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Human Factors (HF) - Inclusive eServices for all: Optimizing the accessibility and the use of upcoming user-interaction technologies

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Inclusive eServices for all: Optimizing the accessibility and the use of upcoming user-interaction technologies

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Foreword

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

Introduction

Europe, as well as other economically developed areas, is facing a number of social and economic challenges including an ageing population and high expectations with regard to quality of life, in particular in healthcare, environmental and transportation concerns. These changes in society are also reflected in new requirements for products and services resulting from changing sensory, cognitive and physical abilities of their users.

Experience shows a predominant pattern of products and services being offered that do not take sufficiently into account the needs of people with mild or severe impairments. This tendency contributes to create gaps between people with disabilities and the average population regarding the usage of Information and Communication Technologies (ICT). Two reasons for this state of affairs can be identified. First, companies do not see a business case in offering barrier-free products. Secondly, product and eService developers are often unaware of the requirements of customers with impairments, neither are they familiar with appropriate design solutions that in many cases are not very demanding in terms of research and development (R&D) and production costs.

The motivation for the development of barrier-free services and technologies can be regarded as demand driven, i.e. users, organisations and policy makers express needs that they are not able to satisfy today with existing eService offerings and products. Adopting a Design for All approach should be perceived as an opportunity as it can frequently lead to innovative design solutions that bring benefits to all users, increasing the overall attractiveness of product offerings.

The present document addresses relevant user requirements by taking a long-term approach in ensuring that new ICT will consider the various needs of all users (including older users and those with disabilities) at the time when the technology is first deployed, not as an afterthought as has been the case for many significant previous technological developments.

Building a Design for All approach into the design process of devices and services will ensure that these products have the broadest possible range of application by users with different abilities and users in different contexts. Fully utilising the provisions in the present document will enable manufacturers and suppliers to demonstrate that they have understood and overcome potential accessibility barriers that would otherwise have been created by new interaction technologies that they are using. Adopting such a planned inclusive design approach can be utilised as a positive marketing message that can be given when introducing such products.

Furthermore, adopting the provisions given in the present document will also significantly reduce the risk that manufacturers and suppliers who employ future interaction technologies will introduce products that fail to meet the needs of all sectors of society. Such use of the provisions will thus help industry to avoid the twin penalties of:

- the damage to corporate image that results from the introduction of products that are seen to discriminate against and exclude sectors of society that command widespread public sympathy;

- the very high costs of having to retrospectively and rapidly re-engineer products in order to ensure that they no longer exclude sectors of society that have already been alienated by previous versions of the product.

Adopting the provisions in the present document may reduce the likelihood that device manufactures and eService providers become the subject of regulation. By doing so, they will be well prepared to comply with any standards or regulation that may in the future be implemented to achieve an inclusive approach to private and public procurement.

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1   Scope

The present document provides guidance for the user interaction design of telecommunication devices and services that are likely to become available for large-scale rollout to consumers in the next five to ten years. In particular, the document identifies provisions that have to be made in order to ensure that forthcoming interaction technologies deployed in devices and services will be usable by all users including older people and/or people with disabilities.

The present document lists user interaction technologies likely to be employed in future devices and services in the form of a technology roadmap. For each identified technology, key characteristics specified include:

- user requirements impacted by the technology;

- benefits and accessibility barriers that will result from deployment;

- solutions related to accessibility barriers (both those benefiting disabled users only as well as those being useful for all users in different contexts).

Measures are identified that need to be addressed prior to the large-scale implementation of those technologies in order to ensure their usability by users with the widest range of characteristics.

Within the scope of the document are those interaction technologies that are likely to be used in information and communication products and services and are likely to achieve a mass-market breakthrough between 2010 and 2020.

Interaction technologies that are exclusively used in:

- stand-alone, off-line products and services;

- assistive devices;

- safety and security-related products and services;

are not within the scope of the present document, even though the guidelines may also apply to some of them.

General user interface design issues (e.g. cognitive workload) that affect the usability and accessibility of user interfaces for eServices are also outside of the scope of the present document.

The intended readers of the present document are the designers, manufacturers and suppliers of all ICT products and services that may use new user interaction technologies in their future offerings. Researchers benefit from the present document by integrating its findings into their research at a very early stage.

It is expected that the present document should be utilised in the earliest stages of the planning of a new product or eService to ensure that the measures proposed can be taken into account during all stages of the product design and implementation process. Such usage should ensure that the resulting product or eService is as barrier free in its design as possible.

2   References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the reference document (including any amendments) applies.

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NOTE: While any hyperlinks included in this clause were valid at the time of publication ETSI cannot guarantee their long term validity.

2.1 Normative references

The following referenced documents are necessary for the application of the present document.

Not applicable.

2.2 Informative references

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ETSI EG 202 116: "Human Factors (HF); Guidelines for ICT products and services; "Design for All"".

[i.2] ETSI TR 102 849: "Human Factors (HF); Inclusive eServices for all; Background analysis of future interaction technologies and supporting information".

[i.3] ISO TR 29138-1: "Information technology - Accessibility considerations for people with disabilities - Part 1: User needs summary".

[i.4] ISO 9241-920: "Ergonomics of human-system interaction - Part 920: Guidance on tactile and haptic interactions".

[i.5] The Center for Universal Design, NC State University.

NOTE: Available at http://www.design.ncsu.edu/cud/about_ud/udprinciplestext.htm.

[i.6] ISO 9241-20: "Ergonomics of human-system interaction. Accessibility guidelines for information/communication technology (ICT) equipment and services".

[i.7] ETSI EG 202 417: "Human Factors (HF); User education guidelines for mobile terminals and services".

[i.8] ETSI TR 102 068: "Human Factors (HF); Requirements for assistive technology devices in ICT".

[i.9] ETSI ES 202 076: "Human Factors (HF); User Interfaces; Generic spoken command vocabulary for ICT devices and services".

3 Definitions and abbreviations

3.1 Definitions

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

augmented reality: augmented reality displays are those in which the image is of a primarily real environment, which is enhanced, or augmented, with computer-generated imagery

NOTE: More generally, augmented reality can be defined as any media that is specific to user's location or context, which is displayed in order to augment or enhance user's specific reality.

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

eService: See service.

eService cluster: collection of multiple (electronic) services aggregating into one (joint, often more abstract) eService

haptic: passive perception through the sense of touch

input modality: sense or channel through which a human can receive the output of an ICT device or service

EXAMPLE: Visual modality.

interaction modality: input modality or output modality

interaction technology: See user interaction technology.

modality: See sensory modality.

multimodal: relating to multiple input modalities and/or output modalities

multimodality: simultaneous support of multiple input modalities and/or output modalities

output modality: channel through which a sensor, device or service can receive the input from the human

EXAMPLE: Kinaesthetic modality.

sensory modality: sense or channel through which a human can send input to or receive output from an ICT device or service

EXAMPLE: Kinaesthetic modality.

service: complete capability, including terminal equipment functions, for communication between users, systems and applications, according to agreed protocols

tactile: perception through the sense of touch while actively moving parts of the body

user interaction technology: any instrument, equipment or technical system enabling a user to interactively communicate with a device or service

user interface: physical and logical interface through which a user communicates with a device or service

3.2 Abbreviations

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

AAC	Augmented and Alternative Communication
ADC	Analogue-to-Digital Converter
AEC	Acoustic Echo Cancellation
AR	Augmented Reality
AT	Assistive Technology
AVSR	Audio-Visual Speech Recognition
BSS	Blind Source Separation
CSCW	Computer Supported Co-operative Work
DOF	Degrees of Freedom
DSR	Distributed Speech Recognition
DTW	Dynamic Time Warping
DVB-S	Digital Video Broadcasting, Satellite television
DVD	Digital Versatile Disk (also known as digital video disk)
DVDD	Direct Volume Display Devices
FOV	Field Of View
GPS	Global Positioning System
GUI	Graphical User Interface
HD	High Definition
HDTV	High Definition Television
HMD	Head-Mounted Displays
HRTF	Head-Related Transfer Function
HUD	Head-Up Displays
ICT	Information and Communication Technologies
IR	Infrared
LCD	Liquid Crystal Display
LED	Light-emitting diode
MEMS	Micro-Electromechanical Systems

NFC	Near Field Communication (wireless)
NGN	Next Generation Network
OIV	Obscured Information Visualization
OLED	Organic Light Emitting Diode
PC	Personal Computer
PDF	Portable Document Format
PIR	Passive Infrared Sensor
QoS	Quality of Service
R&D	Research and Development
RF	Radio Frequency
RFID	Radio-Frequency Identification
RSVP	Rapid Serial Visual Presentation
SID	Spatially Immersive Display
TTS	Text-To-Speech
UI	User Interface
WAI	Web Accessibility Initiative
WCG	Wide-Colour Gamut
WFS	Wave Field Synthesis

4   Rationale

An analysis of the deployment of existing services and their user interfaces shows a common pattern of addressing the requirements of older people and those with disabilities significantly after the initial availability of innovative new user interaction technologies. This pattern is so common because new and sometimes disruptive technologies are usually developed for and targeted at mainstream consumers, or at narrow target groups of early adopters, the wealthy or the technology-aware.

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Those new and/or disruptive technologies did not initially include the easy accommodation of the requirements of people with disabilities. Subsequent measures for compensating these shortcomings have often been late and costly. Examples of technologies deployed without appropriate consideration for the requirements of users with disabilities are listed in table 4.1.

Table 4.1: Examples of accessibility gaps in consumer products

Technology	Accessibility weaknesses
Personal computer (PC)	The first PCs with character-based user interfaces were easily usable by blind users with a Braille-keyboard device. The advent of graphical user interfaces (GUI) suddenly excluded blind users until screen readers became available.
The Internet	The problems are similar to the ones described for the PC, as early communications services (e.g. gopher services and first E-mail services) were text based and were later replaced by graphical interfaces such as web browsers. The Web Accessibility Initiative (WAI) stepped in late, and took long to evolve if compared to the very dynamic development of web technologies.
Document file formats	Documents produced in image-based versions of the PDF-format are not accessible to blind users.
Digital music or media players	Many classic cassette players have mechanical switches and mechanisms that rely on the physical insertion and turning of a cassette to select different audio segments. However, modern digital music players are increasingly relying on on-screen interfaces with few, if any, physical controls to offer suitable feedback and are therefore unsuitable for people with poor eyesight.
Biometric systems	Biometric applications are more and more used for supporting authorisation and access control. People with disabilities (e.g. physical or speech impairments) are likely to face barriers as users of these systems. Multimodality may contribute to accessibility in this field, as well as to higher levels of performance and user acceptance.

The introduction of forthcoming applications and technologies such as ambient intelligence, ubiquitous communications and others enabled by Next Generation Networks (NGN) should not follow the same pattern, but adopt a true "Design for All" approach instead. This implies that the specific requirements of older users and users with disabilities should be taken into account prior to the large-scale introduction of such technologies. These requirements lead to provisions that should be made prior to or at the introduction of new technologies in order to meet the needs of all users.

Emerging user interaction technologies may pose interaction challenges that still remain unaddressed by available standards on generic accessibility of ICT products and services. One of the reasons for this may be that certain modalities (e.g. haptic/tactile) have acquired an increasing importance in user interfaces, whereas previously they have been used mainly as a complement to other modalities (e.g. visual and auditory). Furthermore, new interaction paradigms (e.g. augmented reality) still lack a holistic analysis of their accessibility implications. The present document addresses these and further issues attempting to identify relevant future interaction technologies and appropriate Design for All provisions.

Implementing the provisions in the present document can result in a higher average revenue per user for eService providers and an increased customer base for device manufacturers. Ensuring that the needs of older users and users with disabilities are addressed in the initial release of a product or eService will avoid the additional re-development costs incurred by the need to address this in later product releases.

Adapting new services and devices according to these provisions will result in inclusion for all users, regardless of their age and impairments. Delivering services and devices that are accessible from the start will empower users, strengthening trust in their ability to master new technologies designed to improve their quality of life. Switching to a new eService or device will be easier for users when the provisions in the present document are adopted.

Previous ETSI work has produced an excellent basis for educating device and eService designers about the requirements of older users and users with disabilities by illustrating design principles for barrier-free products and services. One example of the many ETSI publications on barrier-free design is [i.1].

However, the current literature, including the documents published by ETSI, largely focuses on existing technologies. The developers of innovative new technologies may be unaware of these resources and, if they are, it may not be possible to apply guidance from these resources to the development of new technologies. The present document addresses both the need for an analysis that anticipates the demands of new technologies and for the development of guidance that is suitable for these forthcoming technologies.

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5 Method
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The technology roadmaps and technology properties listed in clause 6 were identified using a combination of desk research and expert consultation. It included literature research and interviews with experts and stakeholders. The development of the Design for All provisions in the present document resulted from an analysis of the options which designers and manufactures have during the design of new services or access devices. Details of the working method are described in [i.2].

Existing and forthcoming eServices were analyzed and grouped into eService clusters such as eHealth, eGovernment and eLearning (see table 5.1). In order to systematically identify potential accessibility barriers to those eServices and appropriate solutions, each interaction technology listed in clause 6 has been assessed against a set of generic user requirements related to ICT accessibility. The main aim was to identify those user requirements that may create accessibility barriers when making use of novel and emerging interaction technologies.

Table 5.1: eService Clusters

eService Clusters	Explanations
eGovernment services	eGovernment services include authentication services, electronic application for id-cards, passports, driver's licenses, etc., remote payment of supplies like energy and water, as well as eTax services that include the electronic filing of tax forms, electronic payment of taxes and communication with tax offices.
eHealth services	eHealth services are, among others telecare services, remote health monitoring, access to patient data, remote diagnosis and electronic prescription services.
Social services delivered through electronic means	Social services delivered through electronic means comprise remote supervision of people in need, ICT-supported caretaking (incl. robotics applications), social communities, electronic support for old people in need, messaging services, sharing services for pictures, video and music, ICT supported access to personalized human assistance.
Home automation services	Home automation services supply services, smart homes, energy management, light and entertainment management in the house, remote building control.
eBanking services	eBanking requires secure transmission and transaction services, remote authentication services as well as data- and secure information delivery to customers (e.g. for bank statements).

eService Clusters	Explanations
Electronic purchasing services	Electronic purchasing services include and require electronic payment, authentication services, information and database search, and secure transactional communication, electronic travel booking and management, download of electronic content (music, video) and applications (app stores).
Information services	Including news, sports results and information retrieval.
eLearning services	eLearning services comprise, among others, remote access to school and university databases, virtual classrooms and remote teaching, remote access to museums.
Mobile office applications and services	Mobile office applications include remote access to office data, Computer Supported Co-operative Work (CSCW) environments, electronic publishing services, remote translation services, messaging services, remote conference services, mobile email access, remote storage of personal data, etc.
eGames and entertainment services	eGames and Entertainment comprise all sorts of interactive games played with remote partners of communication networks, delivery of information and entertainment content to customers, electronic pets, eSex services and remote support and monitoring of activities like exercising.

The primary source of this set of accessibility requirements was [i.3]. Other relevant standards on ICT accessibility have been applied where appropriate, such as [i.1]. As stated in clause 4, emerging user interaction technologies may pose interaction challenges that still remain unaddressed by available standards on generic accessibility to ICT. Additional sources that have been used include:

- Accessibility standards which are specific to such modality or user interaction technology, such as [i.4].

- A literature review of scientific evidence on modality/technology specific ergonomics.

The outcome of the final step was the definition of provisions that have to be made prior to or at the introduction of each new technology in order to enable the support of emerging services for older and/or disabled users and citizens. In addition, interaction technology areas needing human-factors harmonization/standardization work have been identified.

The technologies within the scope of the present document are predominantly related to the user interaction components of communication enabling devices. Examples of these user interaction technologies are 3-dimensional touch interfaces or wallpaper projection. The functional components of those devices that enable the communication of the device with eServices such as data-exchange protocols and networks are within the scope of the present document only to such an extent as they allow for the employment of novel types of interaction technologies.

6   Roadmaps of user interaction technologies

6.1   General

6.1.1   Contents of the user interaction technology roadmaps

The user interaction technology roadmaps included in this clause group upcoming technologies according to interaction modalities (e.g. acoustic/audio input, acoustic/audio output). Within each roadmap, technologies are organised in sub categories where appropriate (e.g. advanced microphones and voice-input technologies are sub categories on the roadmap for acoustic/audio input technologies). The individual technologies are positioned along a time dimension covering ten years according to their expected mass-market availability for the general consumer. Estimates of the time of mass-market availability are based on expert interviews and literature studies. As such, they represent the best estimates available at the time of writing. The indicated dates should not be relied upon if making any important design or deployment decisions, as it will always be necessary to seek more current mass-market availability information before making such decisions.

Technologies that are potentially relevant for more than one roadmap are marked with an asterisk to indicate that they are being dealt with in detail in the context of another roadmap (e.g. the technology 'communications badge' is listed on the roadmap acoustic/audio output with an asterisk, and it is being dealt with in detail in roadmap acoustic/audio input).

An alphabetic listing of all the user interaction technologies covered in the present document appears in table A.1.

6.1.2   Contents of the technology properties

Each roadmap is followed by tables with various properties of the technologies covered by the roadmap. Table 6.1 gives explanations of the rows of those tables.

Table 6.1: Categories of technology property tables

Table field	Explanations
Name	The generic name by which the technology is commonly known.
Description	A brief description of the user interaction technology covered in the table. This may include reference to other technologies in order to point out similarities and/or differences. In some cases, a table may actually cover a group of related technologies that exhibit a significant common characteristic that is clear and obvious.
Mass market deployment	The expected timeframe ('by 2012', 'by 2015', 'after 2015') within which the technology will have matured to the extent of being ready for mass-market availability for mainstream customers.
Sub category	The sub category of the interaction modalities the technology in question is grouped in. Technologies that have significant similarities from an end-user perspective are grouped into the same sub category.
Related technology	Technologies or sub categories, that are in one or more ways related to the technology in question (e.g. by presenting an alternative, by possessing certain similarities, by representing a technological basis a technology relies on, or by contributing to the technology in some way).
User requirements	User requirement, adapted from [i.3]: User needs summary that for a given technology may either: - be unmet; - be poorly met; - be partially met (when other common alternative technologies fail to meet the requirement); - be fully met (when other common alternative technologies fail to meet the requirement well or at all).
Accessibility barriers	Potential characteristics of the technology that create obstacles for older people or people with disabilities, or for all users in certain contexts of use.
Solutions related to accessibility barriers	Any solutions to the accessibility barriers identified above (wherever meaningful, this also addresses the "unmet" or "poorly met" user requirements identified above).
Cultural issues	Potential positive or negative issues when the technology is used by people from different cultural backgrounds or when the product is used in particular cultural environments.
Benefit for all users	Benefits that the use of this technology presents to all users (frequently in comparison to the use of other existing or alternative technologies).
Benefits for older people and people with disabilities	Benefits that the use of the technology in question presents to users with certain impairments, linking the benefits to the type of disability or need (frequently in addition to any general benefits identified in "Benefits for all users").
Deployment pros	Potential benefits to those deploying the user interaction technology (in terms of factors such as ease of deployment, cost, ability to offer new services, etc.).
Deployment cons	Any technical and commercial problems of deploying the technology as well as any potential disadvantages to users, not related to accessibility, of deploying this technology.
Implementation requirements	Factors that need to be taken into account before the technology in question is used e.g. the need for other technologies to be developed before this technology can be successfully deployed, or some non-technical factors like the need for the design to meet various fashion criteria.
Harmonization	Reference to relevant existing standards or to the need for new standards to be developed.

6.1.3   Key Design for All solutions

One central element of the technology property tables as described in clause 6.1.2 is the "solutions related to accessibility barriers" field, describing Design for All provisions that ought to be implemented prior to the mass-market introduction of a product containing a particular user interaction technology. Table 6.2 lists solutions commonly recurring in the technology property tables, together with explanations and references.

Table 6.2: Key Design for All solutions

Solution	Explanation	Reference
Multimodal presentation	Use different modes (visual, acoustic, tactile) for redundant presentation of information. Also support simultaneous use of different modes.	[i.5]
Multimodal control	Use different modes (visual, acoustic, tactile) for providing control location and function information.	[i.5]
Independent control	Provide independent controls for different output channels.	[i.6]
Multimodal feedback	Provide effective and multi-modal feedback during and after task completion.	[i.5]
Object navigation	Allow navigating among presented objects (e.g. visual objects, haptic/tactile).	Adapted from [i.6]
Object adjustability	Allow adjusting the size of displayed objects.	[i.6]
Selective magnification	Allow magnifying portions of a visual or tactile display.	Adapted from [i.6]
Displayed information adjustability	Allow adjusting characteristics of displayed information (e.g. contrast, volume, force, size).	Adapted from [i.6]
Equivalent simultaneous control	Provide equivalent control through different modes (kinaesthetic, vocal, etc.). Also support simultaneous use of different modes.	Adapted from [i.6]
User limitation compensation	Compensate for limitations in user's actions over the system (e.g. compensate tremors, robust voice recognition systems for people with speech impairments).	Adapted from [i.6]
Reasonable operating forces	Use reasonable operating forces.	Adapted from [i.6]
Sustained effort minimization	Minimize sustained physical effort.	[i.6]
Low complexity	Eliminate unnecessary complexity.	[i.6]
Consistency with expectations	Be consistent with user expectations and intuition.	[i.6]
Training need minimization	Minimize the need for training.	[i.6]
Barrier-free user education	Barrier-free provision of user-education materials (e.g. user guides).	[i.7]
Describability	Differentiate elements in ways that can be described (i.e. make it easy to give instructions or directions).	[i.6]
Standardized Assistive Device connection	Provide for a standardized option to connect assistive devices.	[i.8]