.4.1).

Additional comments:

None.

8.4.5 Toggle Switches

(Linear switches)

An input device where a snap action changes position between two states (sometimes three). The control lever projects from the panel and is itself a feedback indicator.

Cross references:

Rocker switches; Rotary Switches; Slider switches; Switches; Pushbuttons.

Recommendations:

- Available for two position switches, not recommended for three or more positions.
- Use switches which require an activating force between 2 N and 3 N and travels through an arc 30° (minimum), or 10mm or more linear displacement with a 3 mm diameter toggle (minimum).

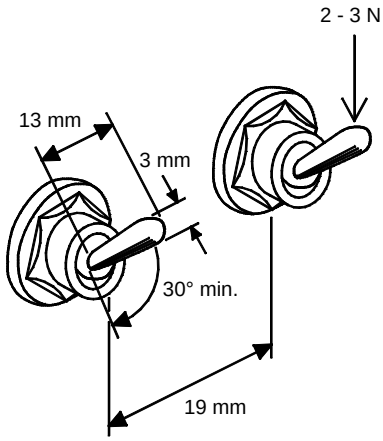


Figure 31: Toggle switches, preferred minimum dimensions

- If several switches are used on the same device, it is useful to have consistency in the significance of the switch settings (for normal operation), but do not compromise motion stereotypes. Allows system checking to be at a glance.
- In banks of switches, provide 19 mm ± 1mm centre to untie spacing horizontally, and 30-35mm centre to centre vertically. Use horizontal rows if switches need to be operated together.
- If banks of switches are provided with increasing functions e.g. lines 1-10, then the progression of functions is expected left to right. However, if the switches represent a mathematical increase, e.g. 10's, 100's, 1 000's etc., the progression may be from right to left.
- Do not intermix toggle and rocker switches on the same device.
- Consider protection from accidental operation if close to manual handling arcs in normal operation.
- Can be spring load and used for momentary switching, but keys or push buttons are more usual.
- For Design-for-All requirements for the design of switches see "Switches, General".

Additional comments:

None

8.4.6 Pushbuttons

(Buttons, Linear switches)

A control input device where a push action on the part of the user makes a contact to signal the input. Momentary pushbuttons maintain switch contact only as long as they are held down. (The control function may be maintained as long as the contact is held, e.g. doorbell, or may initiate a state change, e.g. Off to On). Latching pushbuttons maintain switch contact for as long as they remain latched. The latched pushbutton may be released by a second finger push on the same button, or by pushing an alternative button in a group of buttons (radio-button style).

Cross references:

Alphanumeric Keyboards; Keyboards; Keys; Labels; Rocker switches; Rotary switches; Slider switches; Switches; Telephone Keypads; Toggle switches.

Recommendations:

- Pushbuttons for finger operation which are not pressed below the surface of the device's casework should have similar dimensions etc. to keys (see "Keys"):
  - Size should be at least > 60 mm^2 and preferably > 110 mm^2.
  - Travel 1 mm to 8 mm and force 0,25 N to 1,5 N (snap action feedback).
  - Clearance 9 mm minimum radius from centre.

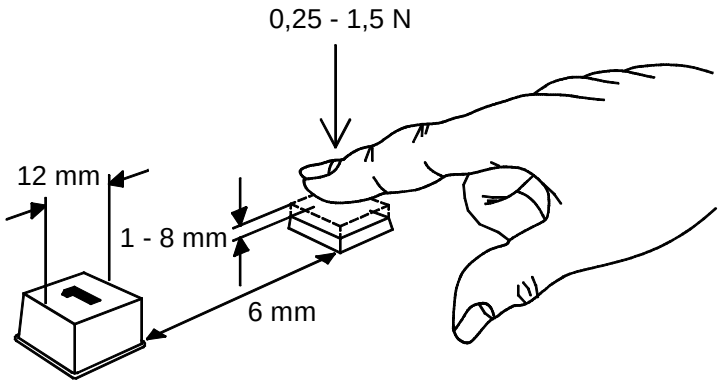


Figure 32: Raised pushbuttons - recommended minimum dimensions

- Pushbuttons for finger operation which go below the surface of the casework have different requirements:
  - Minimum dimension 19 mm in any direction.
  - Minimum travel 3 mm (5 mm for latching switches).
  - Minimum force 2,8 N (5,6 N if used in a moving vehicle).
  - Minimum width 3mm between adjacent pushbuttons.

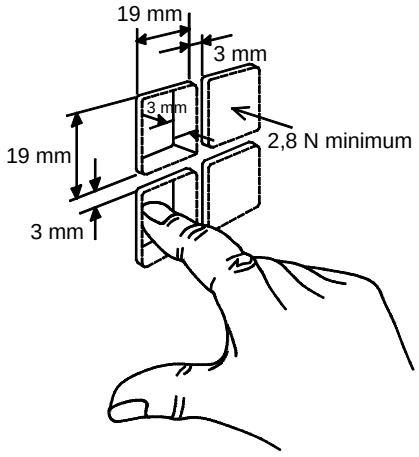


Figure 33: Recessed pushbuttons - recommended minimum dimensions

- Pushbutton activation should be indicated by tactile feedback, e.g. snap-action, hard stop, or click.
- For detailed Design-for-All requirements see clauses 8.2.4 and 8.4.1.

Additional comments:

Pushbuttons and keys are for most design engineers one and the same thing. The separation in the present document is largely artificial, but does allow different features to be discussed.

8.5 Tactile input: Variable controls (continuous controls)

8.5.1 General

(Analogue controls, Controls, Knobs, Sliders,)

A control input device for selecting the chosen level of a continuous variable, e.g. audio volume. Variable controls are usually operated in a linear (slider) or circular motion (rotary control, thumb/finger wheel).

Cross references:

Slider controls; Rotary Controls; Thumb/Finger Wheels; Joysticks, Hand/Finger.

Recommendations:

- Take advantage of people's stereotypes for the direction of motion used to increase the setting of the variable:
  - For linear sliders - to the right, back or top.
  - For rotary knobs - to the right, clockwise.
  - For thumb, finger wheels - to the right, back or top.
- Provide labels, legends and/or markings to:
  - Identify the function of the continuous control.
  - Identify the direction and function of the variable.
  - Indicate the current setting of the control and of the controlled variable.
- Variable controls may be implemented in hardware, or in software as part of a screen based application. The analogue controls on the screen exhibit the same functionality as the hardware implementation. The screen based control will require a pointing device to change its setting, and cannot provide direct tactile feedback to the degree of change chosen.

- Controls should be designed so that they can be operated without requiring undue deviations of the hand, fingers, arm, shoulder and head from their respective neutral positions [58].
- Finger, hand-held or grasped controls should be designed to accommodate the hand size of the largest possible user population or the intended user population if the product is target-group specific (e.g. a device for children) [58].
- The control should be sufficiently stable, such that the accuracy of the input device should not be degraded during normal operation [58].
- The weight, and hence inertia, of the control should not degrade the accuracy of the device during use under a defined normal range of actions including translation, rotation and button activation [58].
- It should be possible to operate the control with either hand or mouthstick/headstick. If this cannot be achieved, alternative input devices (e.g. concavely-shaped keys) or an additional redundant input mechanism (e.g. voice activation) should be implemented.
- It should be possible to operate the control with an impaired dexterity (e.g. a tremor). In addition, they should also be usable by people with restricted grip or significantly reduced muscle strength. If this cannot be achieved, an additional redundant input mechanism (e.g. voice activation) should be implemented.
- Controls should be grouped and labelled such that visually-impaired people can discern their functions.
- As a switchable option, auditory as well as visual feedback for variable controls should be provided. For example, a rising tone or more frequent clicks could indicate the increasing variable, especially for people with special needs.

Additional comments:

The table below gives some user/task related guidance on the different types of variable controls.

Table 12: Comparison of variable controls

	Sliders	Rotary Controls	Thumb wheels	Joysticks
Size of scale	Limited to length of slide	Multiple turns are possible	Multiple turns are impractical	Control in more than one dimension
Precision of setting fine tuning	Moderate	Good with large knob	Poor	Good
Speed to approximate position	Good	Good with scale limited to 270° maximum	Poor	Good
Ease for visual check of control setting	Good	Good with limited scale. Poor with multiple rotation	Poor	Poor
Ease for non-visual check of control setting	Moderate	Moderate with distinct pointer and limited scale	Poor	Poor
Ease of operating simultaneously with array of similar controls	Good	Poor	Moderate	Poor
Space requirements	Large	Moderate	Smallish	Smallish

8.5.2 Slider controls

(Linear controls, Sliders)

A control input device in the form of a slider, used for setting the chosen level of a continuous variable, where the operation is in a linear motion.

Cross references:

Rotary controls; Slider switches; Thumb/Finger wheels; Variable controls; Joysticks, Hand/Finger.

Recommendations:

- Implement the slider according to established stereotypes (left and bottom is low, little, and right and up is high, much).
- Provide a label/legend parallel to the direction of movement, with a wedge element to demonstrate the variable increasing; provide indicator values if required.
- Use finger tip sliders with force resistance of 1,5 N to 2 N or larger sliders with force resistance of 2 N to 3 N.
- Sliders for finger/thumb grasping should be a minimum of 13mm high, 13mm wide and 6mm thick.
- For people with uncoordinated movements or reduced movement capability, it is important that the slider can be adjusted in a way which is easy to handle, e.g. all slider positions must also be reachable by a person with a small tremor.
- Feedback on the effects of the chosen slider position is required for all users but in particular for blind and visually-impaired people.
- For more Design-for-All requirements for the design of variable controls see clause 8.5.1.

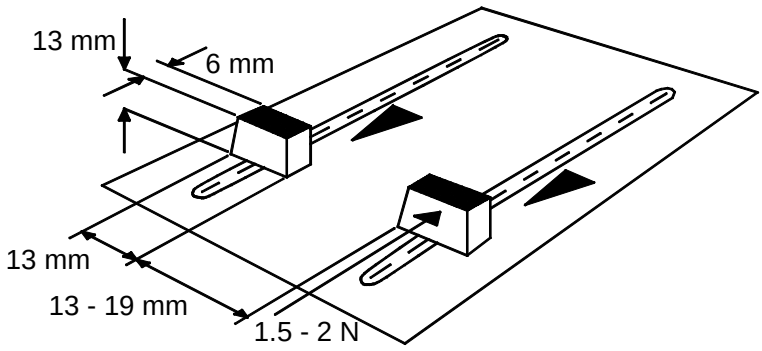


Figure 34: Example slider controls

Additional comments:

None.

8.5.3 Rotary Controls

(Knobs)

A control input device for selection of desired value of a continuous variable by a rotary action.

Cross references:

Slider Controls; Thumb Wheels; Variable controls; Thumb/Finger wheels; Joysticks, Hand/Finger; Rotary switches.

Recommendations:

- The direction in which the controlled variable increases should always be to the right, i.e. clockwise, irrespective of where the control is situated.

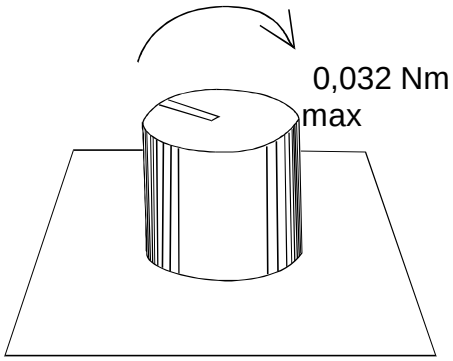


Figure 35: Example rotary control

- Provide labels and legends which are parallel to the direction of motion, i.e. circular, as a wedge with the thickest part to the right. Give indicated values if required.
- Provide a mark on the control to indicate the current set value if required.
- Use rotary controls with the following minimum dimensions:
- Thumb/finger grip - 13 mm diameter, 13 mm high.
- Five finger grip - 25 mm to 75 mm diameter, 13 mm to 25 mm high.
- The finer the degree of control necessary, the larger the control diameter is necessary, up to the maximum for one hand (75 mm).
- Use knobs with straight sides and clear serrations with sharp peaks.
- Use controls with the following maximum torque requirements:
  - Thumb/finger grip up to 25 mm diameter up to 0,032 Nm.
  - Five finger grip greater than 25 mm diameter up to 0,042 Nm.

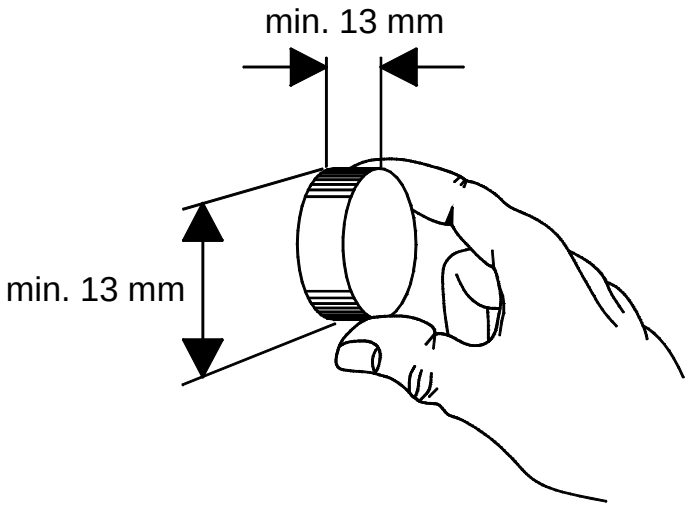


Figure 36: Rotary knob - recommended minimum dimensions

- If smaller knobs are essential, ensure that they are used only for occasional setting tasks and have minimum dimension of 6mm diameter, 13 mm height from casework.
- For people with uncoordinated movements or reduced movement capability, it is important that the rotary knob can be adjusted in a way which is easy to handle, e.g. all knob positions must also be reachable by a person with a small tremor.
- Feedback on the effects of the chosen knob position is required for all users but in particular for blind and visually-impaired people.
- For more Design-for-All requirements for the design of continuous controls see clause 8.5.1.

Additional comments:

None.

8.5.4 Thumb/Finger Wheels

(Finger Wheels, Thumb Wheels)

A control input device for selection of a continuous variable. These are usually mounted "invisibly" leaving just a small segment of the wheel for the user to push.

Cross references:

Slider controls; Rotary Controls; Rotary switches; Variable controls; Joysticks, Hand/Finger.

Recommendations:

- The preferred mounting position is vertical, parallel to the front edge and operated from above, the wheel and its label can be clearly seen. However, it is expected that other orientations will be used to meet printed circuit board (PCB) requirements and to avoid ingress of dust.
- The direction of motion stereotypes depend on the controls mounting position. The direction for increases in the value of the variable controlled, are shown in figure 37.

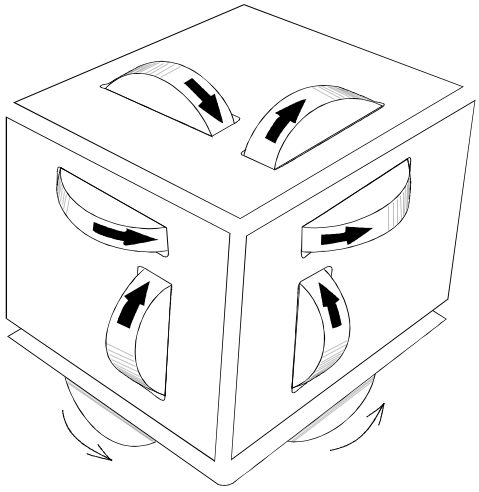


Figure 37: Thumb/finger wheels, direction of control movement vs. control mounting orientation

Table 13: Thumb/finger wheels, direction of control movement vs. control mounting orientation

Mounting Orientation	Movement Direction for Parameter Increase
Mounted horizontal, at front or back	to the right
Mounted horizontal, at side	to the back
Mounted vertically, operated from above or below, parallel to front edge	to the right
Mounted vertically, operated from above or below, parallel to side edge	to the back
Mounted vertically, operated from the side	to the top

- Provide a label or legend to indicate the function of the wheel and to indicate the current value of the setting.
- Ensure the edge of the wheel has high friction surface (usually serrations) to enable easy setting.
- Use wheels with the following dimensions:
  - Minimum rim exposure 25 mm.
  - Minimum wheel width 3 mm.
  - Maximum resistance 3,3 N.

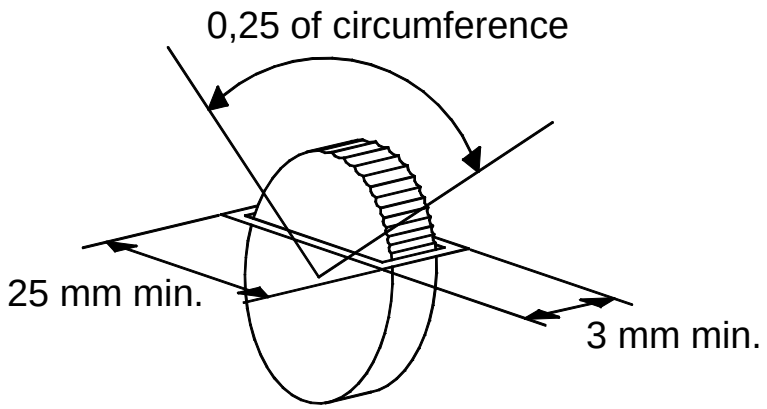


Figure 38: Thumb/finger wheel, preferred minimum dimensions

Additional comments:

None.

8.5.5 Joysticks, Hand/Finger

Hand joysticks are input devices consisting of sticks or handgrips that protrude from a fixed socket, they may be moved or pushed/pulled in any direction. Finger joysticks have been developed for hand held devices. The thumb or forefinger rests on a small concave pad which can move short distances in any direction.

Cross references:

Pointing Devices; Roll Balls.

Recommendations:

- Requires a separate control to select the object once the cursor is positioned, this may be integrated into the hand joystick, for finger or thumb operation.

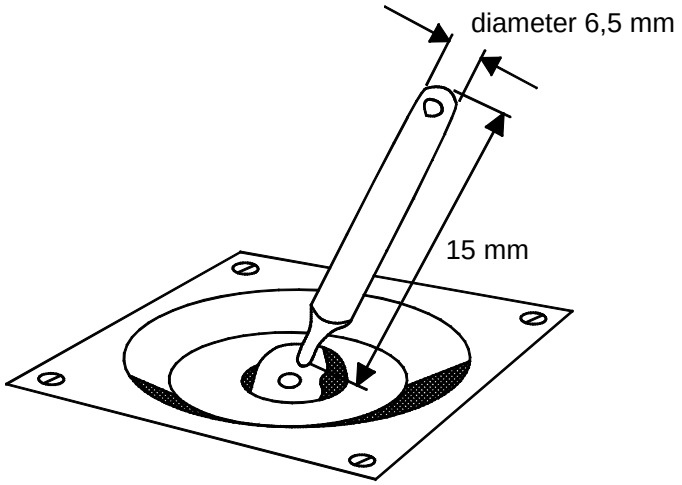


Figure 39: Example hand joystick

- Best suited to continuous tracking tasks and to pointing tasks that do not require great precision.
- Joysticks may be displacement (also called isotonic, the stick will physically move in the required direction), or force (also called isometric, the stick does not move but the force and its direction is detected and converted to a cursor movement). Either type may affect the distance the cursor moves directly or may affect the rate or speed of movement of the cursor.
- Use displacement joysticks when positioning accuracy is more essential than positioning speed.
- Ensure displacement joysticks which control the rate of the cursor movement return to the centre or null position when released. Ensure movement is smooth in all directions, without backlash (movement of the released joystick beyond the null position which causes a corresponding unintentional movement in the cursor). Enable the control movement/display response to be variable, to allow fine tuning to the specific task.
- Use hand displacement joysticks with the following minimum dimensions:
  - Diameter 6,5 mm;
  - Length 75 mm;
  - Resistance 3,3 N. (Maximum displacement 45°).
- If the joystick can control the cursor beyond the current active screen area, provide indication on the edge of the area on the current direction of the cursor.
- Allow the user to set the translation factor (ratio of joystick movement and the quantity of resulting effect).
- Joysticks are of extremely limited value for visually-impaired and dexterity-impaired people. Alternative input modes should be offered together with a joystick.

Additional comments:

There are no recommendations available about finger controlled joysticks, except the basic one of providing adequate friction to minimize the finger/thumb slipping in the control. If the thumb is the intended controlling limb, ensure the control is sufficiently close to the device edge to enable comfortable placement and an adequate range of movement.

8.6 Tactile input: Software controls and indications

A number of input devices can be used to interact with a graphical user interface to carry out a number of standard operations on software objects: navigation, selection, editing, transfer, and creation. A number of interactive components are usually provided to carry out commands and to specify values. Some of these components are based on hardware metaphors (as presented in clauses 8.2, 8.4 and 8.5), other are unique to the software environment. The most important interactive components are menus (see clause 7.2.2), controls and on-screen keyboards (see "The Biometric Consortium", Bibliography).

Controls are graphic objects that represent the properties or operations of other objects. Some controls display and allow editing of particular values. Other controls start an associated command. Each control has a unique appearance and operation designed for a specific form of interaction. The most common controls include buttons, list boxes a text boxes:

- *Buttons:* controls that start actions or change properties. There are three basic types of buttons: command buttons, option buttons, and check boxes. A *command button* (push button) is a control, commonly rectangular in shape that includes a label. An *option button* (radio button) offers a single choice within a limited set of mutually exclusive choices (in any group of option buttons, only one option in the group can be set). A *check box* support options that are either on or off; check boxes differ from option buttons in that you typically use check boxes for independent or nonexclusive choices.

- *List box:* a convenient, pre-constructed control for displaying a list of choices for the user. The choices can be text, colour, icons, or other graphics. The purpose of a list box is to display a collection of items and, in most cases, support selection of a choice of an item or items in the list. They are best for displaying large numbers of choices that vary in number or content.

- *Text box:* a usually rectangular control where the user enters or edits text.

Less common controls include tabs, scroll bars and sliders:

- *Tab*: a tab control is analogous to a divider in a file cabinet or notebook, and can be used to define multiple logical pages or sections of information within the same window.

- *Scroll bar*: horizontal or vertical scrolling controls that can be used to create scrollable areas other than the window frame or list box.

- *Slider* (trackbar control): a control that consists of a bar that defines the extent or range of the adjustment, and an indicator that both shows the current value for the control and provides the means for changing the value.

In addition, there are some pen-specific controls:

- *Text edit control*: provides the user with a discrete area for entering characters (like in a writing tool window).

- *Ink edit control*: pen control in which the user can create and edit lines drawn as ink: no character recognition occurs here. It is a drawing area designed for ink input.

An on-screen keyboard is an interactive keyboard displayed on the screen that can input characters/symbols with selection by a pointing device or a switch.

Cross references:

Keys, Keyboards, Switches, Pushbuttons, Linear sliders, Menu dialogues, Graphical user interfaces.

Recommendations:

- Provide shortcuts to text labels to provide the user direct keyboard access to a control. Because shortcut keys carry out a command directly, they provide a more efficient interface for common or frequently used actions, or for users who have trouble operating a mouse or pen.

- Make sure the area for selecting a control is large enough, so that it is easy to aim at and does not allow an easy mix-up with proximate objects.

- Provide auditory and/or tactile feedback if a certain control is accessed or selected.

- Do not rely on colour alone. Ensure that text and graphics are understandable when viewed without colour. If colour alone is used to convey information, people who cannot differentiate between certain colours and users with devices that have non-colour or non-visual displays will not receive the information. When foreground and background colours are too close to the same hue, they may not provide sufficient contrast when viewed using monochrome displays or by people with different types of colour deficits [133].

- Controls should provide labels (or tool tips) to help the user identify the purpose of a control.

- Button labels should be unambiguously defined, and as verbs (e.g. save, cancel etc.) or symbolic (e.g. audio controls). There may also be an icon associated with the label.

- If selection of the button results in the appearance of a dialogue box or other window these should bear the same label as the button.
- When the button's function is not available, its label should be greyed out whilst remaining visible and readable. If a button option is a default option, it should be highlighted to indicate this.
- Buttons should look functional, avoiding excessive embellishment. 3D design can be used to give feedback when pressing and releasing the button.
- Button names and appearance should be used to clearly distinguish between different function and purposes. If some buttons have similar functions (e.g. numbers, characters, "Yes"-button and "No"-button in a two-choice menu) then build a group of buttons forming a closed, symmetrical, simple and balanced shape.
- The grouping of buttons should be supported by the "principle of similarity", e.g. by colouring a certain type of button, the grouping can be stressed.
- The "principle of proximity" says that those objects belonging together should be near to each other (intragroup-distance). The intergroup-distance should be higher than the intragroup distance. The qualitative rule of this guideline is very simple but hard to apply. If time allows it is possible to perform user tests to find the best recognizable intra- and intergroup distances.
- Decide on a small set of button sizes: one as a standard size for single word button labels; a slightly wider button (same height) to accommodate a word and two explanation arrows indicating that a further window will appear; a wider button (same height) to accommodate two or three words when required on a button.
- Scrolling is a non-intuitive technique for novice users.
- The guidelines that are formulated for keyboards in clause 8.2.2 are also applicable for on-screen keyboards. However, due to the limited size of the display, the on-screen keyboard will generally be smaller than a standard keyboard.
- An on-screen keyboard is specifically useful for people who are restricted in the range of movement of their hands due to severe physical impairment and also have difficulty in input by means of multiple keys with a standard keyboard.
- A facility is necessary which enables changing the size and arrangement of keys, the switch input method (direct selection, scan input, etc.) and the temporarily hiding of the on-screen keyboard.
- A facility is necessary which registers a key activation when the on-screen pointer dwells on the key for a determined period.

Additional comments:

Further information may be found in clause 7.2 and in [108].

8.7 Acoustic input

8.7.1 General

Acoustic input is mainly in the form of speech. Spoken input can be used for a number of purposes: controlling the system (voice commands), data input (speech-to-text), communicating (conversational services), or recording (Dictaphone). Non-speech sounds can also be used to control the system, e.g. a system can be activated by a certain sound (e.g. clapping hands) or if a certain sound intensity is reached. Microphones are necessary for capturing the acoustic input.

8.7.2 Microphones

(Mike)

An input device for capturing acoustic (usually voice) information and presenting it electronically into a transmission, recording or recognition system. Typically, microphones have a limited pick-up range. Microphones can be mounted within a device (e.g. telephone handsets, PCs), they can be tabletop or body worn devices (e.g. for mobile telephones), or mounted in headsets.

Cross references:

Acoustic Input; Speech recognition.

Recommendations:

- Ensure the mounting of a microphone within a device minimizes the effects of echo, sound reflection and reverberation from the expected terminal environment.
- Ensure the mounting of the microphone enables the pick-up envelope (distance and direction) to include the likely physical location of the intended acoustic sources.
- Ensure the acoustic properties of the microphone match the potential range of acoustic inputs possible from the expected acoustic sources.
- Ensure that typical background noises do not interfere with capturing the relevant acoustic information.
- Ensure the quality of the signal is maintained in progressing from acoustic to electronic media.
- For telephony services, the microphone should be such that recommended sensitivity and loudness requirements can be met. Handset telephony requirements for ISDN, DECT and PSTN connected telephones can be found in TBR 008 [43], TBR 010 [44] and TBR 038 [45]. Requirements for Loudspeaking telephony terminals can be found in I-ETS 300 245-3 [36].
- Where telephones are intended to be used by disabled users it can be advantageous to provide adjustable microphone sensitivity so that they can be used by people with impaired speech.
- In particular for telephony services, the microphone should be able to be muted for reasons of privacy [108].
- For extended use of headsets, comfort of wearing should be ensured.

Additional comments:

Consider the presentation and mounting of microphones intended for voice capture. Ensure that users can easily keep their lips/mouth within the pick-up envelope without constraining their posture. For example, the standard handset or telephone headset allows the user to keep the microphone close to the mouth and at the same time be able to move, relative to the terminal.

Voice quality is a potentially very emotive aspect of telephony and voice transmission. People make psychological and emotional assessments of the people they are talking with, as part of the communication. It is essential, therefore, that the technology does nothing to interfere with this process.

There are a small but significant number of people who have vocal disabilities who could be helped with specialized microphone equipment. Where this type of facility is provided it should be very easy to switch between everyday and specialized use of the microphone circuits.

8.7.3 Speech Recognition

(Speech input)

Speech recognition uses sophisticated software technology for recognizing human vocal sounds and converting these into dialogue commands, menu selections or data items. An alternative to the usual manually controlled input devices. The speech recognition systems used can be speaker independent (available to different users) or speaker dependent (available to one or a restricted set of users).

Cross references:

Phone-based Interface; Natural language dialogues; Speech Output, Voice dialogues.

Recommendations:

- Use speech input where the demands of the primary task results in inability to use other input techniques, e.g. data capture, command entry whilst hands/eyes are fully occupied.
- If the costs of entering incorrect data are high, consider choosing another type of input technology.
- Position the input microphone to minimize external noise and to minimize breathing and other mouth noises which can affect the detection of word boundaries.
- Speech can be combined with other tasks only if they are non-verbal. The use of a speech recognition system will interfere with any other verbal tasks, but interference with other types of tasks, e.g. motor activity is less likely [108].
- Differences in pronunciation, e.g. regional accents, may cause problems [108]. Also, the technology is not very suited for people with speech impairments.
- Allow more than one word to have the same response, i.e. redundancy in choice of command inputs (sometimes called "multiple mapping").
- Use a small vocabulary of familiar words, to minimize user memory load.
- Use longer rather than short monosyllabic words to assist in recognition. Avoid single character/digit words.
- Select speech input vocabulary words to minimize possible recognition confusions (speech recognition and auditory confusions are similar). (A minimum set of spoken commands to be used to control the generic and most common functions of ICT products and services that use speaker independent speech recognition can be found in [7]).
- Allow for a system recognition window, i.e. train users to pause after each input, single word or word string or sentence.
- Ensure recognition windows start early enough and are of sufficient duration; to minimize false errors by expert users who predict the dialogue and give "too early responses", and to ensure new users do not feel "rushed".
- Provide recognition feedback after each input. Feedback method will depend upon the dialogue, e.g. commands may require repeating back to the user with a confirmation request or the response may be to integrate the keyword into the next display item. The feedback method used can also be guided by recognition confidence measures. If the confidence measure is high, confirmation is probably not necessary. This approach can speed up the dialogue, which is especially beneficiary to experienced users.
- Make sure that users are immediately signalled that they are using a speech recognition system, as otherwise they may be confused as to whether the equipment is switched on or not [108]. Also, it gives the user the opportunity to choose another type of system.
- Speech based feedback is likely to be perceived as being too slow, and therefore it may better to use visual feedback or tones. Textual feedback of speech input can also be more useful than voice if this is an appropriate output medium.
- Provide opportunity for user to undo incorrect inputs from whatever source (user giving wrong input, system making false recognition).
- Be aware of the types of errors that users are likely to make (e.g. "err" in front of a command, inadvertent sounds that cause insertion errors), and try to take these into account.
- Provide the possibility for experienced users to take the initiative of giving a command, only provide the command menu if the user has failed to say something or gives an inappropriate command.
- Provide the possibility for the more experienced user to use shortcut commands, to avoid having to go through a lengthy dialogue.

- Be aware that the user might feel lost at some point in the dialogue. Therefore, good feedback is needed and easy ways of returning to a fixed point in the dialogue (e.g. the main menu), for instance by saying "stop".
- If keyboard inputs, DTMF tones and voice are all used as inputs in telephone dialogues, provide clear prompts to state which is expected at any point in the dialogue.
- If voice input fails, direct the user to an alternative solution (an alternative input, or the possibility to contact a human operator). This is also important for hearing or speech impaired people. Inform the user on how to gracefully exit the system at any stage in the interaction.
- Where possible, messages to the user should be phrased in terms that imply blame on the part of the speech recognition system for not recognizing input rather than the other way round [108].
- Provide an introduction to the given system at the start of the user interaction, with repetition subsequently being provided on demand.

Additional comments:

Speech recognition systems are usually reported to have recognition rates between 95 % and 100 % correct (or failure rates of between 5 in 100 to 5 in 1 000). However, user performance levels are more usually reported around 70 % (3 in 10 failures). Note that recognition rates depend on a large number of factors, including the specific recognition system used (e.g. word spotting, digit recognition, continuous, speaker (in)dependent), the size and content of the lexicon, and the communication channel (e.g. microphone, fixed or mobile telephone).

Encouraging use is an issue. Many users may still feel uncomfortable and self conscious when talking to a machine.

Do not expect speech input to compete directly with keyboard entry tasks, the error rates in speech are much higher and the data capture rates are much slower, except where keyboard entry is difficult, e.g. for some people with special needs or users suffering from Repetitive Strain Injury (RSI).

Speech recognition systems require consistency of speech parameters to maximize the likelihood of correct recognition. Changes of speech, pitch, emphasis, rhythm, loudness, etc. may all increase recognition failure. Evidence suggests that perhaps 75 % of people can be sufficiently consistent as long as task and environmental conditions remain the same.

At the current state of technology it is essential to make provision to compensate for errors by having redundancy within the dialogue, minimizing the amount of human input and allowing the input to be corrected and confirmed before an action is initiated.

Whether a speech interface is used in unimodal or multi-modal applications, the success of the application as a whole depends on a careful design of the interfaces (voice, screen, type of feedback, etc.). This requires an understanding of the principles for interface design for each modality and the cognitive implications of using single or multiple modalities.

8.8 Visual input

8.8.1 General

(Videotelephony)

This clause covers devices for visual input. Visual input is used for communicating in conversational services like videotelephony, and for storing and communicating visual data including text, graphics, photographs and moving images. More details on the human factors aspects of the design of videotelephony terminals are covered in ETR 297 [20].

Cross references:

Cameras; Eye/Head Movement; Scanner; OCR.

8.8.2 Cameras

The lens, aperture, light sensitive surface and electronics to convert visual images or pictures into electronic format. It may be coupled to electronic circuits or codecs for conversion into standard digitized formats to enable transmission. Cameras can be integrated into a terminal, used as add-on components (e.g. external cameras used with PCs) or self-contained units. The camera may capture still, slow scan or real-time live images.

Cross references:

Videophones; Scanner; OCR; Visual input.

Recommendations:

- For ensuring visual privacy, it must be apparent at any time whether a camera is capturing (e.g. for transmitting or recording) or whether it is idle. This can be achieved by using a mechanical shutter in front of the camera, and by using the camera off function. The camera off function inhibits outgoing video transmission or recording as long as it is activated. It should not have any effect on the active service mode or call connection, i.e. when it is selected the call will continue in the same service mode as before the function was activated.

- A mechanical shutter is the most trusted solution and gives clear feedback to a visually-impaired person on the status of the camera.

- For cameras used for conversational services, it should be possible to pre-set a default state of the camera on/off function, i.e. whether is it normally on or off.

- A self-view function enables users to view themselves to ensure that they have a presentable image. It may also be used to view documents or other objects if a separate document camera is used. It should be possible to select self-view anytime regardless of whether the camera is recording/transmitting or not. In videotelephony, the use of self-view should not have an effect on outgoing video. The self-view image can also be presented in a picture-in-picture (PiP) format.

- Provide any user controls for the camera in an accessible form. Comply with the motion stereotypes for the direction of movements.

- If multiple cameras are provided to work through the same interface, ensure there is clear visual indication at the control and on the camera to show which is currently live.

- Cameras used for videophone applications should be positioned to provide a basic head and shoulders image. It is desirable for good face to face communications for the camera systems focal plane to be coincidental to the eyes on the imaged face. If parallax differences are unavoidable, ensure the camera's focal plane is situated centrally above the display, and the difference does not exceed 8° at the furthest point of the preferred viewing distance.

- In videotelephony, to accommodate the normal range of different eye heights of the sitting and standing users within the camera's field of view, it is recommended that the camera system's focal plane be adjustable vertically. No preference is made between vertical linear or tilt adjustment, except that significant distortion should not be introduced. Available technology will invariably dictate screen size, but to maintain a preferred viewing distance of between 50 cm and 120 cm, see table 14.

Table 14: Screen sizes and viewing distances

Diagonal Screen Size	Height of Screen	Viewing Distance
15 cm	10 cm	60 cm
23 cm	15 cm	90 cm
30 cm	20 cm	120 cm

- Provide cameras used for videophone applications with automatic iris control and automatic "white balance" adjustment. If additional manual control is also provided, ensure there is a clear quick control action that will return the camera to the pre-set default settings.

- For cameras used for videophone applications focus control, if provided, should be available from the normal viewing position. If automatic focusing is provided, then it should be activated for only one focusing action at a time. There should also be some indication to the user that the camera is auto-focusing and of the field of view it is using to focus.

Additional comments:

None.

8.8.3 Eye/Head Movement

(Eye movement, Head movement, Gesture interfaces)

An input method where the movements of the eyes and/or head are detected and digitized for relating the current cursor position relative to the corresponding eye/head movement.

Cross references:

Pointing Devices; Visual input; Cameras.

Recommendations:

- Can be useful for item selection and tracking, particularly when the hands are fully occupied or for users with impaired mobility or impaired limbs. Use only for selecting and tracking relatively large objects, as natural involuntary movements of the eyes will make fine control very difficult [116].

- Lightweight head movement tracking devices are available which are usually combined with a blow switch, specifically for people with special needs. The control display ratio which controls the rate of cursor movement relative to any head movement can usually be configured for the user.

Additional comments:

Eye movement monitoring usually requires special head mounted equipment to detect the small changes in position. Corneal reflection and electrooculography are typical sensor techniques. Both require expert assistance for implementation.

Gesture recognition is a related method for inputting commands and data. It offers potential benefits in particular to speech-impaired users. At this early stage of R&D in gesture recognition, no scientifically-based recommendations can be given. The same applies to face-recognition systems.

8.8.4 Scanner

(Photocopier)

Scanners convert an optical image into an electronic output. The output can be a simple picture image or by using OCR, editable text can be entered into a computer without being re-typed. As well as being a time saving device in an office environment, they are also useful to blind computer users, providing a way of translating print material into an electronic text file. Once the text is in editable electronic form, it can be read with devices such as a screen reader, speech synthesizer or an electronic Braille display. Some software can even read simpler forms of handwriting.

Cross references:

Bar-code readers; Casework; Cables; Connectors; Input components; Output components; Paper Handling; Stylus/Pen.

Recommendations:

There are no specific Human Factors recommendations in the available literature with respect to the design of scanners. However, when designing the scanner consider the following principles:

- Ensure the user interface is simple and intuitive.

- Provide a preview of the scan image.

- Provide feedback to the user when the device is busy.

- Provide a clear overview of the available scan options.
- Arrange any software controls to indicate the sequence of operation.
- Ensure that the required position and orientation of the document is easy for the user to determine.
- Ensure that paper trays in sheet feed scanners are easily accessible and easy to use.

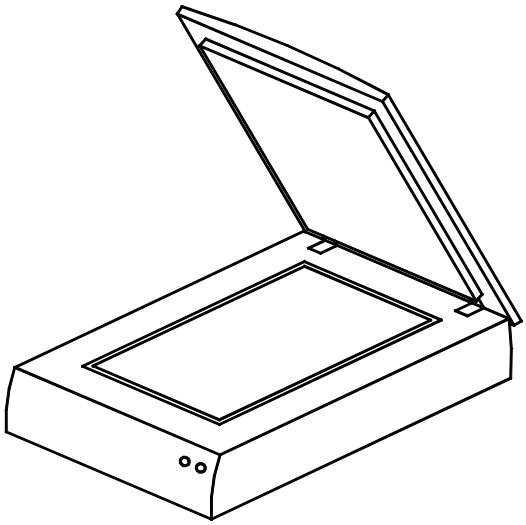


Figure 40: A flat bed scanner

Additional comments:

The electronic output from a scanner can be used to replicate the functions of a photocopier or a fax machine.

It is appropriate for new designs to be tested against expected usability criteria, ensuring that a "Design for All" philosophy is followed.

8.9 Biometric input

8.9.1 General

(User Identification)

Biometrics is the technology of automatically identifying an individual based on his or her distinguishing physiological and/or behavioural characteristics. It associates or dissociates an individual with a previously determined identity based on how one is or what one does. Biometric technologies include facial imaging (both optical and infrared), hand and finger geometry, eye-based methods (iris and retina), signature, voice, vein geometry, keystroke, and finger- and palm-print imaging [117]. See table 15 for a comparison of these technologies. In this clause, only fingerprint and iris identification are discussed, since these are the most advanced technologies available. In addition, voice identification is discussed briefly in clause 8.7.3 on speech recognition.

Table 15: Comparison of biometric technologies [117]

Biometrics	Universality	Uniqueness	Permanence	Collecta-bility	Perfor-mance	Accepta-bility	Circum-vention
Face	High	Low	Medium	High	Low	High	Low
Fingerprint	Medium	High	High	Medium	High	Medium	High
Hand geometry	Medium	Medium	Medium	High	Medium	Medium	Medium
Iris	High	High	High	Medium	High	Low	High
Retinal scan	High	High	Medium	Low	High	Low	High
Signature	Low	Low	Low	High	Low	High	Low
Voice print	Medium	Low	Low	Medium	Low	High	Low
Facial Thermogram	High	High	Low	High	Medium	High	High

Cross-references:

Speech recognition; Iris recognition; Fingerprint recognition.

Recommendations:

- It should be easy and comfortable to acquire a given biometric.
- Measurements that do not involve touching an individual may be perceived as user-friendlier.
- Biometric technologies requiring little co-operation or participation from the users may be perceived as more convenient to users.
- Take into account that the general public may have a perception that biometrics are a threat to the privacy of an individual. Gradual acceptance could be gained by introducing it on a voluntary basis with either explicit or implicit incentives for opting for a biometrics-based solution.
- Biometric identification is recommended for people who have problems remembering (multiple) PINs, who tend to forget or lose ID cards, or have problems using electronic cards. Note, however, that a verification system still requires feeding an electronic card into the system.
- For consumer applications, it should be attempted to operate the system with a low percentage of both false matches (unjust acceptance of an impostor as a valid individual) and false non-matches (unjust rejection of a valid individual).
- For typical access-control applications (for instance an ATM), the system should make an authentication decision in real-time.
- Clear instructions on how to operate the biometric identification device should be provided to the user.

Additional comments:

More traditional personal means of identification can be divided into token-based and knowledge-based approaches. Token-based approaches use something you have to make a personal identification, such as a passport, driver's license, ID card or credit card. Knowledge-based approaches use something you know to make a personal identification, such as a password or a personal identification number (PIN). The disadvantages of these traditional methods are that tokens may be lost, stolen, forgotten or misplaced, and a PIN may be forgotten by a valid user or guessed by an impostor. Unlike these approaches, biometric identification is able to differentiate between an authorized person and an impostor.

Biometric data is perceived as being particularly personal in nature, with an increased risk factor to the bona fide individual if this information is misappropriated or otherwise compromised. We can replace a password, we can change our telephone number, we can even move house, but we cannot (practically) replace or change our biometrics. For further information see (see "The Biometric Consortium", Bibliography). Specific recommendations for iris and fingerprint identification are provided in clauses 8.9.2 and 8.9.3.

8.9.2 Iris recognition

Biometric iris recognition technology involves the use of a camera to capture an image of the iris, the coloured portion of the eye. The visual texture of the iris stabilizes during the first two years of life and its complex structure carries very distinctive information useful for identification of individuals. Recently, more user-friendly and cost-effective versions of iris-based identification systems are being built.

Cross-references:

Biometric input; Fingerprint identification.

Recommendations:

- Risks of light damage should be avoided, [47].

Additional comments:

Iris identification is the most accurate form of biometric identification.

Those at the extremes of the height range (very tall or very short or those in wheelchairs) may have difficulty using iris recognition. Iris recognition may fail in the case of a blind eye.

Further general information may be found in clause 8.9.1.

8.9.3 Fingerprint recognition

A fingerprint is the pattern of ridges and furrows on the surface of a fingertip, the formation of which is determined during the foetal period and does not change over time. They are so distinct that even fingerprints of identical twins are different as are the prints on each finger of the same person. The fingerprint scanner captures an image of the fingerprint and uses complex algorithms to either convert the image into a unique "map" of local ridge characteristics or analyse the pattern. The validity of fingerprint identification has been well established.

Cross-references:

Biometric input; Iris identification.

Recommendations:

- It should be easy to clean the surface where the finger is put.
- Be aware that fingerprints of a small fraction of the population may be unsuitable for automatic identification, because of genetic, ageing, environmental, or occupational reasons. Prostheses also prevent identification.

Additional comments:

There may be a lack of acceptability by a typical user, because fingerprints have traditionally been associated with criminal investigations and police work. They are more likely to be acceptable when used to control access to a self contained unit such as a portable computer.

Further general information may be found in clause 8.9.1.

8.10 Electronic input

8.10.1 General

An input device which stores in electronic form some or all of the information a user provides as input when using a device or service.

Cross references:

Card Readers, Machine-readable Cards, Contactless Cards, Bar-code Readers.

Recommendations:

- If the electronic input devices has to be used (inserted, held, moved, etc) in a certain way, the required orientation and/or direction has to be clearly marked using visual and tactile elements.
- The purpose and usage context of the input device (e.g. bank card, electronic payment card, electronic key) should be clearly discernible as it is to be expected that future users will be dealing with a multitude of electronic input devices.
- Electronic input devices should be manufactured to be robust, i.e. cards should not break easily, electronic contacts on the surface should not be damaged easily, and contact with magnets should not render the device unusable.

8.10.2 Card Readers

(Credit Cards, Identification Cards, Phone Cards, Smart-cards)

An input device for accessing alphanumeric and/or coded data stored electronically in standard formats on or in plastic or paper-based cards, usually of credit card dimensions.

Cross references:

Machine-readable Cards; Contactless Cards; Bar code readers.

Recommendations:

- Ensure the positioning of card readers in public terminals takes account of wheelchair users and children.
- In preference allow users to retain hold of the card throughout the transaction exchange, particularly for high value credit or prepaid cards.
- For card readers that require a swipe action to enter the data consider the following user requirements:
  - Horizontal swipes, available in either direction with either hand.
  - Vertical swipes, ensure swipe is downwards and available to either hand.
  - Provide space to access the swipe channel, and use guiding grooves or sculpting on the insert and retrieve ends of the channel.
  - Ensure there is sufficient space for at least 95th percentile fingers to grip the card, when it is inserted for swiping.
  - Ensure the channel edges are smooth and robust to withstand wear, and protect against skin or finger nail damage.
  - Provide clear indication to show the required orientation of the card and the direction of travel, and test this with a representative sample of users.
  - Wherever possible, allow for the card to be swiped in more than one orientation.
  - Ensure that the pull forces required to swipe the card are possible across 99 % of the possible user population.
- For card readers that require an insert and retrieve action to enter the data consider the following user requirements:
  - In preference use card readers that accept cards with the short edge leading, it allows the user better grip with the card, and prevents accidental insertion with the wrong longer edge.
  - Provide clear indication to show any required orientation of the card, and test this on a sample of representative users.
  - Wherever possible, allow for the card to be inserted in more than one orientation.

- Provide smooth sculpted grooves to aid correct insertion, and provide sufficient space for at least 95th percentile fingers to retrieve the card with an adequate finger grip on the card.
- Ensure that the push/pull forces required to insert and retrieve the card are less than 25 N such that they are possible across 99 % of the possible user population.

Additional comments:

None.

8.10.3 Machine-readable Cards

(Credit Cards, Identification Cards, Phone Cards, Smart-cards)

An input device in the form of a card which stores information in electronic form. Machine-readable cards are often referred to as "Smart Cards".

Cross references:

Card Readers; Contactless Cards; Bar code readers; Electronic input.

Recommendations:

- The orientation and/or direction of the card required when using it should be clearly discernable by visual and tactile markers.
- The tactile marker in the form of a notch is defined in ETS 300 767 [39] and as shown in clause 9.6.1.
- The user interface for retrieving data from and storing data onto a machine-readable card should accommodate the broadest possible range of users:
  - Allow all user input and output in more than one perceptual mode (i.e. visual and optionally auditory; tactile and optionally verbal).
  - In particular in devices also used by travellers (e.g. ATMs), offer the user dialogue in several languages.
- Maximize the privacy and safety of the users.

8.10.4 Contactless Cards

(Electronic keys)

An input device in the form of a card with electronically stored information and that can be used without physical contact with the card reader (e.g. as an electronic key for opening doors).

Cross references:

Card Readers; Machine-readable Cards; Bar code readers; Electronic input.

Recommendations:

- Ideally, contactless cards function also when the card is kept e.g. in a pocket or wallet.
- The user interface for retrieving data from and storing data onto a machine-readable card should accommodate the broadest possible range of users:
  - Allow all user input and output in more than one perceptual mode (i.e. visual and optionally auditory; tactile and optionally verbal).
  - In particular in devices also used by travellers (e.g. ATMs), offer the user dialogue in several languages.
  - Place the card reader in such a position that small users or those in wheelchairs can use contactless cards with the same ease as average and tall users.
- Maximize the privacy and safety of the users.

8.10.5 Bar-code Readers

An input device for accessing alphanumeric data codes presented in the standard format of printed lines of varying thickness and spacing.

Cross references:

Machine readable cards; Card readers; Contactless cards.

Recommendations:

- Ensure the bar-code is sited on a flattish surface.
- Avoid covering the bar-code with any opaque or semi-transparent material, or transparent material which can tear or crinkle.
- Provide a clean flat surface for scanning bar-codes with a stylus scanner.

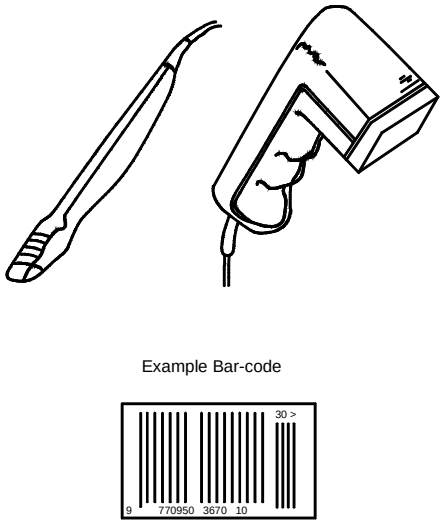


Figure 41: Example of bar-code readers and bar code

- Ensure the bar-code reader gives a clear indication as to which part is the sensor, when it is active and clear feedback when a code has been read correctly or if needs a second scan.

Additional comments:

No real guidance is currently available from the human factors literature. Therefore, if a bar-code reader is a key element of the terminal design, it is imperative to do prototype testing early in the design process to ensure the user's needs are being accommodated.

9 Output components - Design Guidelines

9.1 Output Components

(Displays)

For the purpose of this document, the output components are those elements of the user-system interface by which the user receives information from the system. The user needs to be able to sense the information, to recognize it and to act upon it.

Although output components rely normally on vision or hearing, an increasing number of haptic devices are based on the human sense of touch to provide feedback to the user. Those output devices can range from simple tactile markers to facilitate proper orientation of smart cards, to ubiquitous vibrating alarms on mobile phones, to complex force feedback data gloves.

Cross references:

Acoustic Output; Auditory Menus; Labels; Music; Non-CRT Displays; Optical Signals; Speech Output; Tactile Displays; Visual Displays.

Recommendations:

- Select output components that are appropriate to the information requirements of the task. (See table 16).
- Whenever possible, provide redundant, alternative output customizable by the user. This is the best way to meet the "Design for all" principle. A clear example can be found on: the use of an adjustable ringing tone, vibrations and screen backlight to indicate an incoming call on mobile phones. Not only users with sensory disabilities benefit from alternative output, but also any user in a noisy, or quiet, or dark ambient, or just for a matter of personal taste
- Ensure display selected meets relevant standards.
- Ensure that the user is given sufficient information in a form that is easily recognized and understood, and in an acceptable form.
- When choosing particular output technologies, designers should be aware of the limitations different technologies present to different people with special needs. In general:
  - choose a modular solution so that alternative output devices can be used;
  - ensure critical warning signals are both audible and visible.

Table 16: Output information: summary of user information requirements

Type of Information	Output Requirements
Status	Display needs to show continuing state, use non-intrusive optical signal.
Warning	Demand user attention with auditory tone, flashing light, or provide centrally positioned text message.
Feedback	Provide rapid acknowledgement of action, such as audible tone, lamp flash, change of display, tactile feel such as click action of keys.
Numeric	Use numeric digital display, consider how to show rate of change, such as dials and clockface, and use of graphs or tables.
System Prompt	System needs input/response from user. Use audible signal to gain immediate user attention. Use specific speech or visual message to instruct user. Place visual message central to user's line of sight. Allow user to cancel message if no longer required. Integrate display/controls to give soft-key interface or to prompt use of function keys.
Text	Use small panels or speech output for text messages. For text documents use sufficiently large alphanumeric display, consider CRT or flat panel display. Needs to conform to accepted standards affecting legibility and safety.
Pictorial	Use high quality graphics display with rapid display rate to show digitized visual images.

Additional comments:

The choice of output medium should be based upon an assessment of user requirements and task complexity. Simple warnings, and indication of on-off status, can be indicated with simple light signals or warning tones. Status and instruction information can be presented using a small visual display or speech output. Displays of text documents and digitized pictures need to be displayed on better quality screens.

Environmental constraints such as darkness or noise, task dependency on one sensory channel either hearing or seeing, or disabilities in relation to sight or hearing may mean that it is beneficial to offer redundancy in the system by providing output information so that it can be perceived by sight, hearing and touch.

9.2 Visual output

9.2.1 Visual displays (General)

(Displays, Indications)

The group of displays that rely on the user seeing the intended information.

Cross references:

Visual Displays types/characteristics; Printed output; Help mechanisms - text.

Recommendations:

- Use visual displays to provide feedback to control input and data entry, to give prompts and system messages and to show text, graphics and pictures.
- Use visual displays to complement auditory information; for example, because an audible signal may be missed due to excessive noise or may be unacceptably intrusive in a quiet environment. Visual displays also help people with special needs for hearing impairment.
- Provide visual displays where the user needs the information for detailed study and to act as a reminder.

Additional comments:

The visual display is an essential element in the design of the user interface and is the most flexible medium ranging from simple light signals used to give status and warning information, through simple alphanumeric character displays, to extensive text and live pictures shown on large CRT and LCD graphic displays.

See the cross reference entries for specific guideline entries.

9.2.2 Visual displays types/characteristics

There is a great diversity of visual displays in terms of size, technology, image quality and so on. With technological advances and increasing complexity, the variety and features of ICT products have proliferated.

It is not easy to give a clear, stable taxonomy of visual displays. Continuous advances in display technology have blurred and complicated traditional technical classifications. For instance, CRT vs. non-CRT displays is not commonly a significant factor of visual quality from the user point of view.

On the other hand, most current and future ICT products include visual displays needed to operate an increasing number of sophisticated features. The old plain telephony with no display at all and current mobile phones clearly illustrate this trend.

Therefore, the following recommendations are targeted to broad "families" of visual displays usages, rather than rigid visual display classification.

Cross references:

Visual Displays (General); Printed output; Help mechanisms - text.

Recommendations:

Visual displays that are intended for frequent communications, transaction handling or data entry should meet the requirements of the European Directive 90/270 EEC [138], ISO 9241 Parts 3 [53], 7 [56] and 8 [57]. The key points are:

- The screen should be free of noticeable flicker.
- The screen should offer positive contrast (dark characters on a light background) with a refresh rate preferably above 70 Hz to 80 Hz.
- Contrast and brightness should be adjustable by the user.

- The characters should appear clear and sharp in all parts of the screen, including the corners and edges, as well as the centre.
- The characters should be well defined and easily distinguishable.
- The screen should be free of glare and reflections.
- Speed of the screen update should be fast enough to avoid ghosting as text fades and if required, to support rapid changes as part of the interface design.
- The user should be able to swivel and tilt the screen to adjust the angle of view, to avoid reflections (see clause 7.1.3).
- If the screen is to be used with a keyboard, the screen and the keyboard should be separable.
- The controls provided to switch on the screen and adjust the display attributes should be available from the front of the screen.

Table 17: Visual display requirements (summary of main points from ISO 9241-3 [53])

Design requirements and recommendations	Measurement
Design viewing distance	minimum 400 mm for office tasks
Maximum line of sight angle	less than 60° below horizontal
Angle of view within which display is legible	at least 40° from normal to display surface
Character height	16' minimum, 20' to 22' preferred
Stroke width	1/6 to 1/12 of character height
Character width-to-height ratio	between 0,5:1 and 1:1 is required but between 0,7:1 to 0.9:1 is recommended
Raster modulation (for CRT displays)	C_m not to exceed 0.4 for monochrome, 0,7 for colour (0,2 preferred for either)
Fill factor (for non-CRT matrix displays)	at least 0,3
Character format	minimum 5 × 7 for numeric and upper case minimum 7 × 9 where legibility is important
Extension of matrix for diacritics/descenders	2 pixels
Subscripts and superscripts	minimum 4 × 5 matrix
Character size uniformity	not vary by more than 5 % anywhere
Between-character spacing	minimum one pixel or stroke width
Between-word spacing	minimum space equivalent to capital N
Between-line spacing	minimum of one pixel
Linearity	less than 2 % variation in row/column length less than 5 % of character height displacement
Orthogonality	less than 0,02 difference of mean height or width of addressable area (0.04 for diagonals)
Display luminance	minimum of 35 cd/m^2, higher preferred
Luminance contrast	minimum 0,5 contrast modulation C_m
Luminance balance	average luminance ratio less than 10:1 for frequently viewed areas
Glare	should be avoided without jeopardizing luminance or contrast requirements
Image polarity	either polarity is acceptable
Luminance uniformity	not to exceed 1.7:1 for display or 1.5:1 for individual character element
Luminance coding	at least 1.5:1
Blink coding	for attention, 1 Hz to 5 Hz, 50 % duty cycle for reading, 1/3 Hz to 1 Hz, 70 % duty cycle
Temporal instability (flicker)	flicker free to at least 90 % of population
Spatial instability (jitter)	location within 0,0002 mm per mm of design viewing distance in range 0,5 Hz to 30 Hz

Additional comments:

Visual displays can improve the usability of a product by providing feedback and prompts to guide the user and support error recovery. The messages need to be clear, legible and concise (see clause 9.3.4).

Studies have shown that the smaller the screen size, the greater the time the user may take to respond. Reading rates for 1 and 2 line displays can be slower than those for 20 line displays. The cut off point seems to be about 4 lines. Small screens may also necessitate greater use of abbreviations, or deeper menu hierarchies, both of which increase the time taken to interpret the display. For ISDN terminals, Bellcore® in the U.S.A., recommend screens larger than 2 × 40 characters, whenever feasible (Perris, 1993).

The European Community Council Directive 90/270 EEC on "Minimum safety and health requirements for work with display screen equipment" [138] is one response to a growing concern with Repetitive Strain Injuries (RSI) potentially related to working with VDUs.

The requirements for display layouts are covered in clause 9.3.5.

9.2.2.1 Small screens

(LCD, LED)

A growing number of ICT products incorporate small screens or visual panels usually providing status or small amount of information such as names and telephone numbers. They are solid state technologies such as LCD, plasma or Thin-Film Transistor (TFT)

Single line and small panel displays typically from 1 to 8 lines by 24 characters are usually LCD, LED, Vacuum Fluorescent Display (VFD), or plasma displays. They may be used to provide numeric or alphanumeric outputs on a variety of products, from basic facsimile terminals to mobile and advanced feature telephones.

Advanced portable devices such as PDAs, where size reduction is imperative, pose a difficult challenge from the usability point of view.

Recommendations:

- Flat panel displays should conform to ISO 9241-3 [53].
- Whenever possible there should be sufficient display space for the amount of information required and the demands of the task, as the size of the display may otherwise cause problems and constrain the dialogue design and the information presentation.
- Backlighting should be used for LCDs used in low ambient light.
- Use lower case letters for text, with uppercase at the beginning of the sentence and according to national language conventions.
- The display should be positioned so that it is at right angles to the line of sight during normal operation. Provide adjustment to the optimum angle in non portable devices: most of these technologies have a restricted field of view.
- Character displays can improve the usability of a product by providing feedback and prompts to guide the user and support error recovery. The messages need to be clear, legible and concise (see clause 9.3.4).
- Studies have shown that the smaller the screen size, the greater the time the user may take to respond. Reading rates for 1 and 2 line displays can be slower than those for 20 line displays. The cut off point seems to be about 4 lines. Small screens may also necessitate greater use of abbreviations, or deeper menu hierarchies, both of which increase the time taken to interpret the display. Some studies recommend screens larger than 2 × 40 characters, whenever feasible.
- LEDs may become illegible in very bright conditions such as full sunlight, with green and yellow LEDs being worst affected. If necessary some form of shading should be provided.

9.2.2.2 Television sets (TV sets)

(TVs)

TV sets are perhaps one of the most universally available devices, and though its use for television display is beyond the scope of this document, its use in recent times to display and interact with ICT applications (e.g. interactive TV, internet access via TV -WebTV) makes it interesting to review some of its properties and some guidelines for this application.

The user of a normal TV set should be sitting at a distance of at least 5 times the height of the screen. All user guidance texts must therefore be presented in a font and font size that are easily legible at that distance.

There are several TV emission and display standards across the world: NTSC in North America, PAL in Europe, PAL-SECAM and others in some other countries.

Table 18 compares the basic features of NTSC and PAL systems.

Table 18: Comparison of basic features of NTSC and PAL

	PAL	NTSC
Frame rate	50 Hz	60 Hz
Line rate	625	525

Now all systems and current TV sets are in colour. The systems usually differ in the number of lines displayed (resolution) and in the refresh rate. But in general none of them was devised to display large quantities of information, especially text. For this reason, it is required to use large fonts (much larger than those used in modern CRTs for GUIs), and also to accommodate to the usually larger viewing distance of the TV set.

Table 19 compares TV sets and computer displays from a practical point of view, taking into account how most people use these systems:

Table 19: Comparison of TV and Computer displays

	Television	Computers
Screen resolution (amount of information displayed)	relatively poor	varies from medium-sized screens to potentially very large screens
Input devices	remote control and optional wireless keyboard that are best for small amounts of input and user actions	mouse and keyboard sitting on desk in fixed positions leading to fast homing time for hands
Viewing distance	several meters	a few inches
User posture	relaxed, reclined	upright, straight
Room	living room, bedroom (ambiance and tradition implies relaxation)	home office (paperwork, tax returns, etc. close by: ambiance implies work)
Integration opportunities with other things on same device	various broadcast shows	productivity applications, user's personal data, user's work data
Number of users	social: many people can see screen (often, several people will be in the room when the TV is on)	solitary: few people can see the screen (user is usually alone while computing)
User engagement	passive: the viewer receives whatever the network executives decide to put on	active: user issues commands and the computer obeys

Jakob Nielsen has devoted two papers to the comparison of TV display and CRTs for web applications. They are available online at http://www.useit.com/alertbox/9702a.html and http://www.useit.com/alertbox/9702b.html.

These web pages also provide links to other recommendations available online.

Cross references:

Projection displays.

Recommendations:

The following guidelines are applicable to displaying Web content on a TV, and may be also applicable for interactive TV applications:

- Try to avoid using images larger than 544 pixels wide or 376 pixels tall.
- Do not include text in images since the characters will be very difficult to read on the TV screen.
- If you need to include text in an image, use 16 point bold Helvetica or larger (or an equally readable font) - the 16 point guideline assumes that the image is small enough that it will not be rescaled.

- Do not use a multi-column layout. If your design requires columns anyway, use at most two columns and make sure that they will work on a 544-pixels-wide screen.

- Provide navigation aids and functions to help the user to quickly scroll through the text, taking into account the much lower resolution and far less information displayed on screen in comparison with computer displays.

The following are guidelines regarding the display of text on a TV set for the purposes of interactive TV applications, extracted from MUSIST guidelines (Multimedia User Interfaces For Interactive Systems and TV) (see Bibliography).

- The limited resolution of TV screens (compared to printers) will degrade the appearance of fonts. At these lower resolutions the subtleties of a font's design become difficult, or impossible, to represent. For this reason, screen optimized fonts must be used. Adding proper hinting (or "intelligence") to the font's outline can prevent letters in the font from becoming distorted and difficult to identify as shown in figure 42.

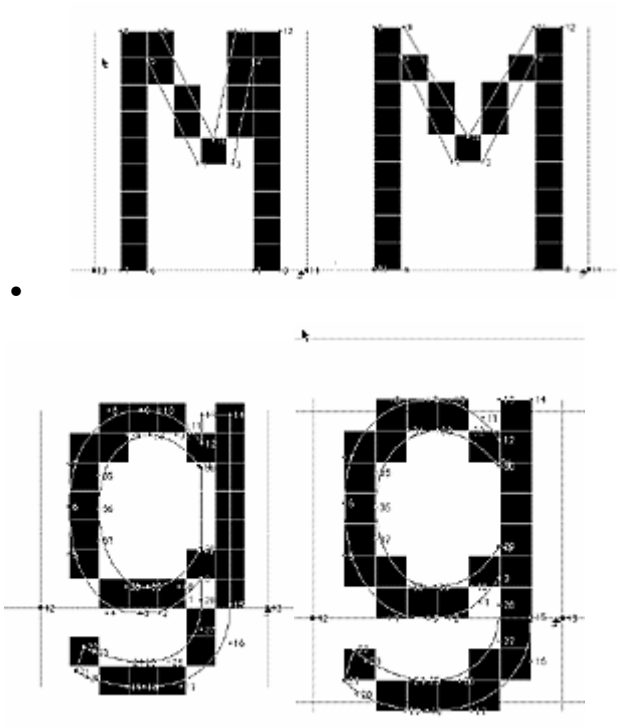


Figure 42: Printer Fonts (Left Example) Versus Screen Optimized Fonts (Right Example)

- Use anti-aliased fonts to present the information on the screen. On account of the lower resolution, diagonal strokes and round shapes are represented by stair-stepping square pixels giving a jagged appearance.

- Font Face: for better legibility the standard font for the text body should have the following characteristics:
  - proportional
  - on-screen optimization
  - clear shaping of letters
  - strong lines
  - wider letters
  - larger height of the lower cases (comparing to the total height of the font)
  - wider letter spacing (comparing to the equivalent printer font)

- Avoid fonts with the following characteristics
  - monospaced
  - containing letters with fine lines

  - smaller height of the lower cases (comparing to the total height of the font)
  - delicate serifs and ornamental details
  - narrow letters
  - less letter spacing

- Serifless standard font faces are less critical than serif fonts. But serifless fonts give the text a more technical unwelcome look.
- For larger text bodies use a very clear and legible font. For example: Gill Sans, Helvetica, Lucida, Times New Roman, Univers, Verdana, etc.
- There are few limitations concerning the use of specific fonts within headlines. If a `critical' font with ornamental, fine lines, etc. should be used for designing a headline, the following points should taken into consideration:
  - make the headline big enough
  - ensure a good contrast to the background
  - format only short headlines (3 - 4 words, no line breaking) with such a font
  - increase the letter spacing
- Recommendations about Font Size for interactive TV applications:
  - Give preference to larger fonts of at least 20 pixels.
  - The minimum font height of a standard font is derived from the reading distance:
  - Hint: Font height h [mm] = 0,0052 × observer distance d [mm].
  - The sign width of a standard font must be approximately 70 %, but not less than 50 % of the font height.
  - The line spacing of a standard font must be at least 15 % of the font height regardless of superscripts and subscripts.
- Font Style:
  - An italic font style should not be used due to the lack of legibility on the ITV-screen (especially when using smaller fonts).
  - Conventional upper and lower case should be used, because the exclusive use of capital or initial letters makes the text harder to read.
- Mixture of Fonts Within a Screen:
  - No more than 3 font types and faces respectively should be used within one screen.
- The fonts should fit together. Good combinations are:
  - Garamond/Frutiger
  - Times/Helvetica
  - New Century/Futura
  - Rockwell/Frutiger
  - Palatino/Avant Garde
  - Shelly Script/Garamond
  - Freestyle/Avant Garde

- The font combinations which are used together within a screen should not compete. If one font has a distinct character combine this font with a more restrained font.
- The line width of the combined fonts should be similar.

9.2.2.3 Projection displays

(Beamers)

There are several applications for projection displays: one of them is to give presentations to a group of people. Another common application is to project TV or video shows in domestic or other settings. The recommendations differ depending on the context of use, and are provided in a generic format:

Cross references:

Television sets.

Recommendations:

- The display should provide enough brightness to be comfortable for viewing in different lighting conditions in the different real settings where it is to be used.
- The system should provide lenses options (e.g. zoom) to project the information in the required, and often variable, size. Designers should also take into account that the projector may be located in the middle of a room, not in one of its extremes.
- Provide information about the distortion (trapezoidal images) introduced by the locating the projector below the horizontal line of the screen, and possible ways to reduce it. The best way is to incorporate in the device an automatic compensation mechanism.

9.3 Quality requirements for different Visual media contents

9.3.1 General

Visual displays are used to present quite different media contents, such as text, graphics, animations, still or moving pictures. For a proper visualization, both the display and the contents itself should follow some basic recommendations. A number of factors such as the amount, importance and frequency of information to be presented also influence the overall result.

9.3.2 Text content

(Fonts, **Characters)**

There should be sufficient display space for the amount of information required and the demands of the task, as the size of the display may otherwise cause problems and constrain the dialogue design and the information presentation.

Cross references:

Visual Displays.

Recommendations:

- Character height, for a capital letter may be calculated as subtending 20 - 22 minutes of arc at the required reading distance. Some sources suggest that for a typical reading distance to a display of 400 - 600mm, the letter height should be a minimum of 2,9mm, with one source suggesting an optimum range of 3,8 - 4,5mm. This larger character size permits more people with impaired vision to use the system and also improves the legibility of lesser quality screens.
- Character width should be 50 % to 80 % of character height, and stroke width should be 8 % to 20 % of character height. Within dot matrix screens the required minimum character cell for capitals is 7 × 5 pixels, however, the preferred minimum is 9 × 7pixels.

- Text lines should be separated so that there is at least a 1 stroke width separation between the top of diacritical marks (accents) on upper case letters (e.g. the top of the umlaut on "Ü") and the bottom of descenders (e.g. the downward stroke of "g"). Increased separation improves reading speed. Based on the preferred minimum dot matrix cell of 9 × 7 for the capital "M", the preferred full cell size including diacritical marks is 14 × 7, with a 1 dot text line separation.

Table 20 gives details of character size and viewing distance derived from ISO 9241-3 [53].

Table 20: Character size and viewing distance

Character size	Preferred viewing distance (20' to 22' of arc)	Maximum acceptable viewing distance (16' of arc)
mm	mm	mm
2,4	375-413	516
2,6	406-447	559
2,8	438-481	602
3,0	469-516	645
3,2	500-550	688
3,4	532-585	731
3,6	563-619	774
3,8	594-654	817
4,0	625-688	860
4,2	657-722	903
4,4	688-757	946
4,6	719-791	989
4,8	750-825	1 032
5,0	782-860	1 075

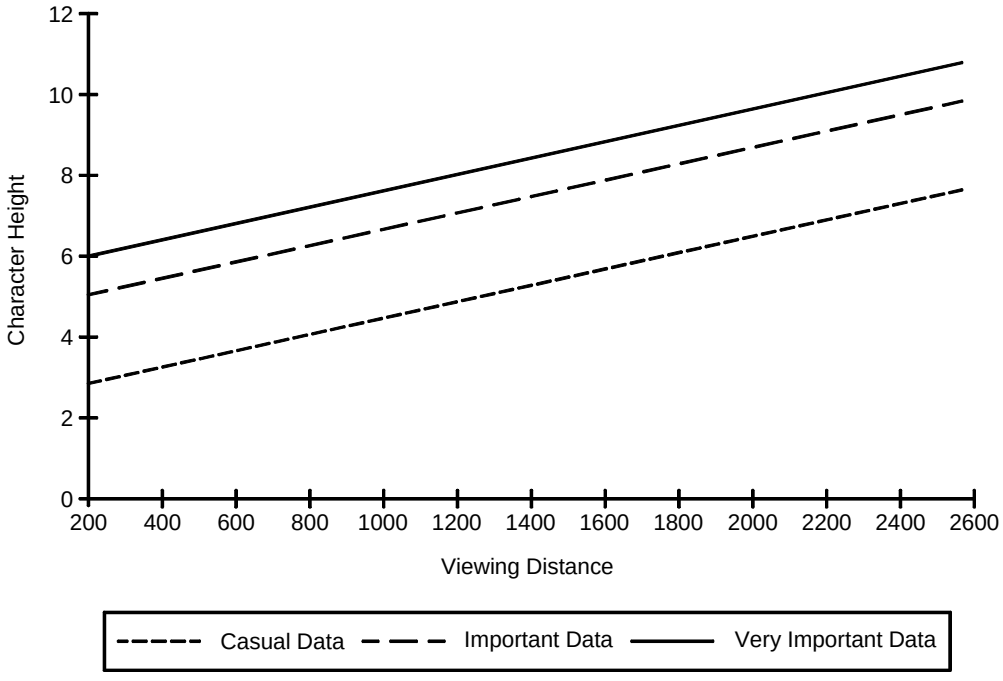


Figure 43: Character height vs. viewing distance

- The simplest 7 or 9 segment displays are acceptable for display of numeric information. They are not recommended for alpha information since legibility is severely compromised by the bit format, resulting in an unsatisfactory mix of upper and lower case letter shapes.

- Use a dot matrix where alpha-numeric information is required. As a minimum, use matrix of 7 × 5 for capitals. Preferably use a matrix of 9 × 7 with additional dots, i.e. 14 × 7 to provide for ascenders and descenders of lower case letters, accents.

- The space between one line of type and the next (known as leading) is important. As a general rule, the space should be 1,5 to 2 times the space between words on a line.

- Characters should be clear and legible. Text should use lower case lettering, with capitals used for the beginning of sentences and in accordance with National language conventions.

- Character/background contrast ratio should be 3:1 minimum ISO 9241-3 [53], 10:1 recommended. Character line thickness should be comparable to bold typeface.

- In general, maximum contrast is achieved with black text over white background. Some people with viewing disabilities prefer the opposite, white text over black background. These options should be considered in the design, and offered for configuration by the user.

- The choice of typeface is generally less important than size and contrast. It is preferable to use typefaces that people are familiar with and will recognize easily. Avoid italic, simulated handwriting and ornate typefaces as these can be difficult to read particularly by users with impaired vision.

- The display should be mounted in or on the product to allow for an optimum viewing angle of 90° to the plane of the display. On a desk mounted display a visual angle of 65° to the horizontal is preferred. This assumes that the user is sitting in a relaxed, slightly slumped posture. Allow for a hand-held device to be held in a similarly relaxed posture.

- Protect from glare and reflections. Mounting the display with a glass or transparent cover at an angle of 75° helps to minimize reflected glare from overhead lights.

- Where the message to be displayed is greater than the display space, provide scrolling, preferably under the user's control, and an indication that there is more information.

- If automatic scrolling is necessary, scroll line by line, or page by page, in preference to character by character. When providing automatic scrolling allow sufficient time for slow reading, e.g. minimum 3 seconds for 24 characters, 5 seconds for 40 characters.

- To gain attention flash only one character cell (e.g. an asterisk *), do not flash the whole display or message as this makes it difficult to read. Use a flash rate 1 second on, 0,5 second off, or for an urgent indication 0,25 second on, 0,25 second off. For urgent attention offer a complementary auditory signal.

- LEDs may become illegible in very bright conditions such as full sunlight, with green and yellow LEDs being worst affected. If necessary some form of shading should be provided.

- LCD displays may have a limited viewing angle, beyond which the display appears blank, or black. The screen needs to be positioned to take account of the known range of viewing angles, and provide for some level of adjustability. In low ambient light provide back-lighting to maintain contrast.

Additional comments:

Text displays can improve the usability of a product by providing feedback and prompts to guide the user and support error recovery. The messages need to be clear, legible and concise (see clause 9.3.4).

People with sight problems often prefer bold or semi-bold weights to normal ones. Avoid light type weights.

If numbers are important in the system, choose a typeface such as Tiresias in which the numbers are clear. Readers with sight problems can easily misread 3, 5, 8 and 0.

Avoid fitting text around images if this means that lines of text start in a different place, and are therefore difficult to find. Set text horizontally as text set vertically is extremely difficult for a partially sighted reader to follow. Avoid setting text over images, for example photographs. This will affect the contrast and, if a partially sighted person is avoiding images, they will miss the text.

9.3.3 Graphics content

Visual graphics in the form of icons, symbols and pictograms are currently used extensively in ICT products and services to facilitate interaction between the product or service and the user. Graphics can provide a language independent means of communicating information to the user. They are part of a graphical interface that can facilitate the user's ability to learn, understand and remember functions of the system, and aid in the manipulation of these elements.

ISO/IEC 11581 [67] deals extensively with standards for graphics in computer-based products and is highly relevant in this context. It also presents a conceptual framework to relate the function within the system to the symbols used, which can be potentially extended to multimodal symbols.

9.3.4 Animations

Animation is a particularly useful component of the presentation of visual information as it draws the attention of the user to the information. Human beings are particularly good at monitoring their visual field for change, even if this is in the periphery of the visual field (round the edges) rather than in the direction we are looking. Thus, people will detect small motions at the edge of their vision, and instinctively look in that direction, a capability symbol designers may capitalize on. Of course, this can also be over-exploited, as too much motion can be very distracting and even lead to motion sickness.

With an LCD display, rapid change may cause the image to smear as the old image fades slowly.

9.3.5 Screen messages

(Indications)

Within the user interface design, one of the main modes of communication from the system to the user is by displaying information on the screen as a message.

Cross references:

Error Management; Feedback; Help; Labels and abbreviations; Screen Formatting; User Prompting.

Recommendations:

- Use screen messages to give instructions, to offer available choices of actions, and to provide error messages and status information.
- Messages should be short, factual and informative, avoid the extremes of being authoritarian or too familiar.
- Avoid excessive use of capital letters as they are generally harder to read. Use lower case lettering for the main part of the text with only the initial letter of the sentence in capitals.
- Use short sentences and familiar words.
- Avoid technical terms, jargon and abbreviations.
- Use an active verb structure, and, when giving instructions, place verb first and object second e.g. "Press cancel key".
- Use the positive "Do" construction in preference to negative "Don't".

Additional comments:

The tone of the message should be factual and informative so that the user clearly understands what to do and what to do next. Humour may not translate well into other languages and over-familiarity may cause offence in different cultures.

Legibility and speed of reading is best served by using mainly lower case text, ensuring adequate interline spacing.

See also: ISO DIS 9241-12 [61] for more information on screen messages.

9.3.6 Screen Formatting

(Display Layout, Legibility, Screen Size)

Screen formatting applies to the layout of the information shown on the screen.

Cross references:

Visual output; Visual indicators; Screen Messages.

Recommendations:

- Minimize the amount of information by presenting only what is necessary.
- Decide on a format that is orderly, clutter free, and aesthetically pleasing.
- Group related information according to user conceptual relationship, sequence, frequency of use, importance, chronological sequence or alphabetic order.
- Develop a consistent layout that helps the user to find the required information. For example:
  - start from the top left of the screen;
  - use a distinctive title for the screen or window;
  - reserve specific areas for specific types of messages;
  - group related information using blank space, lines, intensity or colour.
- When screen space is very limited (e.g. 2 line display) use a consistent strategy, e.g. line 1 for working information and line 2 for control information.
- When screen space is limited (e.g. less than 10 lines) display the information in the following order of priority:
  - responses to keying by user;
  - user guidance e.g. prompts;
  - system event messages;
  - display information e.g. menu items;
  - permanent messages e.g. call forward on;
  - idle state messages.
- Locate information according to user expectations. In Western cultures people will usually start searching from the top left as they do when reading.
- Distinguish titles and captions by coding with a larger font size, bold typeface, or upper case letters. Separate from the main text if space allows.
- Avoid abbreviations except where space is limited in which case:
  - use internationally accepted abbreviations;
  - use a consistent scheme for creating abbreviations;
  - provide a dictionary of abbreviations.
- Information should progress from generalities to specifics.
- For ease of reading limit line length to 40 to 60 characters per line and increase interline spacing.
- Text for reading should be presented in lower case lettering, even letter spacing, line spacing in the ratio 1:2 and line length of no more than 60 characters.

- Use cues to aid search and retrieval such as consistent location, colour, highlighting, flashing.
- Parts of the screen may be coded by using up to two levels of brightness and using different colours of foreground, or background.
- Flashing should be reserved for critical attention getting with a flash rate cycle of 2 to 5 Hz, and with a minimum on-period of 50 %.
- Use colour coding sparingly and use other coding devices where some users may have monochrome display units.
- When creating control key dialogues using soft-keys, position display elements close to control keys.

Additional comments:

Users look to the screen to search for feedback, system prompts, status information and to read text. Search times of small and large displays can be greatly improved by using a logical format. Colour should be used conservatively in order to avoid creating colourful confusion. In preference, design the screen formats for monochrome presentation first, then add colour as an enhancing, attractive supplement, not as a necessity.

Consistency is a particularly important principle in screen layout design so that the user can quickly learn where to scan for the information required. At the same time it is important to provide variable features so that the user can recognize different types of information, or changes that have occurred.

See also: ISO9241-12 [61] for more information on screen formatting.

9.4 Visual indicators

9.4.1 Optical signals

(Display {Brightness, Colour, Contrast}, Flashing, Flash Rates, Lamps, LEDs {Light Emitting Diodes}, Lights, Indicator Lights, Panel Lamps)

Optical signals and lights are the simplest visual display devices. They are usually used to augment a control or label to indicate the current status. They include running (status) lights, panel lamps, warning signals and simple flashing light codes.

Cross references:

Colour.

Recommendations:

- Status lights should be large enough and bright enough to be seen easily, across the range of expected environmental conditions, without being distracting, e.g.:

  recommended brightness level: 160 candelas/m^2 minimum
  minimum contrast ratio on:off: 5:1
  angle of view; 160° minimum.

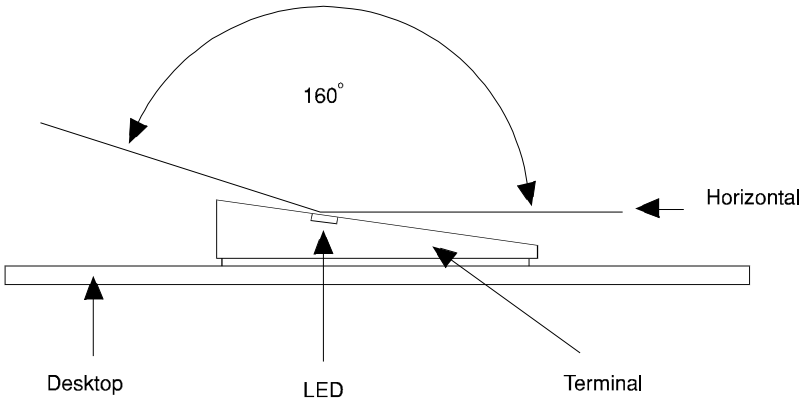


Figure 43a: LED preferred viewing angle

- Use accepted colour coding conventions, e.g.:
  - red for stop, or danger
  - green for normal or go
  - amber/yellow for caution
  - white/blue for normal conditions
- To attract user attention use a change of colour or flashing light. Supplement with an auditory signal if the condition is urgent, or where user may not be facing the display.
- If flashing is used, limit the number of different flash rates to 2 (preferred) or 3 (maximum) across the complete terminal.
- Preferred rate of flashing light is 3 to 10 flashes per second, with equal on-off intervals. Do not exceed 12 flashes per second. Avoid flash rates with long off periods and short on periods.
- Limit the number of status indications on one optical indicator to three or a maximum of four. For example: OFF, ON (steady), ON (slow flash), ON (fast flash).
- Position warning signals within 30° of the user's expected line of sight.

Additional comments:

Optical light signals can be used as simple indicators of on-off status, and to attract attention with flashing codes.

The attention getting qualities of optical lights can be improved particularly for people with special needs, by providing a complementary audible signal.

9.4.2 Icons, symbols

(Pictograms)

Symbols, pictograms and icons are all graphic devices used to label control keys, or to give information on screen, casework or in user guides. The word symbol is sometimes used specifically to refer to abstract representations. Pictograms may be used specifically for pictorial representations, and icons for screen based graphical user interfaces. In practice these distinctions are often unclear and so the term symbol is used here generically.

Cross references:

Labels and abbreviations; help mechanisms - text.

- **Recommendations:** Use internationally accepted and publicly recognized symbols, such as the ITU-T telephone symbol (ITU-T Recommendation E.121 [69]), the ISO symbols ISO7000 [109], ISO7001 [106], IEC symbols for equipment (IEC 60417 [46]), and ETSI symbols for videophone functions [30].

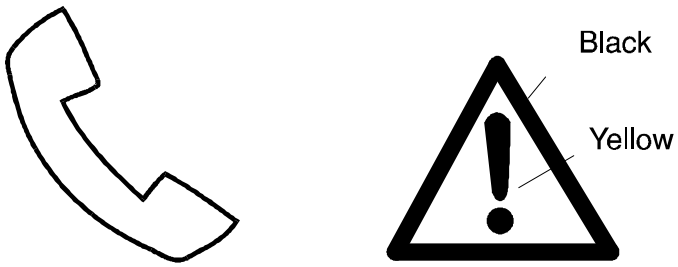


Figure 44: ITU-T telephone and ISO warning symbols

- Where possible, use accepted or "industry standard" symbols or icons in screen based graphical user interfaces.
- Ensure printed symbols are clear, legible and durable.
- Ensure on-screen icons are sufficiently large to be clearly distinguishable, for the predicted viewing distance.
- Ensure supporting documentation provides a glossary of symbols and icons to enable identification and learning.
- Create new symbols only if essential and do so in accordance with IEC 80416-1 [48].Test for acceptability to the intended user group using an agreed test procedure as recommended by ETR 070 [12], EG 201 379 [3] or ISO 9186 [51].

Additional comments:

The main advantage of symbols as compared with written text is that they are independent of language. Pictorial representations of concrete objects such as the telephone handset, are easily recognized as indicating a telephone service. Symbolic representations of abstract concepts as used to represent telephone supplementary services places demands on the user to learn a new language of symbols in combination with the new features offered. The benefit of language independence may be lost to new and casual users who will need a guide to recognizing the symbols.

The advantage of the symbols then lies in their space saving compactness on keys, the casework or on the screen. Where the symbol is being used to label a control function, consideration should be given to providing feedback that allows the user to detect errors.

9.5 Acoustic output

9.5.1 Auditory displays

(Displays, Sounds)

The group of information displays that rely on the user hearing the information.

Cross-reference:

Acoustic Signals; Auditory Menus; Music; Speech Output.

Recommendations:

- Use auditory displays (acoustic signals, speech output, etc.) to complement visual information, to assist some categories of people with special needs, such as the visually impaired.
- Use auditory displays when users are unlikely to be attending to, or facing a visual display.
- Use speech output when more message flexibility is necessary, when specific data has to be conveyed, when there is a need for two way exchange of information, when listeners cannot be trained in the meaning of acoustic signals.

- Use acoustic signals: where immediate action is required, when a point in time (but not a value) has to be indicated, to override speech communication.
- Allow the user to control the acoustic output in terms of volume tone and balance.

Additional Comments:

Review the individual guideline entries for specific recommendations on each type of auditory display.

Acoustic output should be limited in order to prevent injury resulting from acoustic shock. The prevention of acoustic shock is a safety requirement outside the scope of the present document and arising from the Low Voltage Directive (73/23/EEC) [136]. In the absence of any relevant safety standard, advice can be found in ES 200 677 [8] and TBR 008 [43].

Recent research in the UK and Australia has cast doubts over the levels of protection afforded by the limits in these references if used with headsets in call centres. Caution is advised in these cases.

9.5.2 Non-speech audio

9.5.2.1 Acoustic Signals

(Auditory Tones, Earcons, Ring Signals, Warning Tones)

Acoustic signals and auditory tones are intended to provide information to the user of the status of terminals, systems and networks. For clarification, acoustic signals include: the ringing signals, equipment warning signals, e.g. error "bleep", and also incidental noises such as the sound of a cooling fan or disc-drive. Auditory tones include: the ring tone (the other terminal is ringing), busy tone, call waiting, fax answerback, etc.

Cross references:

Call Handling; Feedback; Music; National Variations; Response Times; Voice Transmission.

Recommendations:

- Use acoustic signals to attract attention, for example, as the ring signal and as a warning signal where immediate action is needed.
- Use auditory tones to provide feedback on the current state of a call, and as a prompt for action within call set-up/handling.
- For signals or tones, use a very limited number of easily recognized codes using rhythm (cadence) and pitch (frequency) variations; preferably less than 7 in any single context. For example, keep the total number of tones possible within call set-up to less than 7.
- Use tones having a frequency (pitch) between 300 Hz and 3 000 Hz where the human ear is most sensitive, irrespective of the auditory channel's bandwidth (3,1 kHz, 7 kHz, 15 kHz etc.).
- Ensure the time delay between terminal, system or network changes and the corresponding signal or tone is minimal; a desirable maximum would be 0,5 seconds (see Response Times).
- Ensure the sound level of tones provided by the terminal independently, or in response to network prompts, meets the ITU-T recommended levels shown in figure 45, (ITU-T Recommendation E.180 [77]).

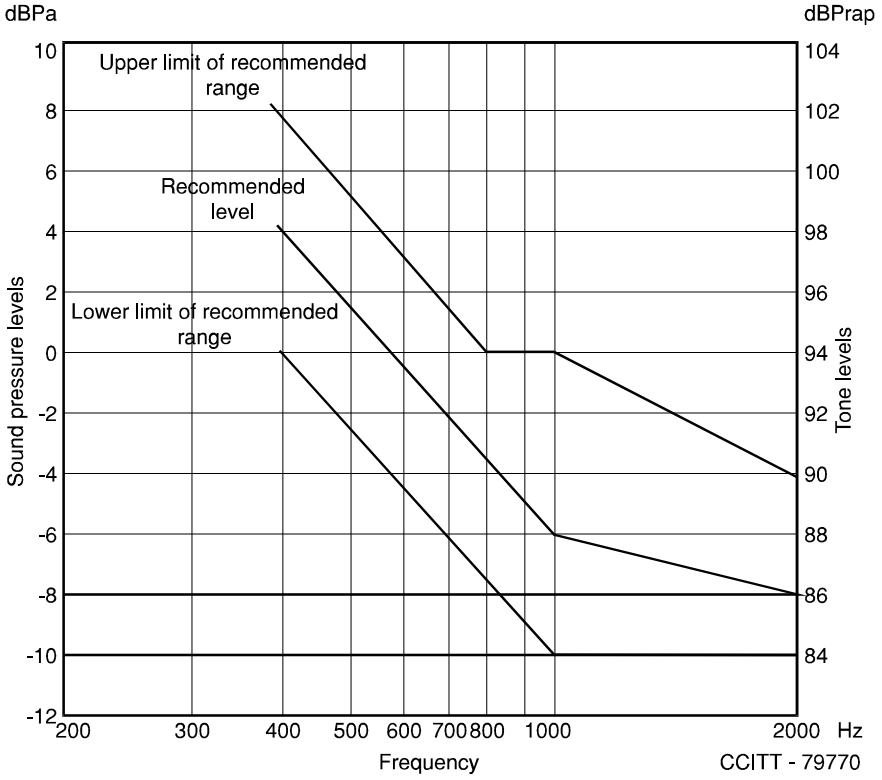


Figure 45: ITU-T recommended listening level limits for tones

- Where possible provide a volume control so that users can adjust the loudness of signals and tones for personal preference and relative to any ambient noise.
- Where tones are generated independently by the terminal in response to signalling from the network, the terminal generated tones should copy the local PSTN generated tones in frequencies, cadence and meaning.
- In general, terminals should not generate new tones. If the terminal provides services which require feedback, it is preferred that the terminal makes use only of the minimum set of PSTN tones (dial tone, special dial tone, ring tone, busy tone, congestion tone, special information tone, call waiting tone and warning tone); these may be supplemented by other auditory or visual announcements.
- Make use of users stereotypes, use accepted telephony tone codes, e.g. for ringing and busy tones. (ITU-T Recommendations E.180 [74], E.181 [78] and E.184 [81]).
- For signals, use complex (multi/variable frequency) sounds, variations in cadence (rhythm) and combinations of sounds to make two to four note patterns as these are easier to identify than single frequency pure tones.
- In general, aim to support signals and tones with confirmatory and supplementary visual information, e.g. a lamp signal in response to a ring signal and an indication who is calling, helps both the people with special needs and the untrained user.
- If possible allow users to control or switch off acoustic signals where they might cause annoyance in quiet or crowded environments.
- Peripheral sounds such as a disc-drive operating may provide important feedback cues, if these are lost due to technological improvements consider providing alternative auditory or visual signals.
- Although often useful information, try to keep the level of continuous operating noises as low as possible, and ensure they are within the relevant noise criterion curves.

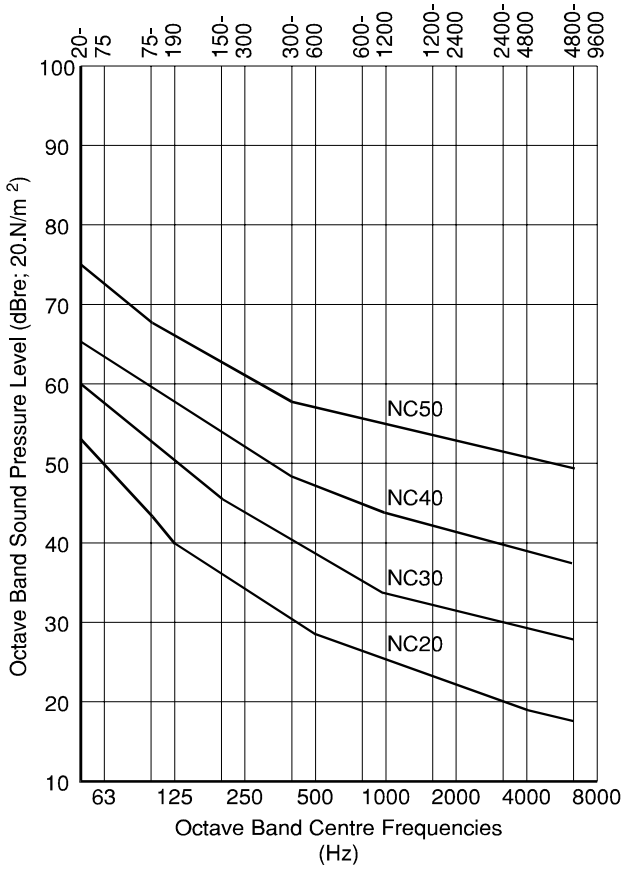


Figure 46: Noise criterion curves

- Where security requirements prevent the giving of auditory feedback, e.g. for PIN numbers, etc.; ensure the user can still receive visual and/or auditory feedback on the other elements of the dialogue, e.g. the dialled out number.

Additional comments:

Audio icons (earcons), coded signals or auditory information tones which the user has to interpret and to respond to differently, should be made as different as possible.

Auditory signals are particularly valuable for attracting attention, and giving warnings. However, the information content of a "ring or beep" is very low and may need to be supplemented by further visual or speech outputs. (ITU-T Recommendations E.182 [76], E.183 [80]).

It is useful in many environments, if users are able to adapt or modify the ring signal, for example, so that they can differentiate between several terminals in close proximity. Where ring signals can be customized, it is desirable for the user to be able to test the changes without having to make or request a call.

Environmental constraints need also to be considered since signals and tones may not be heard in noisy conditions, or may be annoying or embarrassing in quiet or crowded conditions. For example, the usability of the basic ring signal can be improved by providing a supplementary lamp signal, which enables the sound to be minimized and incidentally helps people with hearing difficulties.

9.5.2.2 Music

(Earcons)

Music is used extensively in ICT products and services such as PABXs and call steering systems as an auditory indication of a current state, e.g. "Still connected, please hold", or to link Audiotex messages. May also be used in very short phrases as earcons (auditory icons), e.g. as an auditory logo, when connecting to an automatic service, or to gain attention to messages.

Cross references:

Acoustic Signals; Auditory Displays.

Recommendations:

- Ensure that any musical phrases used are reproducible within the bandwidth of the network used. Music usually needs better sound quality than speech as quality limitations in the system can produce annoying effects.
- Low quality sound reproduction is normally adequate for differentiating between earcons. However, if earcons are to be used in these conditions the earcons need to be designed to make the differences clear and appropriately evaluated to establish their usability in the target environments.
- Ensure the music is presented at a similar volume to acoustic signals, and that the dynamic range is limited to prevent apparent silences and sudden loud bursts.
- Ensure the length of the repetition cycle of any musical phrase (excluding earcons) is greater than 150 seconds (2,5 minutes), or exceeds 95 % of the expected waiting time on the system.
- Ensure popular and recognizable music phrases are completed within their repetition cycle time.
- Use a spoken message, e.g. "Please wait, we are trying to connect you" to introduce music on hold. Consider repeating a message, or use subsidiary messages, e.g. "Still trying to connect you" at between 30 and 60 seconds intervals. Consider offering the caller a method to get back to the operator and/or to leave a message.

Additional comments:

Be sensitive to the potential user's listening habits, avoid musical extremes, acoustically harsh electronically reproduced sounds. Consider the fact that the musical quality should reflect the image of the company making use of it.

9.5.3 Void

9.5.4 Speech Output

(Messages, Recorded Messages, Synthetic Speech, Voice Messages)

Speech output includes the use of recorded natural and synthetic speech used to give information or feedback to the user.

Cross references:

Auditory Displays; Auditory Menus; Phone-based Interface; Speech Recognition.

Recommendations:

- Selection of speech output should be based on a full assessment of the task requirements (ITU-T Recommendation E.183 [80]).
- For maximum intelligibility of speech output recorded natural speech is preferable to concatenated speech, with synthetic speech ranked third.
- Speech output has an advantage where the user needs to be free to attend to other tasks such as watching a visual display or driving, or is unable to read because it is too dark, or the user is visually impaired.
- Speech output may be considered in telecommunications to provide feedback, to give messages and provide instructions when there may be no visual display available.
- Minimize the load on human memory by allowing users to hear the message repeated, and to enter commands or data immediately and not to have to remember and wait to the end of the message.
- Respect limits of the human working memory and the echoic store (approx. 3-4 elements) when designing menus.

- A user can listen to 150 -160 words per minute comfortably. This speed should not be increased unless the user configures so (e.g. a blind user). Absolute speed output limit is 210 words per minute.
- Never present two verbal tasks at the same time (e.g. two messages). Every prompt must wait for a response.
- Modulate output as much as possible to human voice in synthetic speech systems. If it is possible, simulate accent, age, and sex of user.
- Use simulations which are similar to human prosody (tones related to the task, e.g. higher tone if it is a warning, interrogation, etc.).
- All non-relevant verbal information should be eliminated.
- Consider whether the message should be available in more than one language for international visitors or international calls.
- Evaluate and test speech messages for intelligibility, understanding and user acceptability during development with representative users. Aim for a high acceptance criteria, e.g. a minimum of 90 % recognition accuracy on the first exposure, to maximize user acceptance in the field.
- In a multimedia system, before offering detail on a page of content, offer a summary or introduction of what is available in it. E.g. this is a page containing 5 images, 2 text paragraphs, etc.
- In a multimedia system, movements between interface elements must be made in a consistent and logical way: top-down, left to right.

Additional comments:

The user needs to find the message intelligible. Users generally prefer natural recorded speech to synthetic speech. Concatenated speech is natural speech stored as a carrier phrase, and variable data. An example is the British speaking clock where the phrase "At the third stroke, the time will be" is the carrier phrase, and the time data "ten" and "thirty" are selected from different files. With more complex phrases it is necessary to apply rules of syntax to alter the rise and fall of the voice, depending on the position of particular words in the sentence or to indicate questions.

A poor spoken interface may be perceived as more irritating than an equivalent poor visual interface. The elderly and partially deaf may have difficulty understanding poor quality speech output.

Integration of speech output with other modalities is always preferable. For instance, integrating a vocal interface with a touch display or with a Braille output device. Speech information may be very poor or difficult to use, so other mechanisms can greatly help to make it usable.

Where speech output is provided using a loudspeaker the speech needs to be loud enough not to be masked by other natural speech communication. Users may prefer some level of privacy of their message; for example, by hearing the message through the telephone receiver or a headset.

When using recorded natural speech it may be desirable to inform the user that it is a recording and/or to emphasize that it is a machine responding to avoid users trying to start up a conversation.

9.5.5 Auditory Menus

Auditory menus are spoken using recorded real speech or synthetic speech. Menu choices are made using key input, sound or speech.

Cross-references:

Menu Dialogues; Speech Output; Phone based interfaces.

Recommendations:

- Develop the menu specifically for speech output. Avoid the use of homonyms (words which sound similar). Use single words, or common (perhaps also jargon) word pairs. Maintain a good rhythm and a near constant speech rate, keep the gap between menu items fairly short (0,5 second to 1,0 second). Use the female voice. Limit the number of choices in any one menu presentation to a maximum of six.

- Ensure the quality and intelligibility of the speech output by testing on a representative sample of users. Set the necessary success rate quite high, e.g. 95 % correct recognitions on the first exposure.
- Avoid developing a hierarchy; if it is necessary, keep the number of levels to a maximum of two.
- Minimize the memory load by allowing the user to select an option immediately. Enable interrupts or "typeover".
- Provide the facility to allow the user to hear the choices repeated.
- Allow short cuts for expert users. Enable users to interrupt and type ahead, i.e. interrupt with one or more known inputs.

Additional comments:

Research has shown that the requirements for auditory menus are more complex than for visually displayed menus. At this time it is particularly important to evaluate and optimize the content and format of the menu during the design stage.

9.6 Tactile Output

9.6.1 Tactile indication

(Tactile Markers, Braille)

The type of display elements that rely on the user perceiving the intended information by touch.

Cross references:

Card Readers; Tactile input; Keys and keyboards.

Recommendations:

- Provide tactile indications on numeric keypads e.g. raised dot on number 5 and on typewriter style alpha keyboards e.g. raised bar on F and J.
- Consider printing or engraving key labels to give texture.
- Provide structure to the layout of keys to assist user orientation, e.g. familiar key groups include the 3 × 4 key-block for numbers, staggered QWERTY (AZERTY etc.) for alpha keys, short rows or blocks of function keys.
- Smart cards and magnetic cards should have a notch or tactile marker to aid orientation. (ETS 300 767 [39], ITU-T Recommendation E.136 [74]).

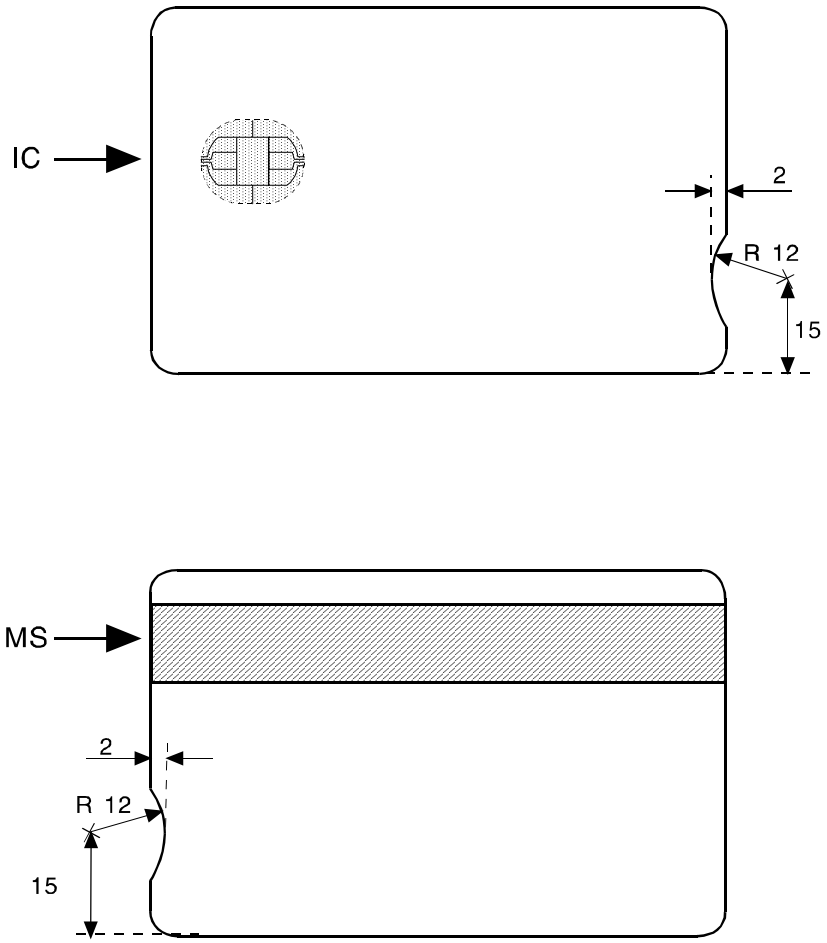


Figure 47: Example tactile marker on telephone card

Additional comments

Tactile displays can aid users with impaired vision and also assist the development of skilled operation where for instance the user no longer needs to search the keyboard for the right key, and provides vital cues when there is a need to work in low ambient light levels.

9.6.2 Vibro-tactile indication

(Vibrator)

Vibro-tactile indication is the provision of information through an active vibrating element. The commonest usage is in a mobile phone to give a silent indication of an incoming call.

Cross-reference:

Auditory Displays; Visual Displays

Recommendations:

- Optimize the detection threshold by frequency and location.
- Use a frequency between 10 Hz and 600 Hz.
- Use an intensity between 15 dB to 20 dB above threshold.
- Frequency can be used to encode information.

Additional comments:

A tactile indicator has the advantages that it is private and can be always ready to receive information or attract attention.

Further information can be found in [5].

9.6.3 Force feedback

Haptic output

Force feedback provides a haptic (simultaneous tactile and kinaesthetic) sensation when operating an ICT device such as a mouse or joystick. Force feedback is generally considered as an active indication but it can also be used in simple switches to give indication of successful operation.

Cross-reference:

Switches; Mouse; Rotary controls.

Recommendations:

- Provide a resistive force on switches to indicate the imminence of a qualitative change before it is completed.
- Provide a collapse action on switches to provide feedback of successful operation.
- Provide detents on rotary controls where there are significant positions on the rotation.
- Consider the use of haptic feedback to a mouse to indicate the border of the active display.

Additional comments:

Haptic feedback can be used in conjunction with audio feedback to produce an audio-tactile system which can provide access to a GUI for visually impaired users.

Further information can be found in [67].

9.7 Printed Output

(Paper, Labels)

The presentation of alpha-numeric characters, pictures or abstract symbols by printing, engraving or etching. This information may be on the product casework, controls, or attached labels.

Cross-reference:

Help mechanisms - text; Labels and abbreviations; Icons; Symbols.

Recommendations:

- Use printed, etched (and filled) or moulded displays to identify controls and displays on the equipment. Avoid the use of condensed, italic, light, or narrow fonts when labelling controls.
- Ensure markings on casework and controls are sufficiently durable for the life of the equipment. Be especially concerned with markings that need to be placed in any user handling areas.
- Provide printed labels and handbooks to offer user guidance, support user learning, and the safe and efficient use of the equipment.
- Ensure printed material is clear, legible and easily understood by the user. Test prototype texts on representative users.

Additional comments:

None.

9.7.1 Paper Handling

(Paper Path)

This covers the requirements for manipulating paper based inputs and outputs for the terminal and the clearance of paper paths.

Cross references:

Casework; Facsimile Machines; Hand Sizes.

Recommendations:

- If the terminal provides for the feeding of paper master, i.e. for scanning in fax transmission, the orientation of the paper master required by the terminal should be clearly indicated and obvious. Orientation includes face up or down, short or long edge leading and left, right or centre registration.

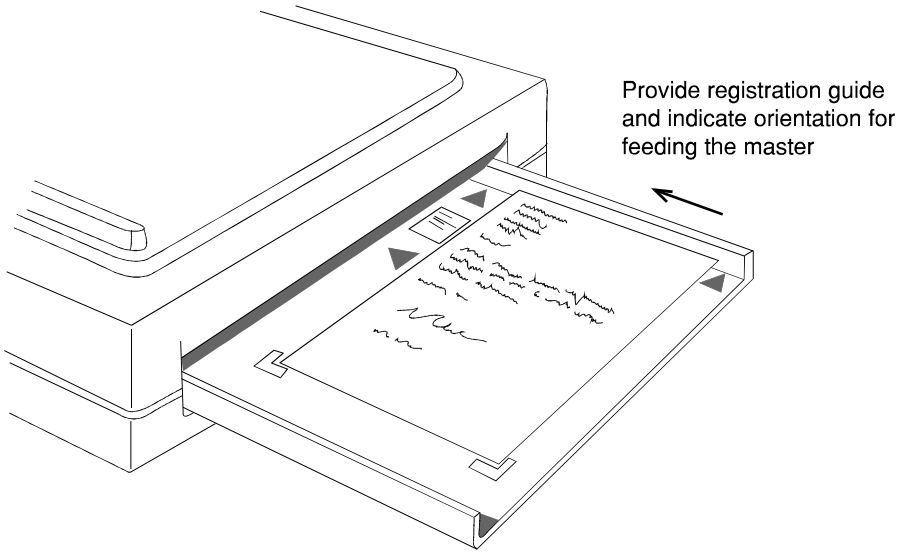


Figure 48: Example paper registration/orientation guide

- If the terminal provides an automatic or semi-automatic feed mechanism, there should be sufficient space to support the standard paper size used (normally A4) on the input side, a similar receiving area on the output side, and a clear indication which is which. If the terminal provides only for manual or semi-automatic feed, clear indications should be given when to insert follow on pages.

- If the terminal provides for the output of printed paper sheets, i.e. for receiving transmitted faxes, it is good practice to provide sufficient clear space to collect and support the pages output.

- Depending on the printing technology, it may be helpful to provide an earthing mechanism to minimize any static electricity build up on the printed pages.

- If continuous stationery is provided, either from fold or roll, it may be helpful for mechanisms to be provided to separate and if possible stack the pages sequentially. If such a facility is provided, it could be a user option to set the size of the cut sheet to enable larger than A4 pages to be received.

- Whatever stationery is used, provide a clear visual (and perhaps auditory) indication, well in advance of the last sheet, that new paper will be needed.

- Provide access to the paper supply area by a simple single action e.g. pull out paper tray, push button to realize lid, etc.

- If fan fold or paper roll stationery is used provide sufficient clearance within the paper store area for gripping, placing and adjusting the new paper supply. Ensure the direction of feed (under or over for paper rolls) and the paper path through the print mechanism is clearly indicated. Ensure the paper lead can be cleanly inserted and fed into the printer mechanism if this is a user task.

- Provide suitable warning indicators if the new paper is loaded incorrectly. If possible, design the paper housing area to make incorrect loading difficult. If incorrect loading is possible, ensure that it is simple to remove the incorrectly loaded paper, without the need for tools, and with minimum damage to the paper stock.
- If cut sheet paper is used, ensure the paper tray gives clear indications of the required orientation(s) and maximum loads the tray can accommodate. If possible, consider avoiding the use of corner retaining lugs within paper trays, or direct paper loading to enable the new stock to be sited correctly under the lugs.
- Consider the user's requirements for clearing paper jams within the scan and print paper path. Provide clear indication when a jam has occurred and consider offering the options to end any current transmissions relating to the paper jam.
- Provide access to any paper path by a single simple control action. If possible enable the user to visually inspect the whole paper path when opened.
- Avoid the need for tools to clear paper jams. If special tools are required ensure they are supplied with and stored securely within the terminals casework, and accessible when the paper path is opened. Provide sufficient clearance space for 95th percentile hands to clear the paths of paper (see Hand Sizes).
- Provide clear warning labels and guidance for any part of the path that may include hazardous elements e.g. heater, units.
- On the scanner or input side, make every effort to ensure paper jams can be cleared with minimal damage to the original master document.

Additional comments:

The designer should be aware that the stereotype response for users who realize they have inserted the master incorrectly may be to attempt to grab back the master. Where possible, this stereotype should be supported, rather than forcing the user to complete the feed, at least for the majority of masters on the input stack.

When designing the paper path for a facsimile terminal, consider that the user may have to read, dial and check the fax address after the leading paper edge has been inserted.

10 Additional product specific guidelines

10.1 Cables and Cords

(Wires, Cords, Equipment Practice,Vandalism)

Cords are used to provide a physical interconnection between modules, to connect to the ICT equipment or network, and to connect to power sources. Typically, they terminate in connectors, plugs or sockets.

Cross references

Casework; Connectors.

Recommendations:

- Use flexible coiled handset cords to connect a handset to a terminal base unit in order to prevent the cord pulling or moving a free-standing base unit. The cord length coiled should be in the range 0,3 m to 0,5 m; and fully extended in the range 1,0 m to 2,0 m, preferably 1,7 m. The coiled cord is considered to be fully extended when it is pulled out to the extent that the base unit begins to move with a force not exceeding 400 grams. For wall mounted telephones a force of 250 g is used.

NOTE: These recommendations do not apply to public access terminals.

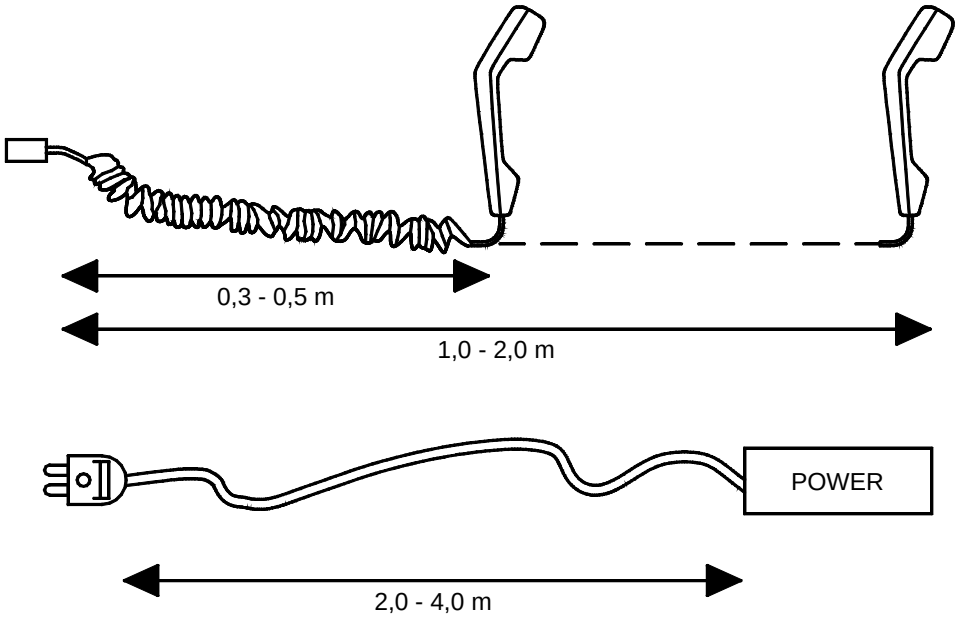


Figure 49: Recommended cord lengths

- Provide flexible cords to connect base units to the network and power sources. The length will depend on the expected location of the base unit and the resource outlets, usually a length in the range 2,0 m to 4,0 m is sufficient.
- Ensure that cables/cords are attached in a manner that means they cannot be disconnected accidentally by pulling, pushing or twisting.
- Ensure that cords will not get in the way when the handset is replaced.
- Ensure that the cord fixing, in conjunction with the handset position, is suitable for either left hand or right hand use.
- Use flexible cords to interconnect between terminal modules. The type and length should be determined by communication needs and the likely range of terminal installation arrangements that users might require. For example, keyboard to base unit cords for integrated terminals may need to be of the flexible coil type to meet the adjustability requirements, and allow users to position the keyboard in their preferred position.
- Consider the need to provide cable/cord storage facilities on terminal modules to keep excess cord safely stowed. If provided the cables/cords should be easy to access and stow and not require precision finger movements or excessive strength.
- Provide labels or other visual and tactile identifiers to enable users to distinguish between different cables/cords used on the same terminal modules, e.g. use connectors of different shapes and sizes.
- Ensure that all necessary cables/cords are supplied and packaged with the terminal before release to the customer, and identify and illustrate the interconnection of modules in the customer documentation.

Additional comments

There are specific requirements for all forms of cables used with public terminals. These include the style/construction of protective sheathing, the length and the design of the mounting points. In general, terminals sited in insecure public areas use short stainless steel reinforced handset cable and stainless steel cable mounting points.

10.2 Casework

(Console, Equipment Practice, Housing, Product Semantics)

The box or boxes that contain the electronics and/or mechanical components that constitute the product. The casework gives the product its distinctive shape and appearance. The casework provides an integral part of the user interface of the product, from the positioning of controls and displays (heights, angles, separation, etc.) to the presentation of on-product graphics (labels, user guidance), and the facilities to assist maintenance, ensure safety and minimize the effects of vandalism.

Cross references:

Adjustability; Casework Colour; Connectors; CRT Displays; Character Displays; Handset; Handset Cradles; Hookswitch; Labels; Maintenance; Paper Handling; Portability; Safety; Surface Finish; Videophones.

Recommendations:

- The primary consideration in the design of the casework, should be for the safety of the user. Requirements for user safety can be found in EN 60950 [2].
- As far as practical, ensure that the casework does not have any components that could be easily detached and swallowed by a young child. Components are considered detachable if children can grip them with their teeth or fingers and then can be detached by applying a tensile force of:
  - 50 N when the largest accessible dimension is less than or equal to 6 mm.
  - 90 N when the largest accessible dimension is greater than 6 mm.
- Where cooling vents are required these should be located to avoid the discharged air being directed at the user.
- Where possible the casework should be designed so as not to provide a finger-trap hazard to children. There should be no openings and gaps with dimensions greater than 5 mm and less than 12 mm, unless the depth is less than 10 mm. (Assembly holes with a diameter of up to 7 mm are acceptable.) (prCEN/TR 13387, see Bibliography).
- Avoid the use of materials that most commonly cause allergic reactions e.g. rubber, nickel particularly on parts of the casework that will be in contact with the user's skin.
- The second consideration in the design of the casework should be the functional requirements of the users, in particular people with special needs, as invariably this makes products more accessible to all users. These requirements should be based on a thorough knowledge of the tasks users need to perform and the capabilities of a broad range of users.
- The base of the casework must be non-slip so that the unit will not move while being used, for example when buttons are pressed, or if accidentally knocked or pulled. So, for example, a telephone that is not exclusively designed for fixed-mounting, should be provided with a non-slip base [128].
- Units designed for wall mounting should also be able to be used on a horizontal surface to allow for users who require a steady terminal [128].
- Space should be provided on the casework to enable the user to rest or steady their hands without accidentally operating the controls, this is particularly important for people with reduced muscular strength and people with uncoordinated movements [53].
- Where possible avoid the use of covers and lids that the user has to open during normal operation, if these must be used consider options that will make this easier for the user. For example, consider electronic operation or covers that remain attached to the product when opened so that they cannot easily be dropped or lost.
- The casework should be as small and compact as possible, but this must not compromise the size of controls and labelling or hamper any upgrading or maintenance that needs to be carried out [52].
- The casework of devices that are intended to be hand-held should be shaped so that it fits into the users hand as is easy to grip [128].

- Use matt rather than gloss surface finish to minimize glare.
- Labels and guidance on the casework should be clear and easy to read.
- Casework labels should be positioned above controls so that they are less likely to be obscured by the users' fingers.
- Embossed labels should not be used as the only method of labelling on the casework as the poor contrast makes them difficult to read. However, when used in addition to another method of labelling embossed labels can provide useful tactile feedback to people who have reduced vision [121].
- Consider providing simple step-by step guidance on the casework for tasks that require the user to perform a series of operations. These could be under a lid, for example where a tape is inserted on a telephone answering machine, or on a card which has a storage slot on the casework to avoid the card being lost.
- Provision should be made for the storage of any special tools that are required for day-to-day maintenance of the product in order that the tools do not get lost. There should be easy-access to the tools with clear labelling.
- If a battery compartment is part of the casework then it should be easily opened without requiring undue force or manipulation, but it must not open accidentally. Ensure that the batteries can be easily removed, either by providing adequate space for grip or a removal tape. Provide a clear indication of the orientation and, if necessary, the order of battery insertion, this indication should be in more than one mode e.g. visual and tactile.
- The casework should be easy to keep clean, not requiring special tools or materials. For example, casework with smooth contours and few recessed corners, particularly on the upper surface, will minimize the dirt traps.

Additional comments

There is a general rule for most product design that the shape and appearance of the product should give good indications about both its purpose and the way the user is expected to operate it. This sometimes goes under the generic name of "Product Semantics", and it includes ideas like "Don't make a phone look like a can of Cola, and then expect people to be able to use it first time", or "If a door just needs to be pulled to open, use a handle which is obviously for pulling, do not use one which suggests the door needs unlatching or pushing".

Form can be used to help identify the function of a new and unfamiliar product. There are opportunities to visually identify and clarify the purpose and operational procedure of a product by the sculptural elements of its shape.

- Use integrated instructions which go beyond the application of symbols and labels.
- Borrow descriptive functional details from diverse but well established intrinsic and learned functional stereotypes, to help instil a sense of familiar on the unfamiliar.
- Work towards a catalogue of broad and unambiguous forms that would comfortably "migrate" across product ranges without losing their functional meaning, e.g. paper handling elements, like insert slots, for photocopiers or printers, may be appropriate for facsimile equipment.

10.3 Casework Colour

(Surface Colour)

The colour of all surfaces and controls that the user will see during their normal operation of the product.

Cross references:

Casework; Surface Finish.

Recommendations

- In general, avoid using highly saturated colours across the majority of the casework (Brigham, 1986). Where possible, if a brightly coloured version of a product is being made to appeal to a certain sector of the market, then provide a more neutral or pastel version as well.
- Use a casework colour that contrasts with the controls on the casework [52].

- Avoid using bright red and blue close together in an area of high visual work loads, these colours have slightly different focal lengths.
- Avoid using very dark or very bright colours, keep the difference in average luminance between different visual task areas within a ratio of 10:1 (ISO 9241-3 [53]).
- If colour is used to code different areas of the casework, or to code different groups of controls etc., avoid using colours too close together in the visual spectrum. (Two or three subtle shades of a pastel colour may simply blur into one for many users).
- Avoid shades of blue, green and violet for conveying information - yellowing of the cornea with age interferes with the passage of blue light and can cause confusions between these shades.
- Use matt rather than gloss finishes in order to minimize glare (diffuse 15 % to 75 %, specular maximum 45 %) [54].

Additional comments:

Colour and finish are typically highly subjective issues of aesthetics and fashion.

It is not normally a human factors function to stipulate specific casework colours or state which are best, but rather to point out some potential problems to be avoided. As with controls, care must be taken to avoid those colour combinations which make identification more difficult for people who are colour-blind.

In general, where the casework is continually in the line of sight - as for example, with the casework surrounding a CRT screen, it is best to use light neutral colours that are restful to the eye. Very bright, saturated colours, and ones that clash can be both visually and psychologically disturbing. Bright colours can be used most effectively to provide highlighting, or when there is a need to attract attention as part of the task requirement e.g. to identify an emergency control, or emergency telephone.

10.4 Surface finish

(Casework Finish, Texture)

The physical appearance and feel of the exterior surfaces of the terminal or product which the user can see or touch during normal operations.

Cross references:

Casework; Casework Colour.

Recommendations:

- The surface finish should be matt rather than shiny to avoid glare (diffuse 15 % to 75 %, specular maximum 45 %) [54].
- On surfaces that users are intended to touch avoid the use of materials that cause an allergic reaction to users, e.g. rubber and nickel.
- The surface finish on areas that are intended to be held by the user should not be too slippery.
- The choice of surface finish should take account of the ease of cleaning of the surface. The surface should be easy to keep clean without the use of special tools or materials.
- If the casework includes a display, particularly for VDU based tasks, ensure the specular reflections of surfaces do not exceed 45 gloss units (silky matt) [54]) and the diffuse reflectance is between 15 % and 50 %.

Additional comments:

None.

10.5 Connectors

(Plugs, Sockets, Equipment Practice)

The plugs and sockets that enable sub-units and modules to be connected to provide full operation of the terminals in all their variants.

Cross references:

Cables, Casework.

Recommendations

- Fixed terminals should be able to be fully operational with no more than two connections to external services; one to the network and one, if required, to a power source, unless this recommendation will compromise electrical or network safety standards.
- The user should always be given adequate protection against electrical voltages in accordance with the requirements of EN 60950 [2].
- Ensure that all connections can be made using minimal dexterity.
- Where possible use a standard connector with a standard pin layout.
- Wherever practical, allow the connection to be made in any orientation, or in as many orientations as possible.
- If alignment is necessary, the plug or socket shall be provided with aligning pins or equivalent devices to aid in correct alignment and to prevent insertions in other than the correct position. Any alignment pins shall extend beyond the plugs electrical pins to ensure that alignment is correct before electrical connection is made [102].
- All plugs should be capable of connection and disconnection without the need for special tools, unless the connection should only be available to specified maintenance personnel.
- Consider the use of colour-coded connectors and sockets.
- Ensure that all connections can be made one-handed [121].
- Connectors should be shaped in such a way that an adequate finger grip is provided for people with large fingers or trembling hands [121].
- All sockets should be clearly labelled to indicate both the function of the socket and the insertion orientation. Additional embossed labels can be useful for people with visual impairment, but this method should not be used as the only method of labelling as it is difficult to see in poor lighting conditions because of the poor contrast.
- Provide clear feedback to the user to confirm that a plug or connector is firmly in place or correctly connected [121].
- Clearly mark the insertion point both visually and with a tactile marker. For example, in addition to clear labelling, provide a raised ridge around sockets and tactile indications for correct insertion direction. A funnel into the centre of the socket can also be used to help guide a plug into a socket [121].
- Where appropriate, provide a stable surface under the socket to allow people to steady their hands when inserting the plug.
- Make it impossible to connect a plug and socket incorrectly or to interconnect two modules the wrong way.
- Provide visual contrast between the insertion point and the rest of the device to make a more obvious target for the user to aim at.
- In order to facilitate removal of the plug provide sufficient space to allow for easy gripping, consider the use of pushbutton ejection or automatic ejection mechanisms.
- Use connectors that enable a good finger/thumb grip for connection/disconnection forces of 25 N or good finger wrap grip if these forces are exceeded.

- Ensure the connector area provides enough space so that each connector can be grasped firmly for connecting and disconnecting. Space between adjacent connectors or any adjacent obstruction shall be compatible with the size and shape of the plug and the necessary handling configuration. As guidance, the space around any plug should not be less than 25 mm (see figure 50), except where connectors can be removed in sequence, then the space can be restricted to 25 mm around 270° of the surround [102].

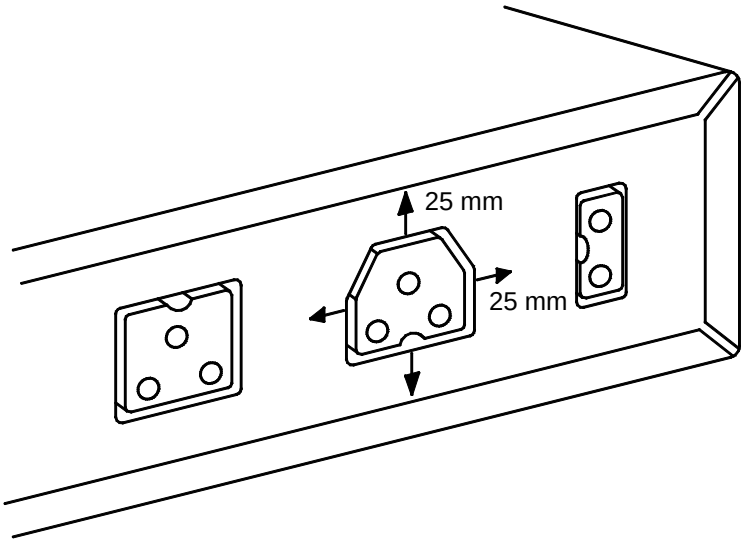


Figure 50: Recommended connector space

- In general, bayonet or clip type locking plugs are preferred to captive screw or screw thread types that require a tool or precise manipulation.
- It is a good practice to label plugs and their corresponding sockets (with text or recognizable symbols) and to co-ordinate the labelling to assist users in matching the required connections.
- Where sub-assemblies have to be removed for maintenance or exchange, these should plug in and not require hard wiring.

Additional comments:

There is an obvious opportunity to use shape and feel in connector design to differentiate between different plugs and their connectors. This becomes particularly important in the inter-connectability of different modules in a multi-media terminal, or in exchange modules for people with special needs.

10.6 Facsimile Machines

(Fax Terminals)

Transfer of digitized image between two machines to a standard format, e.g. ITU-T Group 3 and Group 4. This was traditionally done from paper to paper, but increasingly software files are being copied to be transferred in fax format, and transmitted faxes to be received and stored as software image files.

Cross references

Call Handling; Casework; Cables; Connectors; Input Components; Output Components; Paper Handling.

Recommendations:

There are no specific Human Factors recommendations in the available literature with respect to the design of facsimile equipment. However, when designing the input and output components follow the recommendations given in clauses 8.1 and 8.2 of the present document. When designing the system as a whole consider the human factors issues raised in clause 6 and consider the following principles:

- Incorporate as much flexibility as possible, for example consider the following:
  - provide the option to have visually displayed information and confirmation of actions available by voice synthesizer for people who have impaired vision
  - allow use of programmable function keys or use of a "default" mode
  - use pre-programmed buttons for common sequences
  - provide the facility to store frequently used numbers
  - allow entry of a short code to program a longer sequence
  - simplify required sequences, limiting the number of steps
  - arrange controls to indicate sequence of operation
  - provide memory cues or simple operating instructions on the device where possible e.g. provide guidance on which way up to place the original copy
  - cue required sequences of action
  - provide an easy exit that returns the user to the original starting point from any point in the program/sequence
  - eliminate timed responses (or make the times adjustable)
  - provide feedback to the user when the device is busy or "thinking."

Additional comments:

It will be appropriate for any new terminal design to be tested against expected usability criteria, ensuring that a "Design for All" philosophy is followed. In general, as users are less familiar with Fax operation than they are with normal call handling it is helpful to conform, as far as possible, to basic call handling stereotypes. (See Call Handling). Incorporating features such as voice-activation, short-cut keys and storing frequently used numbers is likely to improve the usability of facsimile equipment.

10.7 Handset

(Finger Clearance, Handset Design Template, Receiver, Telephone Receiver)

The standard telephone component which combines the earphone and microphone and is intended to be held close to the head to enable users to carry on a telephone conversation.

Cross references:

Cables; Handset Cradle; Hookswitch; Surface finish; Voice Transmission.

Recommendations

- ensure the handset provides inductive coupling compatible with a hearing aid (ETS 300 381 [31]).
- The weight of the handset should be within the range 150 g to 250 g, ideally 150 g to 175 g. The method of assessment is by weighing the handset with any cord attached at a height of 400 mm above the base unit (if appropriate).

- The balance of a conventional handset should be evenly distributed between the ear and mouthpiece If balance is not possible, then it is preferable that the microphone end is heavier than the earpiece end. This will not apply to small handsets which are intended to be held at the earpiece end. The balance is evaluated subjectively by observing how the balance feels when held in the hand.

- The shape of the handset should enable users to grip it comfortably, the width should be less than 44 mm. People with uncoordinated movement or reduced strength may find it difficult to hold if the shape is too round and smooth or if it is too wide or too small [128].

- The handset should have a profile which will fit comfortably to the user's ear and present the microphone close to the user's lips (see figure 51).

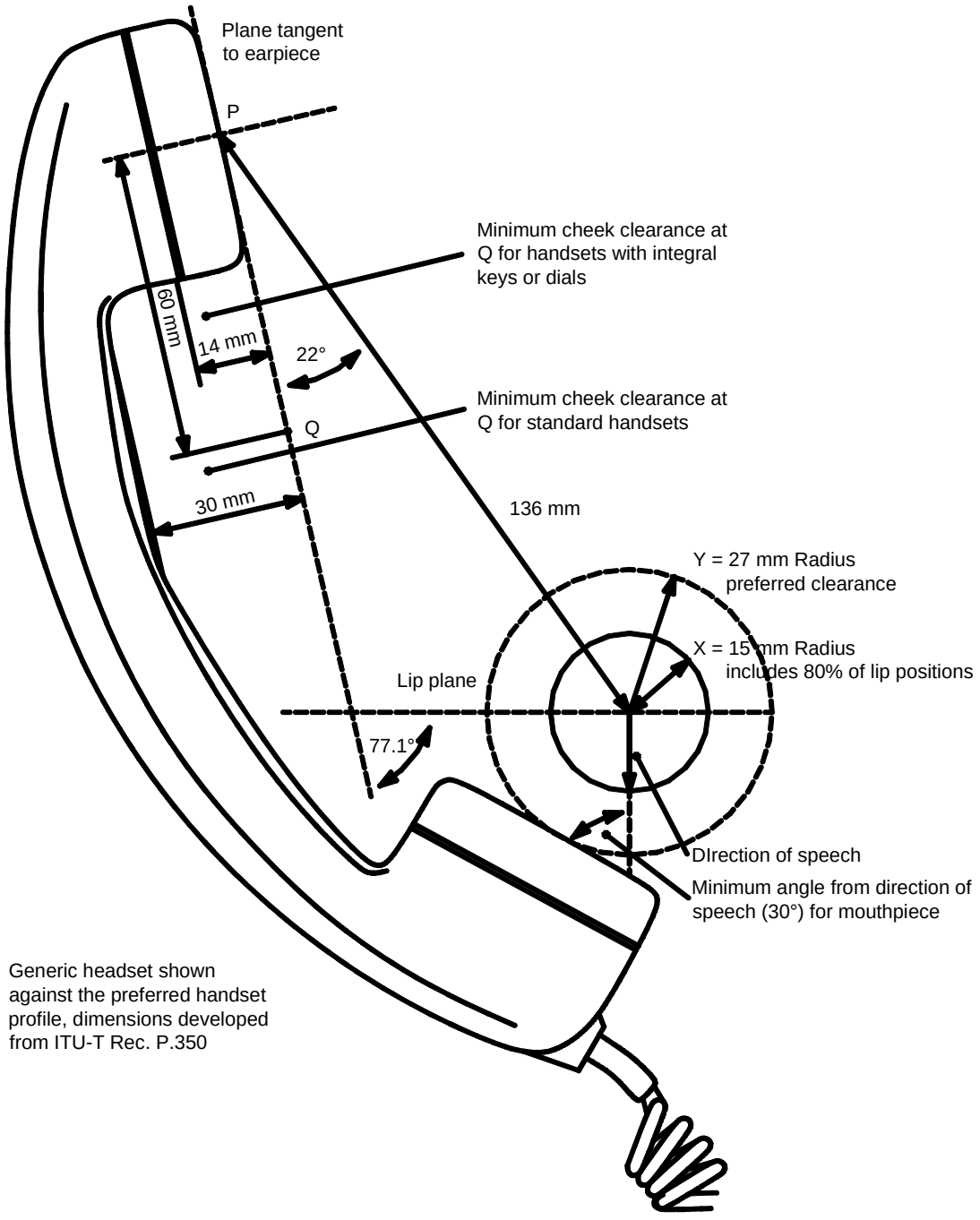


Figure 51: ITU-T preferred handset profile dimensions

- Ensure a sculptured earpiece is provided with suitable radiused curves to avoid sharp edges being presented to the pinna, and to avoid discomfort with the moving jaw bone when talking. The aim is to enable it to seal well and to prevent external noise interfering with the call.
- Provide an easy comfortable handhold area between the ear and mouthpiece, including enough space for the fingers of a person with large hands to wrap around and the handset to be held without the users fingers touching his/her cheeks.
- The handset should have a profile which presents the microphone close in front of the user's mouth taking account of a wide range of head sizes.
- Provide the mouthpiece with slots/holes or some other indication of where the microphone is located.
- Ensure the mouthpiece is outside of the lip circle (minimum radius, marked X, 15mm; preferred radius, marked Y, 27 mm).
- The handset profile should present sufficient clearance between the microphone and loudspeaker to enable fingers to wrap around it without touching the cheek or compromising the acoustic coupling with the pinna i.e. the outer folds of the ear [97], (see figure 51).
- Provide a handset profile which enables the frequent ear-shoulder "cupping" position, without undue lifting (abduction) of the shoulder as shown in figure 52, [105].

Figure 52: Ear-shoulder "cupping" position

- Ensure split lines (the join between two or more sections of the casework) within the handset moulding do not cause sharp edges or skin pinching.
- Ensure there are no catch points which may prevent a clean, single handed direct lift from the cradle.
- Ensure flex and connector point to handset, if provided, do not interfere with hand and finger positions. (See Cables).
- Ensure the optical reflectance values of the handset meet the requirements of other office equipment (diffuse 15 % to 75 % [53] specular maximum 45 gloss units (silky matt)) [54].
- Ensure any aerials provided within the handset are sited away from areas of the handset which are normally in contact with the human face or hands.
- Ensure any controls provided on the handset, e.g. volume control for the loudspeaker, or microphone mute, are within finger or thumb reach from the accepted handling positions, irrespective of the hand being used (left or right), when the handset is operational.

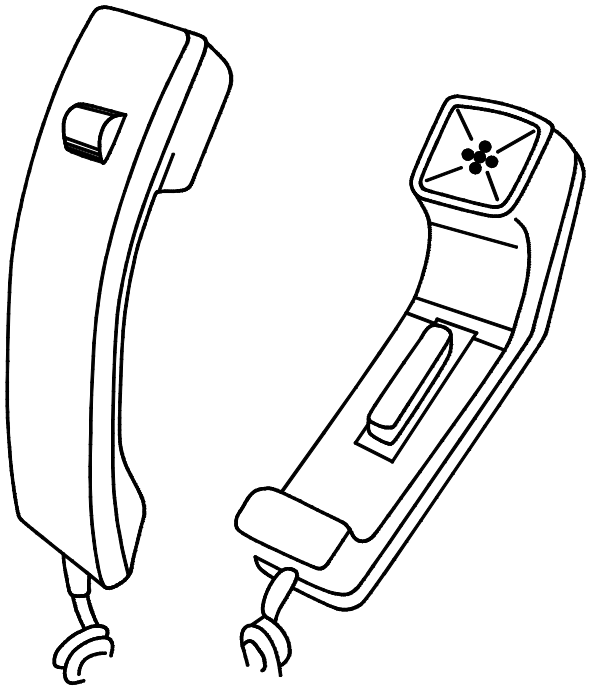


Figure 53: Example handset controls

Additional comments:

People with manual dexterity problems or reduced strength have difficulties when the keypad is positioned in the handset and they may press a key by mistake [128].

Give the handset a feel of quality and ensure the casework is robust and rigid and not susceptible to flexing and creaking when handled.

10.8 Handset Rest

(Finger Clearance, Handset Cradle)

That part of the casework which is designed to accommodate the handset during idle. Usually incorporates the hookswitch.

Cross references:

Handset; Hookswitch.

Recommendations:

- Provide for easy pick up and replacement of the handset by either hand.
- Ensure the pick up angle is at a comfortable angle for the wrist, maximum 5° to 10° abduction in any plane.
- Ensure there is adequate room for 95th percentile fingers to wrap around the handset to provide lift. Ensure there are no catch points (e.g. for fingernails) to prevent a clean, direct lift from the cradle to the ear single handed.

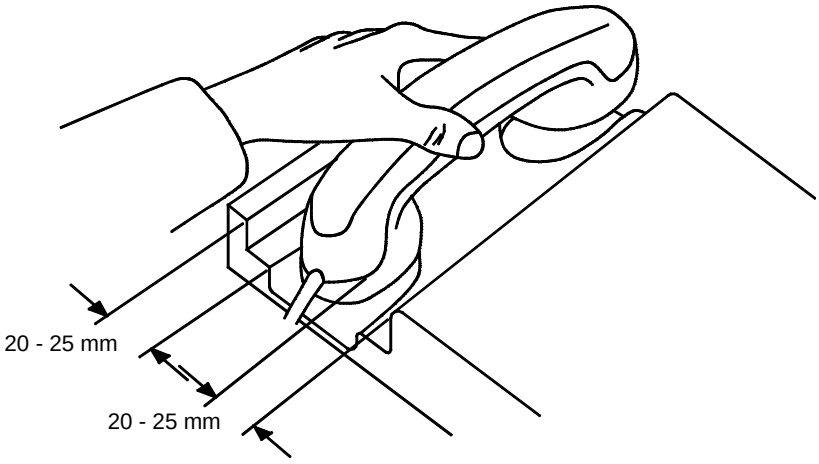


Figure 54: Finger clearance around handset

- Provide for easy and rapid replacement of the handset to the cradle with either hand, with good positive tactile feedback when the handset locates correctly.
- Ensure the handset relocates easily and correctly within the cradle under its own weight, provide guiding slopes to help guide the handset home.
- On portrait orientated handset cradles provide a good back stop at the rear of the cradle to prevent overshoot when the handset is replaced in a hurry.
- Avoid the use of locating pegs or similar devices which require precise detailed hand movements.
- Design the cradle so that the handset does not fall off easily during transportation.
- If the base is designed to be attached to the wall, ensure that there is a good lip to the front part of the cradle so that the handset can easily be supported in a near vertical position. When attached, the cradle angle should be at least 30º from the vertical. When the bracket is attached to the wall, make sure that the telephone can be hooked on to it easily without awkward hand movements.

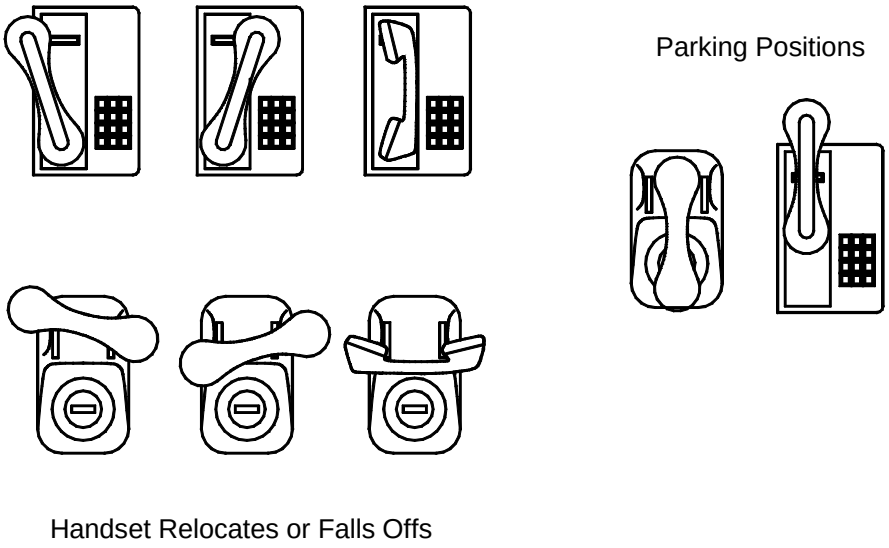


Figure 55: Example handset parking positions

Additional comments:

None.

10.9 Hookswitch

(Dial-in-handset, Handset/Handsfree Operation)

A switch to electronically connect and disconnect the terminal from the network, usually operated by lifting the handset or by replacement of the handset on the cradle. May be mechanical (operated by the weight of the handset), and/or sometimes non-mechanical, e.g. magnetic (operated by the proximity of the handset).

Cross references:

Call Handling; Handset; Handset Cradle.

Recommendations:

- If a magnetic or electronic hookswitch is employed, some other means should be provided for terminating a call prior to re-dialling, to avoid replacing the handset each time.
- If the hookswitch is provided within the cradle, ensure that it operates when the handset correctly locates under its own weight.
- If the hookswitch is provided within the cradle and the handset fails to locate correctly and fails to operate the hookswitch successfully, ensure that it is visually obvious that it is still off-hook, e.g. it will fall off the cradle.
- If the hookswitch is provided within the cradle, ensure it is accessible during a call, that it is obvious and presents a good target, to enable rapid cancelling of the current call and return of dial tone.
- If there is no handset cradle, the hookswitch should be provided within the primary area (the area most easily reached) of the main keyboard or control block, and be clearly labelled.
- If the terminal has a handset cradle hookswitch and an independent hookswitch (or control with a hookswitch function, e.g. Handsfree On/Off) then care should be taken to integrate the operation of the two hookswitches and to give clear indication to the user on the current state of the equipment. Ensure the control procedures for the terminals with two hookswitches (e.g. Handset and Handsfree) do not compromise user stereotypes. For example, users expect a single action to terminate a call, i.e. handset down or hookswitch on (Handsfree off).
- Terminals that require other procedures for initiating a call than lifting the handset off-hook to dial, must have an easily recognizable control, with standardized marking for both tactile and visual identification and simple acoustic prompts.

Additional comments:

Care should be taken in wall mounted and portable handset terminals on the siting of the hookswitch, to ensure calls are not ended accidentally, but at the same time enable easy access to recall dial tone quickly.

In the case of a Dial-in-handset - refers which contains the keypad and hookswitch, care needs to be taken that users are not able to terminate a call (go on-hook) accidentally.

10.10 Key Operated Switches

(Call Barring, Locks)

Control devices incorporating a lock with a removable key and used to prevent accidental or unauthorized change of the switch's state or setting.

Cross references:

Input Components; Security.

Recommendations:

- Use to lock a device in a particular state, setting or mode. Available with two or more switch positions, enabling the terminal to be locked in one of two or more settings.
- Use the key position to indicate the current setting, ensure there is no ambiguity in the keys positioning, i.e. the key is not in the same orientation for two different settings.
- Ensure that the function and settings of the control are clearly labelled.
- Use a key switch which provides a minimum of 30° but preferably 45° to 90° rotation between positions, which requires a torque of 0,1 Nm to 0,2 Nm and has a distinct tactile detent or indent at each position.

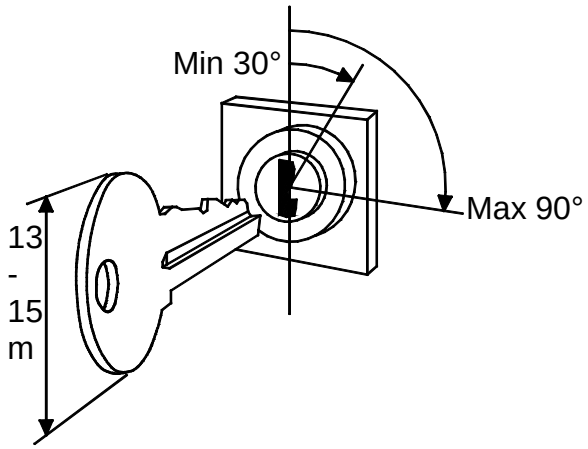


Figure 56: Example key operated switch

- Provide a stop at either end of the range of positions.
- Enable the removal of the key at the safe or lowest level position. This is usually in the vertical (or front to back) plane.
- Keys which can be entered into the lock with either side up or forward are preferred. Tumbler action keys (Yale ® or similar) which have a single orientation should have their teeth or similar, pointing up or forward to be inserted [102]. Conventional lever action keys are normally inserted with the "teeth" pointing downwards or backwards.

Additional comments:

None.

10.11 Payment Facilities (coins and paper money)

(Coin handling, Note handling)

The methods used to pay for goods and services. Electronic payment methods are covered in the relevant sections in Input Components.

Cross references:

Casework; Input components; Smart cards; Machine-readable cards; Contactless cards; Call handling.

Recommendations:

- Locate any coin/note slots within easy reach of a user's arm, taking account of people of shorter than average stature, wheelchair users and, where appropriate, children. Where possible, locate any coin/note insertion slots in such a way that coins can be inserted using a personal tool, or in an emergency, directly by mouth.

- Provide the facility to pre-feed coins so that people who wish to use this facility do not have to worry about feeding coins during a call.
- Provide the option to have the information about the amount of money that needs to be inserted in auditory as well as visual mode.
- Insertion slots should be identifiable both visually and by tactile identifiers. Where both electronic and coin/note payment methods are included it must be very easy for the user to identify both visually and by touch which slots are intended for which method of payment.
- There should be both visual and tactile identification information on the accepted coin/note denominations [10].
- Insertion slots should be funnel shaped to guide the coin into place [53].
- Where possible the need to insert notes should be avoided as these present more problems to users. However, if notes have to be inserted there should be clear indication of the correct orientation required.
- Procedures for paying must be simple and standardized. Any instructions should be available in more than one mode e.g. visual and audio and extremely simple to comprehend.
- The method for return of unused coins should be simple, for example a "return coin' button. The preferred position of the button is immediately to the right of the coin insertion slot, but not too close to prevent inadvertent operation [52].
- The return slot should be designed so that it is easy for the user to grasp the coins, but so that it prevents coins dropping onto the floor [52].

Additional comments:

Although most domestic telephones do not use coins or cards, payphones are often used in retirement homes and in unfamiliar locations such as hotels.

Whatever payment method is used, electronic or coin/note, all costs must be transparent to the user. Cost information should be provided in a clear and easy to understand manner.

10.12 Portable and Mobile equipment

Portability, Mobility

Portable equipment can be picked up and carried, to be relocated but is not intended to be held during normal use. Mobile equipment is intended to be used while it is being held in the hand.

Cross references:

Hand sizes.

Recommendations:

Units that may need to be moved occasionally

- Where possible make the device compact and light enough for one person to lift and carry short distances, 16 kg maximum [102].
- Consider the requirements for lifting and carrying devices, for example, as part of normal installation, and provide carrying points or handles large enough to accommodate 95th percentile fingers or hands, using the anthropometric data for the target user population, with recesses, grooves or textured surface to aid gripping [102].
- Position carrying points or handles over, or symmetrically distributed to the sides of, the units centre of gravity, to ensure stable, clean lifting.

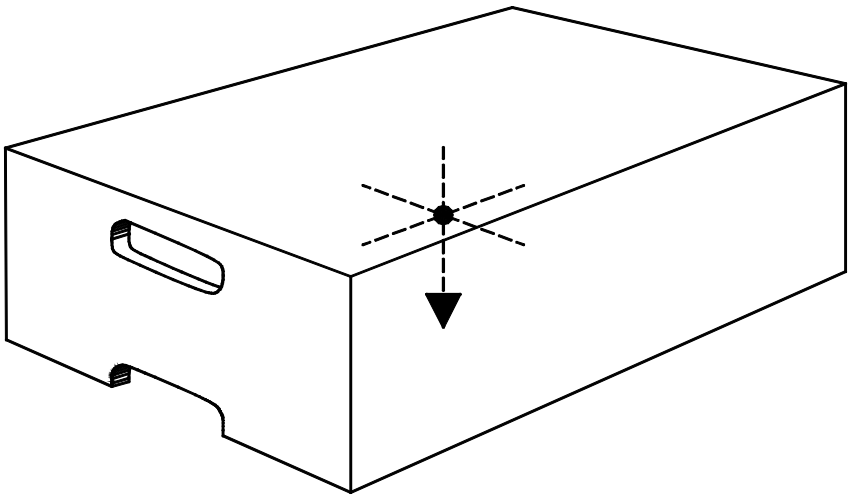


Figure 57: Handholds in relation to centre of gravity

Units that are intended to be moved around but not used while being held:

- The weight of a unit such as a telephone that is intended to be moved around should be less than 925 g, and ideally approximately 375 g. If a telephone is much lighter than this it may skid too easily during dialling. The weight includes the handset and cord.
- It should be possible to grip and carry a unit around with one hand without elements falling off, e.g. it should be possible to carry a telephone around with one hand without the handset falling off easily.

Units that are intended to be used while being held in the hand:

- Fully portable terminals should be as light as possible, preferably less than 280 g [103].
- If the unit is intended to be held to the ear, e.g. a mobile phone, the circumference where grasped should not exceed 18 cm [103].
- Controls should not intrude into the main handling area, which should be contoured to present a comfortable surface.
- Hand held equipment should have the centre of gravity close to the approximate centre of the casework, to ensure it is well balanced when handled.
- Ensure the unit maintains a stable position when it is operated on a desk top or in a holder. Make sure it has four points of contact if the base is not flat.
- If the terminal is designed to be carried in the pocket or a pouch, its surface should not have any projections likely to snag, or any controls that can be inadvertently operated when storing/accessing the equipment.

Figure 58: Smooth sided pocket terminal

- Provide a mechanism for relocating misplaced portable terminals, e.g. an acoustic signal triggered from a base unit.

Additional comments:

More than a quarter of all reported industrial accidents are associated with manual handling. There are also a very significant number of working days lost each year through back pain, frequently caused by the inappropriate lifting of manual loads. The European Directive 90/269/EEC [137] lays down some very basic guidance on how some of these problems can be avoided. The provision of proper handholds and the limiting of the overall weight of separate terminal modules could go some way to helping alleviate this situation.

10.13 Videophones

(Codec)

Cross references:

Call Handling; Cameras; Casework; Input components; Output components; Screens.

Recommendations:

A videotelephone combines audio telephony with video capability. The basic set-up for videophone communications requires at least one monitor, a camera, an audio connection and some form of input device, all of which can be integrated in the form of a dedicated terminal, a PC, or a multimedia terminal.

ETR 297 [20] provides a comprehensive guide to the Human Factors issues related to the design of videotelephony terminals and the man-machine interface necessary for the access to services and the control of tasks involved in videotelephony.

Recommendations for the individual input and output devices are contained in the relevant clauses 8.1 and 8.2, the purpose of this clause is to provide information about the human requirements of the complete system.

- Design the videophone in accordance with the Human Factors issues raised in ETR 297 [20] and ETR 175 [17], and to comply with the relevant European standards (see ETS 300 143 [23],ETS 300 145 [24], ETS 300 264 [25], ETS 300 266 [26], ETS 300 267 [27], I-ETS 300 302 [28], ETS 300 303 [29], ETS 300 375 [30], I-ETS 300 442 [32], I-ETS 300 654 [34] and EN 301 462 [6]).

- Design the videotelephone to be easy to use and to ensure the privacy of the users.

- Design the procedures and equipment to be consistent wit current and future audio telephony procedures and equipment.

Call control functions

In order to make the service safe and simple to use the following control functions should be provided:

- On/off hook and dialling function i.e. call set-up function.

- The facility for the user to control the service mode. (See ETR 297 [20] for further details.) The user procedures for control of the service mode should follow the following principles:

    - the user should be able to select a service mode from a limited set with not more than five or six modes; this simplifies the dialogue;

    - the active mode should be indicated to both calling and called user;

    - the user should be guided to set the default service mode for incoming and outgoing calls to be the same. There is evidence that users get confused if, for example, the default service mode on incoming calls is audio-only (to ensure privacy) and on outgoing calls is audio-visual;

    - for the preservation of privacy, users should be able to recognize an incoming call as being in video mode before they answer the call;

    - both the calling and called user may change the service mode at any time during a call. Any increase in cost should be charged to the person requiring the service mode change;

  - an indication that the selected mode is not possible should be given if the user selects a mode which is not supported by the other side, or if the called user selects a mode which would increase the cost of the call. The same indication should be given in both cases to make the procedure appear symmetrical with respect to calling and called user;
  - it should be possible to change service mode (e.g. upgrading from one to two channels to improve video quality) during a call without having to terminate the call;
  - it should be possible to select one of the modes in the set as a default mode to be active whenever a call starts. In this way, consistency with telephony call set-up procedures can be kept as the user does not have to take an active part in the initial service mode negotiation procedure (see previous clause), i.e. the user does not have to select service mode in every call set-up phase.

- Ensure the user's privacy by providing the called user an indication of the mode of the incoming call, this indication should be in both a visual and audio mode.
- Enable the user to control the output mode, for example provide an easy-to-use camera on/off function which could be a mechanical shutter pushed by the user in front of the optic of the camera.
- Provide the user with a self-view facility to ensure they have a presentable image. Ideally, self-view should display continuously, but if this is not possible it should be able to be selected at any time, on or off-hook or during a call. The self-view facility should have no effect on the outgoing video.
- In videophones with a single fixed camera system, self-view should be displayed in mirror image form to comply with user expectations of movement direction, and in coded form to enable checking of the transmitted image quality. If manual focus is provided, it is recommended that focusing is available on the uncoded image to remove the codec delay and to optimize sharp edges to achieve best focus.
- Ideally ensure that a head and torso image be captured. The camera field of view at the nearest point of the preferred viewing range should provide at least head and shoulders image. Accommodate the range of different eye heights for the sitting/standing users within the camera's field of view. It is recommended that this is done by enabling the camera system's focal plane to be adjusted vertically.
- The positioning of the screen should be user adjustable in order to accommodate the range of eye heights of the users and to avoid screen reflections. It is recommended that tilt adjustment be provided, swivel and vertical adjustment are desirable.
- Users should be provided with clear instructions on basic lighting and background requirements within the user documentation.
- Three audio functions should normally be provided: hands-free mode; normal handset mode; loudspeaking i.e. handset mode augmented by loudspeaker listening. The hands-free mode is usually the preferred mode. (ETR 297 [20] contains more detailed information).
- To ensure user privacy, the videotelephone should be equipped with a mute - a control for switching the transmission of the local microphone on and off.
- Ensure synchronization between the displayed audio and visual signals, the total round-trip delay should not exceed 800 ms unless under the most exceptional circumstances. To preserve lip synchronization, the delay difference between sound and vision channels should not exceed 40ms when the sound arrives after the vision, or 20 ms when the sound arrives before the vision.

Additional comments:

Videotelephony is very important for some groups of people with disabilities. People who are pre-lingually deaf often use sign language or lip reading, which give adequate picture quality, can be achieved using videotelephones. Another application is remote sign language interpretation. Instead of an interpreter having to come to a certain location a video connection can be established and the interpretation made.

11 Additional service specific guidelines

11.1 Addresses

(Telephone Numbers)

The expression used to describe the string of alphanumeric characters and symbols required to dial a call, or refer to a subscriber number. Addresses used for a wide range of telecommunications services (voice, facsimile, telex, videophony) are principally numeric, whereas data communications addresses, e.g. electronic mail boxes, are commonly alphanumeric, and may include other conventional keyboard symbols.

Cross references:

Call Handling; Dialling.

Recommendations:

- Use the ITU-T preferred format for all printed forms of national and international numbers (ITU-T Recommendation E.123 [70]). The international number should be printed below the national number with the digits lined up one under the other to facilitate understanding of the composition of the international number as shown:

Telephone	National	(0607) 123 4567
	International	+ 22 607 123 4567

Where it is desired to save space to accommodate the printing of several different numbers e.g. for FAX or mobile as well as the ordinary number, each number should be printed as a short label (e.g. tel) followed by the number in the desired national or international format. In this case the words "National" and "International" should be omitted.

Tel	(0607) 123 4567
Fax	(0607) 123 4567
Mobile	(0607) 321 9867

Or

Tel	+22 607 123 4567
Fax	+22 607 123 4567
Mobile	+22 607 321 9867

To show an extension number of a PABX without direct dialling inwards, the nationally used word or abbreviation for "extension" should be written immediately after the telephone numbers as shown:

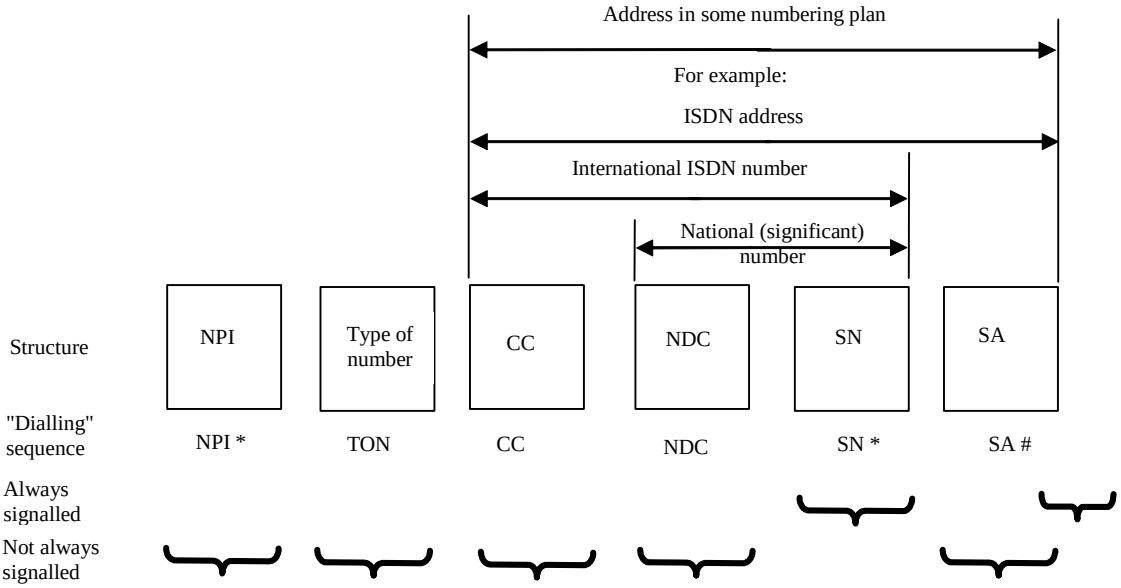
Telephone International +22 607 123 4567 ext. 876

An electronic mail address, if present, should be printed in the SMTP style below the telephone number information. A web address should be printed without the prefix http://:

Telephone:	National	(0607) 123 4567
	International	+22 607 123 4567
E-mail:		jdoe@isp.com
Web:		www.doecorp.com

Additional comments:

Consideration may also be necessary of ITU-T Recommendation E.331 [82] if the terminal may be used within a private or similar numbering plan environment (see figure 59).



CC Country code
NDC National destination code
NPI Numbering plan identification
SA Sub-address
SN Subscriber number
TON Type of number
[a] For the terminating #, "always signalled" means either that the # is signalled, or that the termination of dialling is deduced by a terminal or switch.

NOTE: It would be seldom, if ever, that every part of this sequence were input for a single connection.

Figure 59: ITU-T recommended ISDN address format

11.2 Call Handling

(Call Set-up, Call Terminate, Outgoing Call, User Procedures)

Call handling refers particularly to the procedures which the user needs to complete in order to set up, control and terminate a call from their terminal via the network to another terminal.

Cross references:

Acoustic Signals; Addresses; Communication and Transmission; Feedback.

Recommendations:

- The call set-up, control and termination dialogues should require the minimum possible user actions and the minimal memory load.
- Basic call handling procedures for voice calls should support user stereotypes and expectations by remaining consistent to existing user models of telephone operation.

Outgoing Calls	
State	Idle
Control action	Go off-hook
Indication	Dial tone
Control action	Dial number
Indication	Dialled number
Indication	Ring tone
State	Connection

Incoming Calls	
State	Idle
Indication	Ring signal
Control action	Go off-hook
Indication	Cease ring signal
State	Connection

Terminating Calls	
State	Connection
Control action	Go on-hook
Indication	Handset or key position
State	Idle

Figure 60: Basic call handling sequence examples

- Novice and casual users should be guided through the basic level of call control using visual display, voice or on-product graphics. At least two modes should be available.
- Enable users to dial during call set-up using "overlap" or "en bloc" dialling. Ensure that "en bloc" dialling (where the user inputs the address, and can edit it, before going off-hook) is supported with a basic numeric display and with last digit editing facilities.
- Prevent time-outs at the start of dialling and/or at inter-digit intervals from affecting people who key slowly (because of motor or cognitive impairment). This should include time-outs when accessing secondary networks.
- In applications where some users may be frequent or skilled, the interaction should allow for time-saving short-cuts, e.g. programmable direct dial keys (with auto off-hook), short code dialling or alphabetic directory.
- The terminal and network should provide clear feedback on the progress of the call, through the use of auditory and visual displays. (See Acoustic Signals).
- Call failure due to user error, terminal and system faults, or congestion should be clearly indicated and options for error recovery or indication of duration of fault condition should be provided.

Additional comments:

Users need to be able to make, receive and terminate calls with minimum training and without making errors, especially for voice communications (telephony), but preferably irrespective of the communication media.

Research has shown that users often have incomplete and inaccurate models of how the telephone and the telephone network operates. These limitations in user models lead to confusions and errors with more complex procedures such as multi-party calls, e.g. call waiting, call transfer, hold and enquiry, etc.; and also in more ordinary scenarios, e.g. loss of dial tone. The design of call procedures needs to offer support and guidance to direct the user towards the correct procedure, and to reduce the risk of errors that lead to rejection of all or parts of the system capabilities. Suppliers should test their chosen procedures with representative users, and should consider a stringent success criteria, e.g. at least 80 % success on the first exposure, 90 % on the second.

To give guidance to the developers of call handling procedures for new services, a set of twelve General Rules for User Control Procedures and a set of six Generic User Procedures have been developed by ETSI in ETR 170 [16] and are reproduced in table 21. User procedures designers should also consider ETR 198 [18], ITU-T Recommendation Q.931 [98], ITU-T Recommendation E.134 [73].

Table 21: Twelve general rules for user control procedures

1	A user procedure comprises a sequence of user control actions and equipment display indications targeted to enable completion of a user's task or sub-task.
2	Every control action requires a clear indication of the status of the system and of the control before the action, and a clear indication (feedback) of the change in status of the control and the system after the action.
3	A user control action is necessary to initiate and complete any task or sub-task. A single action may complete one task and initiate a new task, if the action is explicit in both tasks. Similarly, a single action may complete a number of nested or parallel tasks, if the action and the corresponding indication explicitly confirms the multiple effect.
4	Any change of status of the system (terminal, network, remote terminal) that affects the user's interaction with the system shall be indicated to the user. Interruptions to a user's task that are initiated by the system (including a remote user's actions) should accommodate the current task, and facilitate the user's choice over the available options.
5	All indications to the user whether static or transitory, shall be appropriate, discriminable, comprehensible and timely, within the range of physical and mental capabilities of the possible user population (with due reference to people with special needs).
6	All control actions required to operate the system shall be within the range of the physical and mental capabilities of the possible user population (with due reference to people with special needs).
7	No indication, control action or status of the system should threaten the physical or mental well-being of the possible user population.
8	Any procedure necessary to complete a task (or sub-task) should be concise, consistent, comprehensible and complete; commensurate with minimum user errors and congruent with targeted user preference levels.
9	Any set of procedures which relate to a set of tasks (or sub-tasks) shall demonstrate the qualities of consistency, flexibility, compatibility, self-explanation and user task orientation, to support the user's modelling or comprehension of the tasks and the system.
10	All procedures should support a simple and comprehensive error recovery strategy to enable the user to backtrack and/or exit from erroneous control actions. As far as possible, error recovery should not be penalized by any loss of data or of the communication path.
11	New procedures should be tested by a representative sample of people drawn from the possible user population (with reference to people with special needs) and evaluated against previously established criteria of usability.
12	Disregard any or all of the above rules in the interests of developing user control procedures and user interfaces which have a proven higher level of usability.

The call handling procedures are shown in the form of a state diagram in figure 61 which has:

- "Incoming" and "Outgoing" call sections that are intended to accommodate both single and multi-service terminals (public or private);
- a "Generic Change" section that is intended to enable any status change the user may require, e.g. Change of Teleservice.

The diagram also covers the termination of calls.

The outgoing call statechart in figure 62 provides the detail of the "Outgoing" section of the state chart of figure 61.

The state diagram is based upon the Universal Modelling Language (UML) [nnn] "State Diagram". A total of 8 states that are of significance to users are identified.

Each transition between states in the diagram is activated when either a user performs an action, some event in the network occurs or some other condition occurs. The conditions on these transitions are labelled as follows:

- "/UC = x" - when the user operates control "x" the transition will occur;
- "/UE = x" - when the user enters the "x" data the transition will occur;
- "/US = x" - when the user selects "x" from a list of options the transition will occur;
- "N = x" - when network event "x" occurs the transition will occur;
- "[x]" - when the "guard condition" "x" is true the transition will occur.

The controls shown in figures 61 and 62 include a "Start" and a "Stop" control. These are typically provided by a handset switch-hook function that is activated when the handset is lifted and replaced. However, figures 61 and 62 express these functions sufficiently generically that buttons can be provided to control the "Start" and "Stop" functions on "handsfree" terminals. Entry of "address data" in figure 62 will normally be digits input by the user using a 12-key keypad.

For each state there is a range of information that users need to know. This information is presented in figure 63. For each state there is a table in figure 63 and the table contains information coded as follows:

- P: Prompt for user action;
- CF: Feedback on the result of a control action;
- TSF: Current Teleservice feedback;
- NSF: Current network status feedback.

Dependant on the size of any visual display (number of lines) and the range of other types of feedback mechanisms available (e.g. lamps associated with controls and audio feedback), it may be possible to display most or all of the information items. In other circumstances the display capabilities may be restricted to as few as one item. In figure 5 the most important item of information has been highlighted in bold text. Where it is likely that it will be possible to display two of the feedback items using different modalities (e.g. visually and audibly) two items have been highlighted in bold text. There is merit in displaying some of the feedback to users through more than one modality simultaneously. For example, network status can be displayed audibly (with network originated tones) and also visually through terminal generated status messages.

The "Current Teleservice" (TSF) item in the tables in figure 63 is only required if the terminal and networks support multiple teleservices. In other circumstances this item can be omitted. It should also be noted that the status changing part of figure 61 (Generic change) would be used to enable the user to change Teleservice using a "Change Teleservice".

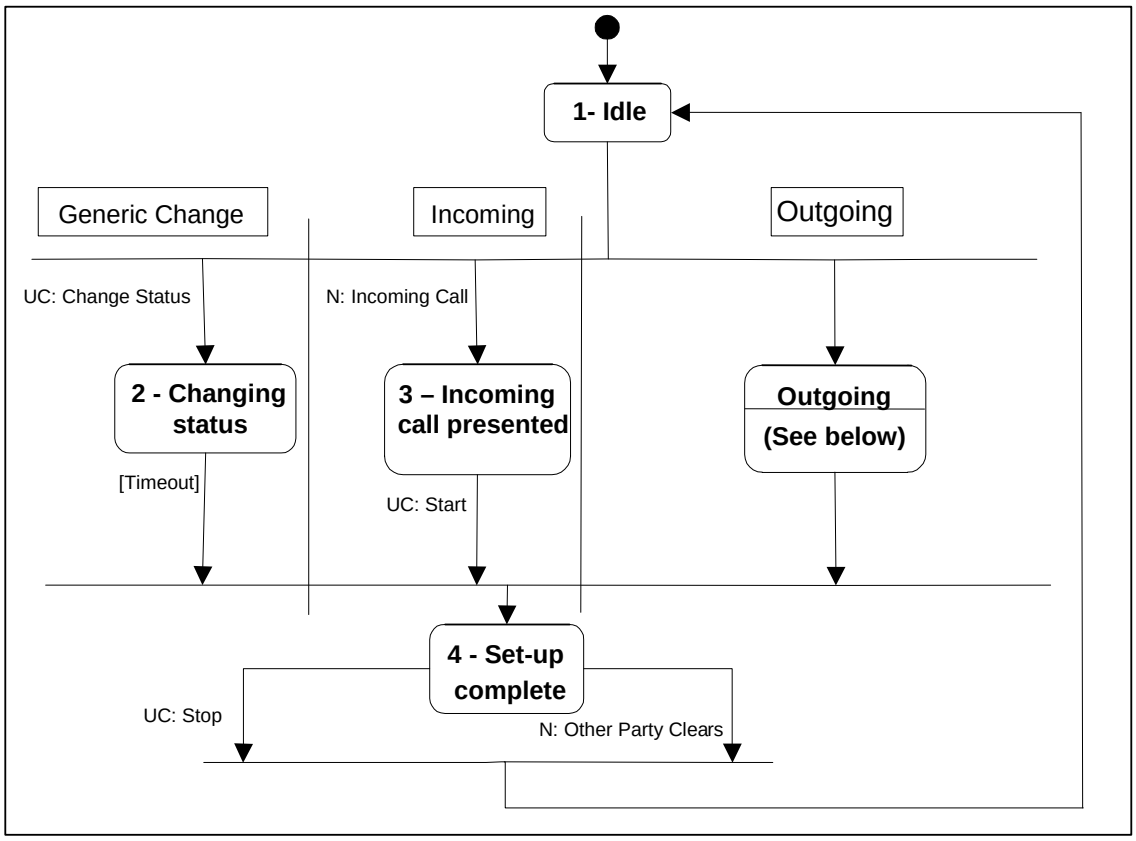


Figure 61: Call handling state chart

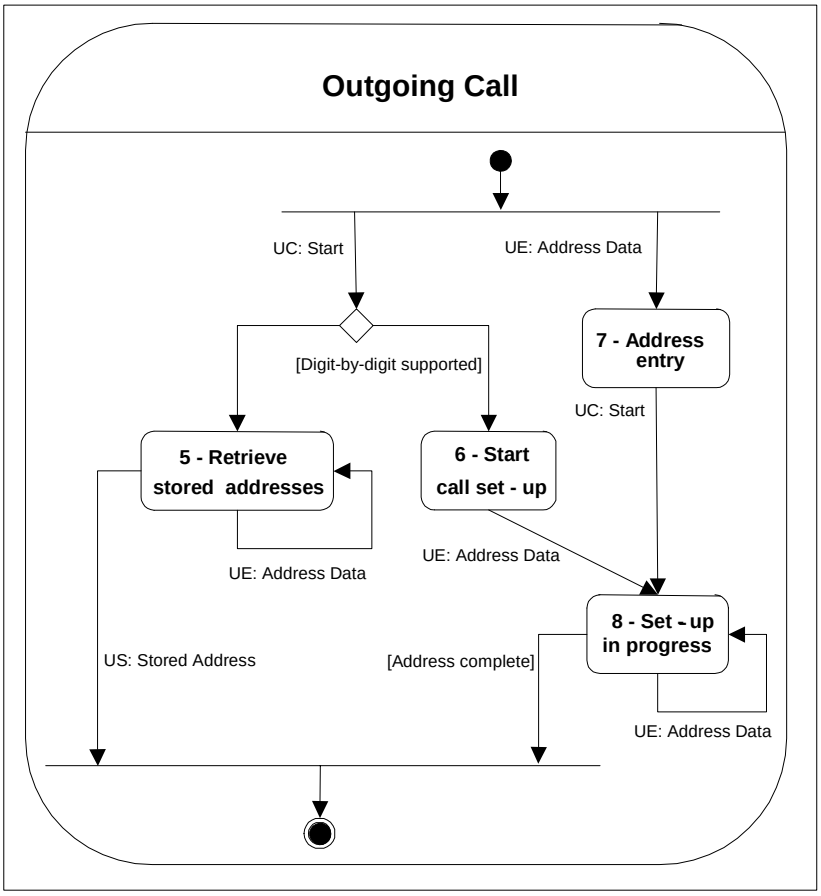


Figure 62: Outgoing call state chart

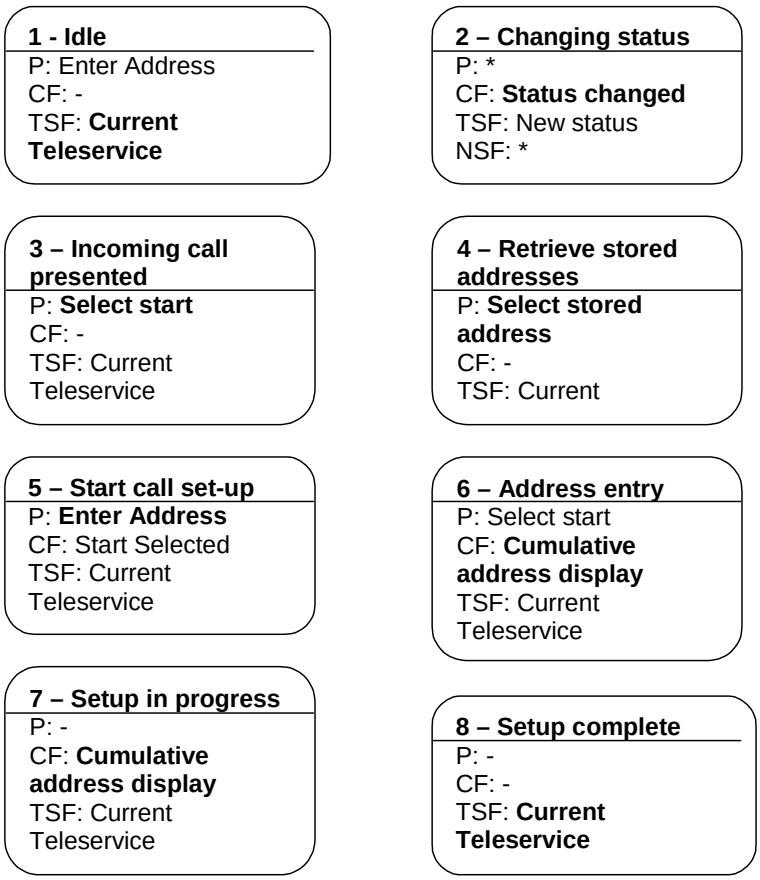


Figure 63: Indications for each state

11.3 Communication and Transmission

(Bearer Services, Teleservices)

The technical facility to transmit and receive voice, data, pictures and images between terminals across the ISDN, PSTN or other networks.

Cross references:

Call Handling; Data Transmission; Facsimile Machine; Security; Supplementary Services; Voice Transmission.

Recommendations:

- Maximize the quality of all transmissions, commensurate with human perceptual limitations.
- Aim to provide all transmissions within "real" time, i.e. minimize transmission delays which interfere with "natural" communication.
- Provide feedback on the reasons, time to correct, and other alternatives for breakdowns in transmission, or network failures and errors.

Additional comments:

The purpose of a network and its associated terminals, products and applications is to allow people to communicate with each other by voice, data and images. Each media may be used independently, but increasingly it is expected that users will want to use integrated multimedia communication sessions, e.g. videophony, or integrated voice and dynamic images. A network will increasingly enable users to explore a vast range of supplementary services and applications, both locally and remotely implemented.

The recommendations given in the cross referenced entries aim to:

- Ensure current communication and transmission quality standards for voice, data and images or pictures are at least maintained and preferably improved upon.
- Give an acceptable minimum standard of procedural compatibility to allow the widest possible range of users to set up and release calls with minimal training, irrespective of the media of communication.
- Encourage optimal (user-task related) new developments, including video-conferencing, and multimedia terminals.
- Improve the acceptance and usability of supplementary services and applications, both locally and remotely implemented.

11.4 Data Transmission

(Modems)

Data transmission is the transfer of digital information across the network from terminal to terminal, or terminal to server. It includes e-mail, document file transfers (Modem, Fax, Telex, Teletex), interactive working (remote access to terminals or databases), data element of voice plus data (electronic shopping), and accessing bulletin boards.

Cross references:

Communication and Transmission; Security; Voice Transmission, the Internet.

Recommendations:

- Call handling procedures for data transmission, e.g. electronic mail systems, should have message addressing which is flexible, and allows full user control; including allowing for single and multiple addressing, use of distribution lists, and reply to message received.
- Within data transmission dialogues try to minimize user's memory load and shorten procedures. Providing standardized forms, pre-formatted letters, automatic address headers may be helpful.
- Initiating transmissions - as far as possible the technical details of communication protocols, computer handshaking, data format conversion etc. should be handled automatically by the terminal.
- Users should have flexibility to select user initiated and computer initiated transmission, with queuing and queue priority.
- The terminal and network should provide feedback of success or failure of data transmission, and provide for record keeping of data transferred.
- During interactive live data transfers users should receive immediate feedback of own control input or keystrokes, and feedback messages where unavoidable transmission delays occur.

Additional comments:

The following types of services have been identified that might be offered using broadband ISDN:

- Interactive high speed data transmission, during which two or more users can exchange information.
- Messaging using a message service to store and forward data and images on demand.
- Retrieval where users can demand information from an information centre or large data base.
- Non-interactive distribution where information is distributed or broadcast from a central source for example, a broadband videotex.

Special consideration is needed of the user requirements for each of these services. In each case the needs and demands of the user will be largely specific to the application.

The more general requirements are:

- The services should be easy to use with minimal training. This means that where possible the set up, control and terminate procedures should be intuitive and compatible with other similar systems.
- The system should guide the user through the procedures keeping the number of keystrokes and memory load to a minimum. This means that additional signalling protocols may need to be defined between the terminal and the network to allow for additional user information.
- The system should be tolerant of errors and aid error recovery.

11.5 Dialling

The action of inputting the target address to the network of a known terminal to establish the wanted connection. It may be completed by keypad, using single digit-by-digit entry, or by short code entry, from an auto-dialler, or from an electronic directory.

Cross references:

Addresses; Call Handling; Telephone Keypads.

Recommendations:

- Ensure that all terminals intended for connection to the fixed telecommunications network fully support "overlap" dialling, i.e. where after going off-hook the user inputs the address digit by digit.
- In general, all terminals should also fully support the "en bloc" form of dialling, where the user inputs the address, and can edit it, before going off-hook. When using the "en bloc" form of dialling there is a minimum requirement for a small numeric display and a control to delete the last digit.

Additional comments:

In general, people have a limited ability to remember long numeric strings. It is desirable to reduce memory load, for example, by offering abbreviated dialling, or directory facilities to store frequently used addresses.

Error rates when entering long strings of alphanumeric characters may be high, and it is helpful to provide visual feedback and to allow simple error correction.

11.6 Phone-based Interfaces

(Analogue Display Services Interface (ADSI), Code Schemes, Stimulus Protocols, Short Message Service (SMS))

Many of the services offered via modern networks can be initiated from a standard telephone, from which the only control entry keys are the 10 numeric keys, * (star) and # (square or hash).

Cross references:

Acoustic Signals; Auditory Displays; Auditory Menus; Speech Output; Supplementary Services; Telephone Keypads; User Dialogue Design Principles.

Recommendations:

- As a minimum, provide tones as feedback to confirm entries and indicate error states. Preferably provide voice messages and speech output to identify services and to give prompts to help the user through the procedures and activities.
- Numeric data entry is preferable to alphabetic data. If alphabetic data is necessary, avoid shift functions on the numeric keys, use the ITU-T preferred alpha key arrangement (see ITU-T Recommendation E.161 [76]).
- Minimize opportunities for user error by keeping data entry strings short and simple, and allowing for error correction.

- Allow "cut through", whereby users can enter required commands without having to wait for the full message. An exception to this is where a service is unavailable and the user needs to receive explicit information.
- Clearly distinguish between menu options and commands. Offer commands to access help, language selection, back step and main menu, preferably available at all times in the dialogue.
- Offer prompts if the user fails to respond.
- Allow user to interrupt and cancel current activity and transaction.

Additional comments:

The ITU-T Recommendation F.902 [84] offers guidelines on the design of interactive services and a separate set of guidelines for the design of Minimum Phone-based User Interfaces exists in ETSI ETR 096 [13]). A definition of a minimum man machine interface for the access and control of public network services is contained in ETS 300 738 [35]; ISO/IEC 13714 [75] provides design guidelines for Voice Messaging systems and ETR 329 [21] deals with all kinds of stored voice services and with Universal Personal Telecommunications.

There are a growing number of services able to be accessed from the 12 key telephone pad. A simple taxonomy subdivides these services into Access, Messaging, Transaction and Information Retrieval.

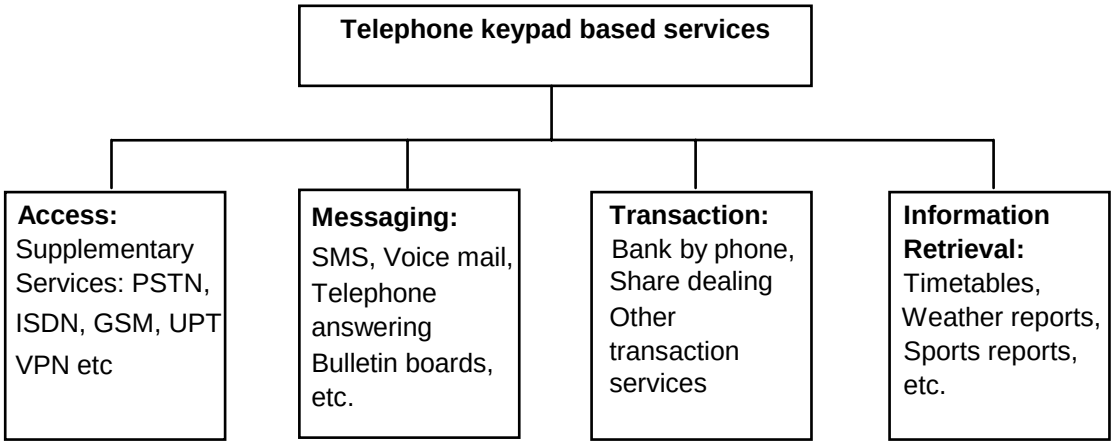


Figure 64: Taxonomy of phone-based services

Although the phone based interface will ensure widest possible availability of the services, its very simplicity creates usability difficulties. Every support needs to be offered within the dialogue design to minimize memory load and reduce impact of keying errors. The user's task is made easier where the telephone incorporates a visual display. Where a display is not available, status information is only available in the auditory mode using tones and speech messages. This presents particular problems to hearing impaired users.

11.7 Supplementary Services

(Analogue Display Services Interface (ADSI), Code Schemes, Stimulus Protocols, User Procedures)

The ITU-T and ETSI have defined a number of supplementary services which modify or supplement basic telecommunications services. The ONP Directive 98/10/EC [139] sets out certain supplementary services required to be generally available and others to be provided by network operators with significant market power.

An ETSI standard for a harmonized minimum man-machine interface for the access and control of public network based telecommunication services exists in ETS 300 738 [35]. The standard attempts to raise the usability of the services by defining the required MMI as including the information, prompts and feedback that support the necessary user's control actions. A listing of those supplementary services that are used on European Networks and that require service codes is contained in TR 102 083 [41] and an updated register of supplementary service codes is available on the TC-HF web site.

Cross references:

Call Handling; Symbols.

Recommendations:

- Design the user interface for accessing and controlling supplementary services to minimize learning time, reduce memory load and reduce error rates.
- Use single action feature keys to support selection of a small range of services but avoid creating a large control panel. Consider a soft-key interface, if access to a larger number of services is necessary.
- Avoid creating a dialogue that requires the user to learn an extensive repertoire of numeric codes.
- Provide a minimum interface to access all available services, ensure the procedures meet user expectations and are fully supported with prompting and feedback indications. As an absolute minimum (not preferred) provide access via an ETSI recognized code scheme or stimulus protocol, using ETS 300 738 [35], TR 102 083 [41] and ITU-T Recommendation E.132 [72].
- Where similar services are provided within the terminal, the customer premises equipment (PBXs, etc.) or the network (PSTN, ISDN, GSM, TETRA, VPN, etc.), the services should appear identical to the user so that they may be perceived as providing the same function. For example, for Call waiting at the terminal and Call waiting at the network level, the procedures, prompts, feedback, and error handling should be common throughout, i.e. they should have the same look, feel and effect at all levels.

Additional comments:

The ONP Directive requires selective outgoing call barring to be generally available and requires Calling line identification, Direct dialling in and Call forwarding to be provided by network operators with significant market power.

An old ITU-T listing of supplementary services may be found in Supplement No. 1 to Volume II of the Blue Book [100]. ITU-T Recommendation E.131 [71] provides early information and some definitions.

Supplementary services may apply to all types of communications (voice, data, fax, picture) or may be exclusive to one or more call types. For example, it is expected that users may be able to set Call forwarding for the different types of calls to different addresses and to set different levels of service for each, e.g. Fax - Call forward on busy to AAA, Voice - Call forward on busy to BBB, Call forward on no reply to CCC, etc.

The relevant International and European Standards should be consulted for the full requirements for network based supplementary services. There are some 40 ITU-T Recommendations (particularly in ITU-T I.250 series of Recommendations [87]) and ETSI has over 800 standardization documents dealing with the subject. A number of the ETSI standards for Private Integrated Services Networks are endorsements of equivalent ISO/IEC standards.

Additional services and features that allow users to modify calls can be implemented in the network, customer premises equipments, or the terminals.

A typical terminal may have a large number of services and features available at the terminal and network level (possibly 40 plus), and potentially considerably more if it is connected on a PABX or a private network. Good dialogue design is required to provide user confidence and take-up of available features. The user interface should be designed to support the user's level of skill and task complexity, without technical barriers preventing common procedures for common services and features.

11.8 Voice transmission

(Telephony, Voice)

Most telephone networks were originally designed for voice transmission (telephony). The ISDN offers two levels of service, the basic 3,1 kHz and the high quality 7 kHz service. Communication with the PSTN is only possible at the lower service level.

Mobile telephone systems use more complex forms of speech coding, which, combined with radio propagation effects can produce unusual speech distortions.

The Internet was originally designed to provide data transmission but voice transmission or telephony is also possible. Due to latency and the possibility of varying delays, the speech quality available may be restricted.

Within voice communication there is the possibility for the full range of supplementary services including multi-party call handling, which in the ISDN may use one or two B channels.

ETR 250 [19] provides a useful source of information on all aspects of speech communication quality for handset telephony.

Cross references:

Communication and Transmission; Multi-media Terminals; Supplementary Services; Telephones; Videophones.

Recommendations:

- To maintain and improve the quality of the audio service, it is essential that the user continues to perceive voice transmission as bi-directional, with both directions continuously and simultaneously active throughout the speech phase. The important element is for the users to feel confident that they continue to share the same auditory space, irrespective of the terminal, system or network technology.
- It is important to ensure the quality of the transmitted voice signal is at least equal to that for analogue telephones for all parameters. ITU-T Recommendations exist which give advice on the transmission characteristics of various types of terminal (See Supplement 10 to the P series Recommendations [101] and ITU-T Recommendations P.30 [89], P.38 [90], P.310 [91], P.311 [92], P.313 [93], P.340 [94], P.341 [95], P.342 [96]).
- It is important to ensure the level of sidetone is within the acceptable range and if possible within the range preferred by users (ITU-T Recommendation P.11 [88] and ITU-T Recommendation G.121 [86]).
- It is important to consider the delay impact on evolving telecommunications applications and to avoid delay increases, especially processing delays, whenever possible (see ITU-T Recommendation G.114 [85]).

Additional comments:

The prime requirement for voice transmission is to be heard and to hear the other person(s) clearly. The techniques used for voice switching and echo cancelling in handsfree operation have to be designed with care to ensure there is minimum impairment to the natural rhythm of voice communication, and to the user's perception of a shared auditory space. Where speech is combined with video in multimedia communication it is important to retain synchronization between lip movement and speech output.

While users are unlikely to be familiar with the technical demands for frequency response, side tone or echo-suppression, they are very sensitive to subtle nuances of tone of voice, expression and hesitation. These can significantly affect the perceived quality of information exchange such as whether the other person is agreeing or disagreeing, understanding or confused.

Annex A (informative): Questionnaires for users

Before the users answer the questionnaire they are introduced to the project and to the questions they are going to answer. It is very important that the user feels comfortable and free to answer the questions as honestly as possible.

Also, they fill in a general questionnaire concerning their disability, age, gender, usual type of telephone, etc.

QUESTIONNAIRE CONCERNING TELEPHONES - VISUALLY IMPAIRED PEOPLE

NAME:_____

THE TYPE OF THE TELEPHONE: _____

If there is any question about something the telephone cannot do or if the question in one or another way not is relevant for the telephone, then you do not have to answer it.

Please rate your answers:

"Very poor"
"Poor"
"Acceptable"
"Good"
Very good"

"Is it easy to grip/push the control for adjusting the volume?"
"Is the control for adjusting the volume large enough?"
"Is it easy to understand how the volume control is operated?"
"Do you think the control for adjusting the volume is located in a suitable place?"
"Is it easy to grip/push the control for adjusting the ringing tone?"
"Is the knob for adjusting the ringing tone large enough?"
"Is it easy to understand how the ringing tone is adjusted?"
"How distinct is the click from the key when it is pressed down sufficiently?"
"What do you think about the contrast between the characters and the background on the display?"
"How distinctly do you find that the key groups are separated?"
"Do you find that the control for adjusting the volume is clearly labelled?"
"Do you find that the control for adjusting the ringing tone is clearly labelled?"

Questions for other user groups are:

Blind people:
"Is it easy to grip/push the control for adjusting the volume?"
"Is the control for adjusting the volume large enough?"
"Is it easy to understand how the volume control is operated?"
"Do you find that the control for adjusting the volume is located in a suitable place?"
"Is it easy to grip/push the control for adjusting the ringing tone?"
"Is the control for adjusting the ringing tone large enough?"
"Is it easy to understand how the ringing tone is adjusted?"
"Do you think the control for adjusting the ringing tone is located in a suitable place?"
"How distinct is the click from the key when it is pressed down sufficiently?"
"Do you hear clearly in the earpiece of the handset when the key is pressed down properly?"
"How distinctly do you find the key groups are separated?"
"Do you find that the control for adjusting the volume is clearly labelled?"
"Do you find that the control for adjusting the ringing tone is clearly labelled?"

People with reduced movement capabilities:

"Is the handset pleasant to hold?"
"Is it easy to speak and listen at the same time with this handset?"
"How do you assess the space for the fingers when you lift or replace the handset?"
"How do you find the grip of the telephone and how easy is it to carry the telephone around?"
"Does the handset fall off easily when the telephone is carried around?"
"What do you think of the balance of the handset?"
"Is it easy to grip/push the control for adjusting the volume?"
"Is the control for adjusting the volume large enough?"
"Is it easy to understand how the volume control is operated?"
"Do you think the control for adjusting the volume is located in a suitable place?"
"Is it easy to grip/push the control for adjusting the ringing tone?"
"Is the control for adjusting the ringing tone large enough?"
"Is it easy to understand how the ringing tone is adjusted?"
"Do you think the control for adjusting the ringing tone is located in a suitable place?"
"How distinct is the click from the key when it is pressed down sufficiently?"

People with unco-ordinated movements:

"How do you assess the space for the fingers when you lift or replace the handset?"
"How do you find the grip of the telephone and how easy is it to carry the telephone around?"
"Is it easy to grip/push the control for adjusting the volume?"
"Is the control for adjusting the volume large enough?"
"Is it easy to understand how the volume control is operated?"
"Do you think the control for adjusting the volume is located in a suitable place?"
"Is it easy to grip/push the control for adjusting the ringing tone?"
"Is the control for adjusting the ringing tone large enough?"
"Is it easy to understand how the ringing tone is adjusted?"

People who are hard of hearing:

"How do you find the seal of the earpiece?"
"How comfortable do you find the feeling of the earpiece against the ear?"
"Do you find the volume in the receiver sufficient loud?"
"Is the ringing tone sufficiently loud?"
"What do you think of the ringing tones?"
"How close can the microphone be held to the mouth when the earpiece is held in the way where there is the best possible coupling between the earpiece and the hearing aid? Does your hearing aid need to be in position T?"

People with learning disabilities:

"Do you think the control for adjusting the volume is located in a suitable place?"
"Is it easy to grip/push the control for adjusting the volume?"
"Is the control for adjusting the volume large enough?"
"Is it easy to understand how the volume control is operated?"
"Do you think the control for adjusting the volume is located in a suitable place?"
"Do you find that the control for adjusting the ringing tone is clearly labelled?"
"Do you find that the control for adjusting the volume is clearly labelled?"

Annex B (informative): Checklists for groups of disabled people

These checklists can be used when the telephone is to be evaluated in relation to one or only a few groups of users.

B.1 Visually impaired people

1.1	**Physical interface - anthropometric usability components**
1.1.4	Key spacing between each key
1.1.5	Size of the keys
1.2	**Physical interface - motoric usability components**
1.2.3	Position of the fastening of the cord
1.2.10	Height/recession of the keys with regard to the surface of the keypad
1.2.11	Operation of the volume control
1.2.12	Position of the control for adjusting the volume
1.2.13	Method for adjusting the volume of the ringing tone
1.2.14	Position of the control for adjusting the ringing tone
1.3	**Physical interface - perceptual usability components**
1.3.1	Incorrect position of the handset
1.3.2	Size of the characters on the numeric keys
1.3.3	Contrast between character and background on the numeric keys
1.3.4	Size of the characters on the supplementary keys
1.3.5	Contrast between characters and the background on the supplementary keys
1.3.6	Contrast between the keys and the background
1.5	**User input/output - perceptual usability components**
1.5.1	Multiple indications of adjustings and choices
1.5.2.	Controls, keys and adjusting settings requirements
1.5.2.1	Activation of adjusting controls and special keys by mistake
1.5.2.2	Haptic feedback from pressing the keys
1.5.4	Screen display requirements
1.5.4.1	Size of the characters on the display
1.5.4.2	Contrast between the characters and the background of the display
1.6	**User input/output - cognitive usability components**
1.6.1	Layout of keys
1.6.2	Tactile marking of the number 5 numeric key
1.6.3	Separation of the key groups
1.6.5	Labelling of the control for adjusting the volume
1.6.6	Labelling of the control for adjusting the ringing tone
2.1	**Conventional facilities**
2.1.3	Quick dialling
2.1.4	Repeat call
2.1.6	Display
2.1.7	Directions for use

B.2 Blind people

1.1	**Physical interface - anthropometric usability components**
1.1.4	Key spacing between each key
1.2	**Physical interface - motoric usability components**
1.2.10	Height/recession of the keys with regard to the surface of the keypad
1.2.11	Operation of the volume control
1.2.12	Position of the control for adjusting the volume
1.2.13	Method for adjusting the volume of the ringing tone
1.2.14	Position of control for adjusting the ringing tone
1.3	**Physical interface - perceptual usability components**
1.3.1	Incorrect position of the handset
1.5	**User input/output - perceptual usability components**
1.5.1	Multiple indications of adjustings and choices
1.5.2.	Controls, keys and adjusting settings requirements
1.5.2.1	Activation of adjusting controls and special keys by mistake
1.5.2.2	Haptic feedback from pressing the keys
1.5.2.3	Auditory feedback from pressing the keys
1.6	**User input/output - cognitive usability components**
1.6.1	Layout of the keys
1.6.2	Tactile marking of the number 5 numeric key
1.6.3	Separation of the key groups
1.6.5	Labelling of the control for adjusting the volume
1.6.6	Labelling of the control for adjusting the ringing tone
2.1	**Conventional facilities**
2.1.3	Quick dialling
2.1.4	Repeat call
2.1.5	Hands free operation
2.1.7	Directions for use
2.2	**Facilities especially for disabled users**
2.2.1	Possibility for a handset holder

B.3 People with reduced movement capability and reduced muscular strength

1.1	**Physical interface - anthropometric usability components**
1.1.1	Shape and size of the handset
1.1.3	Space for the fingers on the handset
1.1.5	Size of the keys
1.1.6	Curvature of the top of the keys
1.1.7	Material of the top of the keys
1.2	**Physical interface - motoric usability components**
1.2.1	Length of the cord
1.2.2	Fastening of the cord of the handset
1.2.3	Position of the fastening of the cord
1.2.4	Weight of the telephone
1.2.5	Portability of the telephone
1.2.6	Weight of the handset
1.2.7	Balance of the handset
1.2.8	Pressure needed to activate the keys
1.2.9	Pressure direction of the keys
1.2.10	Height/recession of the keys with regard to the surface of the keypad
1.2.11	Operation of the volume control
1.2.12	Position of control for adjusting the volume
1.2.13	Method for adjusting the volume of the ringing tone
1.2.14	Position of the control for adjusting the ringing tone
1.2.15	Tilt of the keypad
1.3	**Physical interface - perceptual usability components**
1.3.1	Incorrect position of the handset
1.4	**User input/output - motoric usability components**
1.4.1	Activation by simultaneous pressing two or more keys
1.5	**User input/output - perceptual usability components**
1.5.2	Controls, keys and adjusting settings requirements
1.5.2.1	Activation of adjusting controls and special keys by mistake
1.5.2.2	Haptic feedback from pressing the keys
2.1	**Conventional facilities**
2.1.3	Quick dialling
2.1.4	Repeat call
2.1.5	Hands free operation
2.1.6	Display
2.1.7	Directions for use
2.2	**Facilities especially for disabled users**
2.2.1	Possibility for a handset holder
2.2.2	Possibility for a keyguard

B.4 People with unco-ordinated movements

1.1	**Physical interface - anthropometric usability components**
1.1.3	Space for the fingers on the handset
1.1.4	Key spacing between each key
1.1.5	Size of the keys
1.1.6	Curvature of the top of the keys
1.1.7	Material of the top of the keys
1.2	**Physical interface - motoric usability components**
1.2.1	Length of the cord of the handset
1.2.2	Fastening of the cord of the handset
1.2.3	Position of the fastening of the cord
1.2.5	Portability of the telephone
1.2.8	Pressure needed to activate the keys
1.2.9	Pressure direction of the keys
1.2.10	Height/recession of the keys with regard to the surface of the keypad
1.2.11	Operation of the volume control
1.2.12	Position of the control for adjusting the volume
1.2.13	Method for adjusting the volume of the ringing tone
1.2.14	Position of the control for adjusting the ringing tone
1.3	**Physical interface - perceptual usability components**
1.3.1	Incorrect position of the handset
1.4	**User input/output - motoric usability components**
1.4.1	Activation by simultaneous pressure of two or more keys
1.5	**User input/output - perceptual usability components**
1.5.2	Controls, keys and adjusting settings requirements
1.5.2.1	Activation of adjusting controls and special keys by mistake
2.1	**Conventional facilities**
2.1.1	Sturdiness
2.1.2	Non-skid
2.1.3	Quick dialling
2.1.4	Repeat call
2.1.5	Hands free operation
2.1.6	Display
2.1.7	Directions for use
2.2	**Facilities especially for disabled users**
2.2.1	Possibility for a handset holder
2.2.2	Possibility for a keyguard

B.5 People who are hard of hearing

1.1	**Physical interface - anthropometric usability components**
1.1.1	Shape and size of the handset
1.1.2	Shape of the earpiece
1.5	**User input/output - perceptual usability components**
1.5.3	Tones and indications requirements
1.5.3.1	Volume
1.5.3.2	Sidetone
1.5.3.3	Adjusting of output volume
1.5.3.4	Volume of the ringing tone
1.5.3.5	The ringing tones
2.1	**Conventional facilities**
2.1.6	Display
2.1.7	Directions for use
2.2.	**Facilities especially for disabled users**
2.2.3	Built-in inductive coupling
2.2.4	Possibility for connection of an inductive coupler and/or audio amplifier

B.6 People with learning difficulties

1.2	**Physical interface - motoric usability components**
1.2.11	Operation of the volume control
1.2.13	Method for adjusting the volume of the ringing tone
1.2.14	Position of control for adjusting of the ringing tone
1.6	**User input/output - cognitive usability components**
1.6.4	Space for symbols or pictures at/on the quick dialling controls
1.6.5	Labelling of the control for adjusting the volume
1.6.6	Labelling of the control for adjusting the ringing tone
2.1.	**Conventional facilities**
2.1.3	Quick dialling
2.1.6	Display
2.1.7	Directions for use

B.7 People with low voice output

1.1	**Shape and size of the handset**
1.1.1	Shape and size of the handset
1.5.3.1	Volume
2.1	**Conventional facilities**
2.1.7	Directions for use

Annex C (informative): Presentation of the evaluation results

C.1 An example of a description of the results of the evaluation

Name of telephone

Description
Table telephone, can also be used as a wall telephone. It has repeat call and 20 quick dial keys, 10 can be activated by pressing only one key. There is volume control, and it is possible to amplify the speech. The telephone has inductive coupling. The tones and the volume of the ringing tone can be regulated. There is a display, and the telephone can be used hands free.

Assessment
The telephone stands firmly, and it seems very sturdy. The wire to the handset is fixed by a solid plug outlet that cannot be loosened by a mistake. The wire does not get caught by the handset. It is easy to carry the telephone as it is possible to use both hands.

It is possible to activate the "secrecy" control by a mistake, because it is only indicated by a light diode, that cannot be seen by visually impaired people, and others cannot see it in sunlight.

The size, shape and balance of the handset is good, and it is not possible to misplace it. There is good room for the fingers when the handset is to be lifted. The shape of the earpiece is good. The handset can be mounted in a standard handset holder.

The keyboard layout follows the ITU-T Recommendation, and there is a pip on the 5-key. The key groups are distinctly separated, and the spacing between each key is good. The size of the keys is also good, but the shape (convexo-concave) is a problem for people with motor disabilities. The keys are very stable to press down, and there is a very distinct haptic feed-back, but the keys are too hard to press down. There is a clear auditory feed-back when the keys are pressed. It is easy to read the numbers and the letters on the keys and the frame. The contrast between the number keys and the frame is very good (black/white), but the contrast between the other keys and the frame is very poor (white/white).

There are 20 quick dial memory keys, of which 10 can be activated by pressing only one key. There is good room for symbols or pictures. When the last 10 quick-dial keys are to be activated, "memory bank B" needs to be called, and a small "B" is shown on the display. This is a problem for blind and other visually impaired people because there are no other ways to know that "memory bank B" is activated. "Battery low" is also indicated on the display as the only indication. The display has big letters, but very poor contrast, which makes it hard to read for visually impaired people.

The volume can be adjusted, and the range is very large. The control for adjusting the volume is placed very well on the top of the telephone, but the shape of the control is not good. The control is clearly labelled. The telephone has inductive coupling, but the orientation of the field is not correct.

The volume of the ringing tone is very loud, and there are three different set of tones, all containing high and low tones. The ringing tone is regulated by a little, poorly marked (small white letters on white background) sliding control. It is possible to place the control on "off" by a mistake.

The directions for use is very detailed, but it is hard to get an overview of how to use the telephone.

Remarks

People who are hard of hearing
+ very loud volume
+ large range of the volume control
+ very loud and adjustable ringing tone
+ earpiece seals well to the ear
+ display
- inductive coupling which is not correctly orientated

People with low voice output
+ good sensitivity of the microphone
+ possibility for microphone amplification
+ very loud volume
+ large range of the volume control
+ microphone which can come close to the mouth

People with learning disabilities
+ 10 quick dialling which keys can be activated by one stroke
+ room for symbols and pictures at/on the quick dialling keys
+ control for adjusting the ringing tone under the telephone
+ display
- secrecy control which may be activated by mistake
- ringing tone which may be turned off by mistake

Visually impaired people
+ numbers and letters which are easy to read
+ quick dialling keys
- ringing tone which may be turned off by mistake
- hard to see if the secrecy function is turned on
- hard to read letters on the display
- activation of "memory bank B" shown by a small letter on the display
- some controls are hard to see (white on white)

Blind people
+ quick dialling facility
+ hands free facility
+ very precise controls with distinct haptic feed-back
+ the key groups are distinctly separated
+ good labelling
- ringing tone may be turned off by mistake
- some functions demand use of the display
- secrecy button which may be activated by mistake

People with reduced movement capabilities
+ 10 quick dialling keys which can be activated by only one stroke
+ hands free facility
+ very precise controls with distinct haptic feed-back
+ display
+ the handset which has a good size and shape
+ easy to lift handset off-hook
+ easy to carry the telephone around
- the keys have a bad shape
- the keys are hard to press down
- ringing tone which is hard to change
- volume control which is hard to use

People with unco-ordinated movements
+ 10 quick dialling keys can be activated by only one stroke
+ hands free facility
+ very precise controls with distinct haptic feed-back
+ the keys are hard to press down
+ good spacing between the controls
+ display
+ the handset is easy to lift off-hook
+ easy to carry the telephone around
- the telephone stands firmly
- the keys have a bad shape
- the ringing tone is hard to change
- volume control which is hard to use

C.2 Final survey sheet

Survey

1 = very poor
2 = poor
3 = average
4 = good
5 = very good

– = not relevant
for this telephone

keys	CCITT-layout	yes	yes
	size (lxh mm)	14 Ø	14 Ø
	readability	4	4
	marking of 5-button	yes	yes
	curvature	-	-
	haptic feedback	5	5
	pressure for activation	180 g	180 g
handset	weight	210 g	210 g
	shape of earpiece	4	4
	shape of handset	4	4
incoming speech	volume	4	4
	volume control	yes	yes
	regulation of volume control	3	3
	marking of volume control	4	4
	inductive coupling	2	2
ringing	volume	5	5
	tones	4	4
	control	3	3
	marking	2	2
functions	quick dial	yes	yes
	repeat call	yes	yes
	handfree	yes	no
general remarks	display	yes	no
	readability of display	3	-
	instructions	3	3
	weight	925 g	840 g
	non-skidding	5	5

Annex D (informative): Bibliography

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History

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