Accessible and Assistive ICT

VERITAS

Virtual and Augmented Environments and Realistic User Interactions To achieve Embedded Accessibility DesignS

247765

Application Guidelines, Research Roadmap, policy and standards recommendations

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4	Preliminary version (November 2014)
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List of Abbreviations

Abbreviation	Explanation
AM	Agile Modeling
AMDD	Agile Model Driven Development
API	Application Programming Interface
A*x.y.z*	VERITAS Activity
DLL	Dynamic Link Library
D*x.y.z*	VERITAS Deliverable
GUI	Graphical User Interface
GVUM	Generic Virtual User Model
HCI	Human-Computer Interaction
ICT	Information and Communication Technologies
LGPL	GNU Lesser General Public License
MDE	Model Driven Engineering
ODE	Open Dynamics Engine
OGRE	Open Source 3D Graphics Engine
O/S	Operating System
QoS	Quality of Service
SP	Sub-project
UCD	User Centered Design
UI	User Interface
WP	Work-package
VR	Virtual Reality
VUM	Virtual User Model

List of Abbreviations for VERITAS tools

Abbreviation	Explanation
VerMIM	Veritas Multimodal Interfaces Manager
MOUSI	Veritas User Model Ontology to UsiXML Converter
VerGen	Veritas User Model Generator
VerMP	Veritas Model Platform
VerSEd-3D	Veritas 3D Simulation Editor
VerSEd-GUI	Veritas GUI Simulation Editor
VerAE	Veritas Avatar Editor
VerSim-3D	Veritas 3D Core Simulation Viewer
VerSim-GUI	Veritas GUI Core Simulation Viewer
IVerSim-3D	Veritas 3D Immersive Simulation Viewer
VerIM	Veritas Interaction Manager

Executive Summary

This work aims to consolidate and present the work performed in the activities regarding design, development and evaluation with the use of the VERITAS tools (see references for a detailed list). The main focus of this Deliverable is to indicate the place of VERITAS within the development process of applications in various domains. Design methodologies used in work activities are presented and analysed in order to illustrate the philosophy behind them and their desirable goals and how VERITAS tools facilitate the design and development process and contribute to the realization of those goals.

Where available from other work packages, an overview of the altered design process (to include VERITAS tools) is given in the form of diagrams and/or specific steps. A discussion of potential uses of VERITAS tools in the various phases of software development is also provided.

The second part of the work is concerned with design guidelines. These are divided into two sections. The first is dedicated to the application domains the VERITAS tools have been employed within the timeframe of the project. They are:

- Automotive
- Infotainment and Games
- Office Workplace
- Healthcare
- Smart Living Spaces
- and Public Spaces which was not included in the project and provided for depicting the possibility of transferring VERITAS to new immerging application domain

A brief description of each domain is provided, along with the main concerns and challenges regarding usability and accessibility.
The second section of design guidelines is divided into 4 categories:

- Large Displays
- Mobile Devices
- Touch-based interfaces
- Gesture-based interaction

These were decided because they are (or can be) common across all domains and the guidelines associated with each apply to all domains. Those were chosen specifically for their increased use today among the public and because they are or expected to be a vital ingredient in the ubiquitous environment of the future.

It should be noted that an exhaustive set of guidelines that would cover the entire spectrum of design challenges is not possible and way beyond the scope of this deliverable. Instead, what were considered to be the most important and relevant advice or recommendations coming from the industry and academia, were selected. The focus of the design guidelines is on the pressing issues of modern interfaces and

applications, not the basic HCI principles which should be adhered at all times (such as select a good mental model, provide affordances, etc.). Likewise, in the domains discussion, not all design challenges are mentioned but specifically those that are inherent to that domain. It should be noted that there are disciplines out of Information Technlogies that also provide design guidelines for specific domains. For example, there is a large volume of literature, standards and legislation regarding accessibility in buildings or standards for Healthcare. These are also not included in this work. Instead, where needed, the co-operation between different disciplines is noted.

Finally, in the last section there is a brief discussion about VERITAS, specifically strengths and weaknesses and what its potential can be in the development of information technology.

1 Introduction

This work aims to consolidate and present the work done in other activities regarding design, development and evaluation with the use of the VERITAS. The main focus of this activity is twofold: to indicate the place of VERITAS within the development process of applications in various domains and list a set of design guidelines for applications, especially in the six application domains VERITAS has been used in. These application domains are:

- Automotive
- Infotainment and Games
- Office Workplace
- Public Spaces
- Healthcare
- Smart Living Spaces

It should be noted that an exhaustive set of guidelines that would cover the entire spectrum of design challenges is not possible and way beyond the scope of this deliverable. Instead, what were considered to be the most important and relevant advice or recommendations coming from the industry and academia, were selected. The focus of the design guidelines is on the pressing issues of modern interfaces and applications, not the basic HCI principles which should be adhered at all times (such as select a good mental model, provide affordances, etc). Likewise, in the domains discussion, not all design challenges are mentioned but specifically those that are inherent to that domain. It should be noted that there are disciplines out of Information Technologies that also provide design guidelines for specific domains. For example, there is a large volume of literature, standards and legislation regarding accessibility in buildings or standards for Healthcare. These are also not included in this work. Instead, where needed, the co-operation between different disciplines is noted.
While there is a wealth of work offering design guidelines to be found amongst the literature, it is spread in many different categories. Interaction design, experience design, usability design, GUI design, product design, ambient intelligence design, web design are just a few examples from a lengthy list of design disciplines and domains. Also lengthy is the list of books written on User Interface Design and User Experience. It is not this work's scope to provide a comprehensive set of design guidelines, since that is an impossible task. The range of detail between guidelines also varies. For example, the design principles presented in Norman's seminal work "Design of everyday things" [1], such as "offer affordances", "choose natural mappings", "use constraints effectively", "design for error" etc. are applicable in many design domains and are undoubtedly relevant to the domains VERITAS is being developed for. Similarly, Microsoft's guidelines to developers regarding design spans everything; design "basics" such as user-centred design and prototyping, the concept of the user experience, color, consistency and typography, including explaining that design is actually a worthwhile investment (notably, accessibility is mentioned in passing as an encouragement to think about it). [2] Microsoft also provides a large set of guidelines as a hierarchy of standards detailing how each

element should be used in Windows applications, how controls should be used and displayed etc. A decision was made to concentrate efforts towards consolidating findings from the various VERITAS WGs and design guidelines relevant to the 6 application domains those activities focused on (including Public Spaces).

1.1 Structure

The structure of this report is divided into two major parts (sections 2-4 and section 5-6).Section 2 presents the major design methodologies and processes influencing the work activities in VERITAS as recorded per working partner. These include user- (and usage-) centered design, model driven engineering (MDE), agile development and Design for All principles, which is at the heart of the VERITAS project. Section 3 briefly presents the various VERITAS tools and explains their functionality. Section 4 introduces the particular application domains and the methods adopted from the various work packages in those specific domains (where available) and how VERITAS fits into the specific process. This is very important as these processes are practical case studies of Design for All principles being incorporated into the software development process from the beginning.

The second major part of the work (section 5) contains the design guidelines deemed more appropriate for the VERITAS project and the respectable application domains. Instead of focusing on "traditional" HCI design guidelines, it was considered more fruitful to supply a set of guidelines divided amongst relevant technologies and interaction techniques. Considering that the bulk of interaction occurs between users and devices embedded into the environment or mobile devices, after careful deliberation, four sets of guidelines and design challenges are provided for four respective categories. These were decided because they are (or can be) common across all domains and the guidelines associated with each apply to all domains. Those were chosen specifically for their increased use today among the public and because they are or expected to be a vital ingredient in the ubiquitous environment of the future.

- Large Displays
- Mobile Devices
- Touch interaction
- Gestures

Section 5 explores design principles, considerations and guidelines specific for each application domain. A brief description of each domain is provided, along with the main concerns regarding usability, a description of inherent requirements and finally accessibility. Additionally, the findings extracted from the activities of WGs are included.

- Automotive
- Infotainment and Games
- Office Workplace
- Public Spaces
- Healthcare
- Smart Living Spaces

In section 6 the standardization activities within the VUMS cluster are discussed. VERITAS allows for the creation of standards in virtual user modelling, in task modelling, in design methodology adoption and of course for the compilation of guidelines such as those presented in section 5.

Finally, in the final section (7) there is a brief discussion about VERITAS and the conclusions drawn from this activity. Specifically the strengths and weaknesses of the tools and what the potential of the VERITAS framework can be if incorporated into the development process.

2 Design Methodologies

VERITAS tools are being developed to be used during the design process of ICT and non-ICT products. This deliverable identifies 6 different application domains where VERITAS tools can be used, each with specific challenges to address, as well as common issues inherent to the development of any kind of application. The design process used by any given developing team is not identical, being influenced by several factors, such as cost, available resources, corporate practice and tradition, application domain particularities, etc. Indeed, the subject of the design process has been a major area of research, starting from the traditional, rigid engineering-based waterfall model to the modern practices of user-centred design or Agile methods. While there is not one absolute process that can be identified as the "correct" process, there are certain methods, approaches and processes that have emerged throughout the years that have been widely adopted by the industry. Some of these have been presented in the various WP associated with VERITAS tools. The reason for this is that usage of the VERITAS toolkit involves a series of steps and practices that must be incorporated to already established practices and methods. This deliverable aims to cover the core design methodologies followed by the VERITAS partners, briefly explain the major issues associated with each of them and finally present a hybrid methodology that will incorporate VERITAS into the design process.

The design methodologies/approaches presented are:

- User centred design
- Usage centred design
- Agile modelling
- Model driven engineering
- Design for All

It should be noted that these are not mutually exclusive nor necessarily different in practice. The difference between them is that of scope, abstraction and focus. User centred design is more of a design philosophy or approach principle than an actual discreet process with discreet steps. Agile modelling is focusing on practice and time management. Design for All is a design philosophy with design principles aiming to expand and fulfil the User Centred Design approach and it is the most relevant to the philosophy behind VERITAS. In each case, this deliverable aims to point out the place VERITAS toolkit has into that specific development practice by presenting the findings of each workgroup as contained in the relevant WPs.

The information of these methodologies was based on excerpts from D2.2.1 [13] and D2.2.2 [14], D2.3.1 [15] and D2.3.3 [16], D2.6.2 [17] and D2.6.3 [18], D2.8.2 [19], as well as the works of Stephanidis et al [3, 4, 5], Vrendenburg et al. [6], ISO 1999 [7], ISO 2010 [8], Savidis and Stephanidis (2004) [9]

2.1.1 User centred design

The term 'user-centred design' originated in Donald Norman's research laboratory at the University of California San Diego (UCSD) in the 1980s and became widely used after the publication of a co-authored book entitled: User-Centred System Design:

New Perspectives on Human-Computer Interaction. He offers four basic suggestions on how a design should be. These recommendations place the user at the center of the design.

User-Centred Design (UCD) is a user interface design process that focuses on usability goals, user characteristics, environment, tasks, and workflow in the design of an interface. In broad terms user-centred design (UCD) is a design philosophy and a process in which the needs, wants, and limitations of the end user of an interface or document are given extensive attention at each stage of the design process. In general, user-centred design (UCD) is an approach to interactive system development that focuses specifically on making systems usable. It is a multi-disciplinary activity.

User-centred design is characterized as a multi-stage problem solving process involving designers who take the lead responsibility in foreseeing and solving the usability problems the users are likely to face while interacting with or using the interface. Such testing is necessary as it is often very difficult for the designers of an interface to understand intuitively what a first-time user of their design experiences, and what each user's learning curve may look like.

UCD processes focus on users through the planning, design and development of an interface. There is an international standard that is the basis for many UCD methodologies. ISO 13407 (Human-centred design process) [7] defines a general process for including human centred activities throughout a development life-cycle, but does not specify exact methods. The ISO 13407 standard concentrates on the process of development.

ISO 13407 is a description of best practice in user centred - design. It provides guidance on design activities that take place throughout the life cycle of interactive systems. It describes an iterative development cycle where interface requirements specifications correctly account for user and organizational requirements as well as specifying the context in which the product is to be used. Design solutions are then produced which can be evaluated by representative users, against these requirements.

The goal of user centred- design (UCD) is to produce interfaces that have a high degree of usability. User centred-design (UCD) has some basic principles such as early focus on users and tasks, empirical measurement and testing of product usage and iterative design.

Furthermore, UCD focuses on understanding the behavioral aspects of the user interacting for the first time so that the user’s learning curve in using the system can be evaluated in order to optimize and reduce it. User-centred design philosophy emphasizes on optimizing the interface around “how users can, want, or need to use the interface”, rather than forcing the users to change their behavior to accommodate the interface.

2.1.2 Usage-centred design

The distinction between usage-centred design and user-centred methods is, as the terms themselves suggest, a matter of emphasis rather than an absolute difference.

Whereas user-centred design makes users the center of attention and seeks to promote user satisfaction with the entire user experience, usage-centred design is more narrowly focused on user performance and on the creation of tools to enhance the efficiency and dependability of the user performance. Although both approaches combine field study and user involvement with modeling, in usage-centred design the models are in the foreground with user studies and user involvement in the background. This difference in emphasis can lead to differences in outcomes. Indeed, it has been argued that over-dependence on user feedback and involvement in user-centred approaches can discourage innovation and contribute to unnecessarily conservative designs.

To do effective design it is crucial to understand the users and their needs. While no credible school of thought in design would take serious exception, opinions vary considerably on how best to gain that understanding and how to record and communicate it once you do. Models of one form or another are the medium for the message in most design methods. Models function as intermediaries between the often ambiguous, overwhelmingly complex reality of actual users and the more narrowly focused and specific needs of designers.

Personas are figurative models rather than abstract models, that is, they are constructed to resemble real users, even down to photos, background information, and personal history. Verisimilitude most likely contributes to the popularity of personas. They sound like people you could know, and over the course of a project can take on a reality that encourages empathy and facilitates thinking from the user perspective.

In usage-centred design, user roles capture and carry the essential understanding about users. User roles, one of the three core models of usage-centred design, are close cousins of personas but differ in a number of ways of potential significance to designers. Compared to typical personas user roles are a more compact and concise representation that is more finely focused on issues with direct relevance for visual and interaction design. For these reasons, user role models can also be simpler and faster to develop. Although roles and personas can complement each other, user role models may also, under some circumstances and for some purposes, offer distinct advantages for designers.

2.1.3 Software engineering and Agile modelling

Agile Modeling (AM) is a practice-based methodology for effective modeling and documentation of software-based systems. Agile Modeling (AM) is a collection of values, principles, and practices for modeling software that can be applied on a software development project in an effective and light-weight manner.

As shown in Figure 1 AM is meant to be tailored into other, full-fledged development methodologies enabling to develop a software process which truly meets the user's needs. The techniques of AM, in particular Agile Model Driven Development (AMDD), enable the developer to scale agile software development to very complex situations.

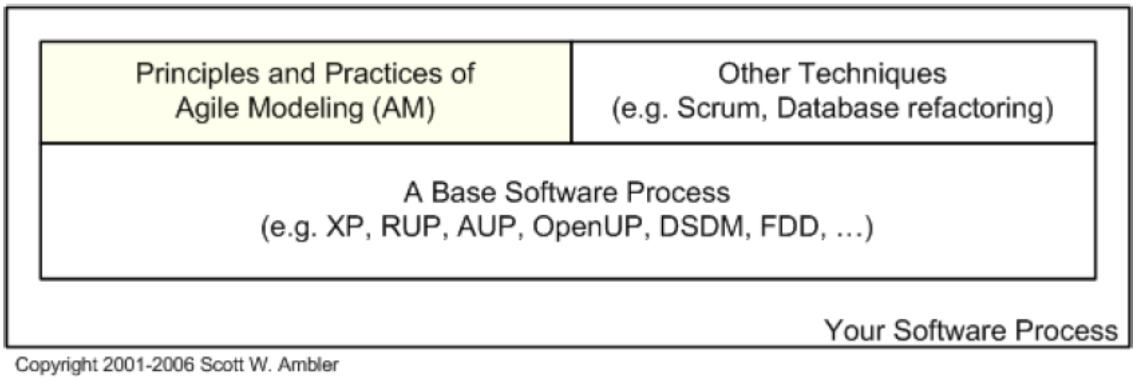

Figure 1 Agile modeling

Agile methodologies are becoming very popular in the software industry as they emphasize the involvement of stakeholders in a context where requirements change continuously.

As healthcare is a complex and multi-disciplinary domain, Agile methodologies have been shown to be suitable for this domain. More recently, the combination of both methodologies (UCD and Agile) has shown great promise, nonetheless the integration between user interaction specialists and programmers is recognized as still being an issue.

2.1.4 Model driven engineering

An emerging area in software development that addresses the above mentioned issues is model driven engineering (MDE). MDE promotes the use of visual, technology-independent design tools which are able to automatically generate part of the application.

MDE tools impose domain-specific constraints and perform model checking that can detect and prevent many errors early in the life cycle. In addition, since today's platforms have much richer functionality and QoS than those in the 1980s and 1990s, MDE tool generators need not be as complicated since they can synthesize artifacts that map onto higher-level, often standardized, middleware platform APIs and frameworks, rather than lower-level OS APIs. As a result, it is often much easier to develop, debug, and evolve MDE tools and applications created with these tools.

This method can be especially useful when coupled with UCD, as it offers tools for representing user interaction paths. More specifically, interaction paths can be represented by machine-readable workflows, which can then be directly converted into code, automating the step between UI design and implementation. In this spectrum of multiple methodologies, SW architectures play a fundamental role as they are the center of the development process.

These rapid prototyping techniques have become fundamental in the development process of commercial systems. Nevertheless, UCD methodologies can differ depending on which aspect of the interaction they put their focus on. Some methodologies aim to optimize the most common tasks (Usage-Centred Design); others focus on the context of the user (Rapid Contextual Design), while others propose the construction of models aiming to fulfill the users' needs and goals (Goal-Oriented Design).

2.1.5 Design for All

Contemporary interactive technologies and environments are used by a large multitude of users with diverse characteristics, needs and requirements, including able-bodied and disabled people, people of all ages, people with different skills and levels of expertise, people from all over the world with different languages, cultures, education, etc. Additionally, interactive technologies are penetrating all aspects of everyday life, including communication, work and collaboration, health and well-being, home control, public services, learning and education, culture, travelling, tourism and leisure, and many others. Stationary, mobile and ambient technologies targeted to satisfy human needs in the above contexts proliferate. A wide variety of devices is already available and new ones appear every day.

In the context outlined above, interaction design acquires a new dimension, and the question arises of how it is possible to design systems that permit systematic and cost-effective approaches to accommodate all users. The term **Design for All** (or Universal Design - the terms are used interchangeably) is rooted in engineering disciplines, such as, for example, civil engineering and architecture. In the context of HCI, the term is defined as [3]: "the conscious and systematic effort to proactively apply principles, methods and tools, in order to develop IT&T products and services which are accessible and usable by all citizens, thus avoiding the need for a posteriori adaptations or specialized design".

Design for All promotes a design perspective that eliminates the need for "special features" and fosters individualization and end-user acceptability. Design for all, in contrast to the common practice of designing a single solution for an illusionary "typical" or "average" user, suggests the development of products integrating numerous alternative solutions that allow them to adapt in order to suit the broadest possible end user population.

Brief history

Design for All in HCI is rooted in the fusion of three traditions, namely: (i) Human-centered approaches to Human-Computer Interaction, placing the user at the centre of design and development process (aka user-centred design); (ii) accessibility and assistive technologies for disabled people; (iii) Universal Design in architecture and the built environment.

From User-centred design to Design for All

User centered design [6-8] is an approach to interactive system design and development that focuses specifically on making systems usable. User centred design is the only design methodology that puts users at the heart of the design process.

The International Usability Standard, ISO 13407, specifies the principles and activities that underlie user centred design:

- The design is based upon an explicit understanding of users, tasks and environments.
- Users are involved throughout design and development.
- The design is driven and refined by user-centred evaluation.
- The process is iterative.
- The design addresses the whole user experience.
- The design team includes multidisciplinary skills and perspectives.

The chief difference from other product design philosophies is that user-centred design tries to optimize the product around how users can, want, or need to use the product, rather than forcing the users to change their behavior to accommodate the product. User centred – design emphasizes the importance of understanding and identifying the details of the context in order to guide early design decisions, and to provide a basis for specifying the content in which usability should be evaluated.

While user centered design focuses on maintaining a multidisciplinary and user-involving perspective into systems development, it does not specify how designers can cope with radically different user groups.

From accessibility and Assistive Technologies to Design for All

Accessibility in the context of Human Computer Interaction (HCI) is traditionally associated with disabled and elderly people and reflects the efforts devoted to the task of meeting prescribed code requirements for use by people with disabilities. For example, someone with limited seeing functions will not be able to use an interactive system which only provides visual output, while someone with limited bone or joint mobility or movement functions which affect the upper limbs will encounter difficulties in using an interactive system which only accepts input through the standard keyboard and mouse.

Accessibility in the context of HCI is strongly related to universal design when the approach involves "direct access." This is about making things accessible to all people (whether they have a disability or not).

The concept of Interaction Styles refers to the different ways of communication between a human and a computer based on a technological platform through interaction techniques which are “way of using a physical input/output device to perform a generic task in a human-computer dialogue”.

An interaction style is a set of perceivable interaction artifacts used by the user (through an interaction technique) or the system to exchange information. Typical examples are menus and direct manipulation.

Interaction styles compose the user interface of a system. User interaction with artifacts results from a physical action. A physical action is an action performed either by the system or the user on a physical device. Examples of input physical actions include pushing a mouse button or typing on a keyboard. Different interaction techniques and styles exploit different sensory modalities. In practice, the modalities related to seeing and hearing are the most commonly employed, but haptics is also used.

Given human diversity regarding the involved functions, accessibility requires the availability of alternative devices and interaction styles to accommodate different needs.

In traditional efforts to improve accessibility, the main direction followed has been to enable disabled users to access interactive applications originally developed for able-bodied users through appropriate assistive technologies.

Assistive technology or adaptive technology (AT) is an umbrella term that includes assistive, adaptive, and rehabilitative devices for people with disabilities and also includes the process used in selecting, locating, and using them. AT promotes greater independence by enabling people to perform tasks that they were formerly unable to accomplish, or had great difficulty accomplishing, by providing enhancements to, or changing methods of interacting with, the technology needed to accomplish such tasks.

Assistive technology is the creation of a new device that assists a person in completing a task that would otherwise be impossible. Assistive technology products are designed to provide additional accessibility to individuals who have physical or cognitive difficulties, impairments, and disabilities. Some examples of assistive technologies include computer software programs and inventions such as assistive listening devices, including hearing aids, and traffic lights with a standard color code that enables colorblind individuals to understand the correct signal. Also examples of assistive technology include screen readers and Braille displays for blind users, screen magnifiers for users with low vision, alternative input and output devices for motor impaired users (e.g., adapted keyboards, mouse emulators, joystick, binary switches, specialized browsers, and text prediction systems).

Assistive Technologies provide product-level and environment-level adaptation of applications and services, originally developed for able-bodied users. The need for more systematic and proactive approaches to the provision of accessibility has led to the concept of Design for All. Such shift from accessibility to design for all is due to: (i) new developments in technology; (ii) increased social interest for people at risk of exclusion, including not only people with disabilities, but any person who may differ with respect to language, culture, computer literacy, etc.

From Universal Design to Design for All in HCI

The term Universal Design was coined by the architect Ronald L. Mace to describe the concept of designing all products and the built environment to be aesthetic and usable to the greatest extent possible by everyone, regardless of their age, ability, or status in life [10]. Although the scope of the concept has always been broader, its focus has tended to be on the built environment.

Universal design refers to broad-spectrum ideas meant to produce buildings, products and environments that are inherently accessible and usable to older people, people without disabilities and people with disabilities. Universal design benefits people of all ages and abilities.

Universal design is not a design style, but an orientation to design, based on the following premises:

- Disability is not a special condition of a few;
- It is ordinary and effects most of us for some part of our lives;
- If a design works well for people with disabilities, it works better for everyone;
- Usability and aesthetics are mutually compatible.

A classic example of universal design is the curb cut (or sidewalk ramp), initially designed to for wheelchair users to navigate from street to sidewalk, and today widely used in all buildings. Other examples are low-floor buses, cabinets with pull-out shelves, as well as kitchen counters at several heights to accommodate different tasks and postures.

Perhaps the most common approach in Universal Design is to make information about an object or a building available through several modalities, such as, for example, Braille on elevator buttons, and acoustic feedback for traffic lights. People without disabilities often can benefit too. For example, subtitles on the TV intended for the deaf people can also be useful to non-native speakers of a language, or to someone watching TV in a noisy environment.

The Center for Universal Design at North Carolina State University expounds the following principles:

- Equitable use
- Flexibility in use
- Simple and intuitive
- Perceptible information
- Tolerance for error
- Low physical effort
- Size and space for approach and use

In the context of HCI, the above mentioned concepts have been revisited at the end of the nineties to denote design for access by anyone, anywhere and anytime to interactive products and services.

The term **Design for All** either subsumes, or is a synonym of terms such as accessible design, inclusive design, barrier-free design, universal design, each highlighting different aspects of the concept.

In the context of HCI, the term is defined as "the conscious and systematic effort to proactively apply principles, methods and tools, in order to develop IT&T products and services which are accessible and usable by all citizens, thus avoiding the need for a posteriori adaptations or specialized design" (Stephanidis et al. 1998).

This entails an effort to build access features into a product starting from its conception, throughout the entire development life-cycle.

Design for All in HCI implies a reconsideration of traditional design qualities such as accessibility and usability.

Accessibility is the degree to which a product, device, service, or environment is available to as many people as possible. Accessibility can be viewed as the "ability to access" and benefit from some system or entity. Accessibility is strongly related to universal design when the approach involves "direct access." This is about making things accessible to all people (whether they have a disability or not).

Usability is the capability of all supported paths towards task accomplishment to “maximally fit” individual users’ needs and requirements in the particular context and situation of use. [9]

3 Accessibility assessment & VERITAS

3.1 User testing and people with disabilities

Accessibility evaluation with users presents all the challenges of standard user evaluation methods (costly, time consuming, difficulty to obtain test subjects etc.), along with additional challenges. It is extremely difficult to gather a large number of users and even more difficult to cover all possible disabilities with a corresponding user sample. While disabilities are generally grouped into 4 high-level categories (visual, auditory, physical and cognitive), there is actually a huge diversity among people in the same group of disabilities and the interaction experience is vastly different. For example, people with visual disabilities include a middle-aged woman who has low vision since birth and is very experienced with screen magnification software, a young man who recently went totally blind from retinitis pigmentosa and is a new screen reader user, an elderly woman whose sight is deteriorating from macular degeneration yet she doesn't use any assistive technology, and a young boy whose color blindness has not yet been diagnosed.[11]

VERITAS presents a viable solution to this problem by allowing developers to create Virtual User Models with any diverse characteristics and run a number of tests that should identify and present potential pitfalls or fails of the application tested. These tests include automatic tests performed rapidly that determine whether certain tasks can be performed by users with specific characteristics. This does not mean that the need to test with real users in real conditions will be eliminated. However, it does mean that a large number of preliminary tests can be conducted without real users, in order to identify the most severe problems. In addition, this testing can occur during design and early development and therefore pre-emptively address accessibility issues, when the cost of correcting them is not prohibitive. The inclusion of the VERITAS tools into the design methodology, as it will be discussed further in section 4 raises the awareness of designers and developers to the needs of people with disabilities and ensure that the developed application conforms to the vision of an information society accessible to all.

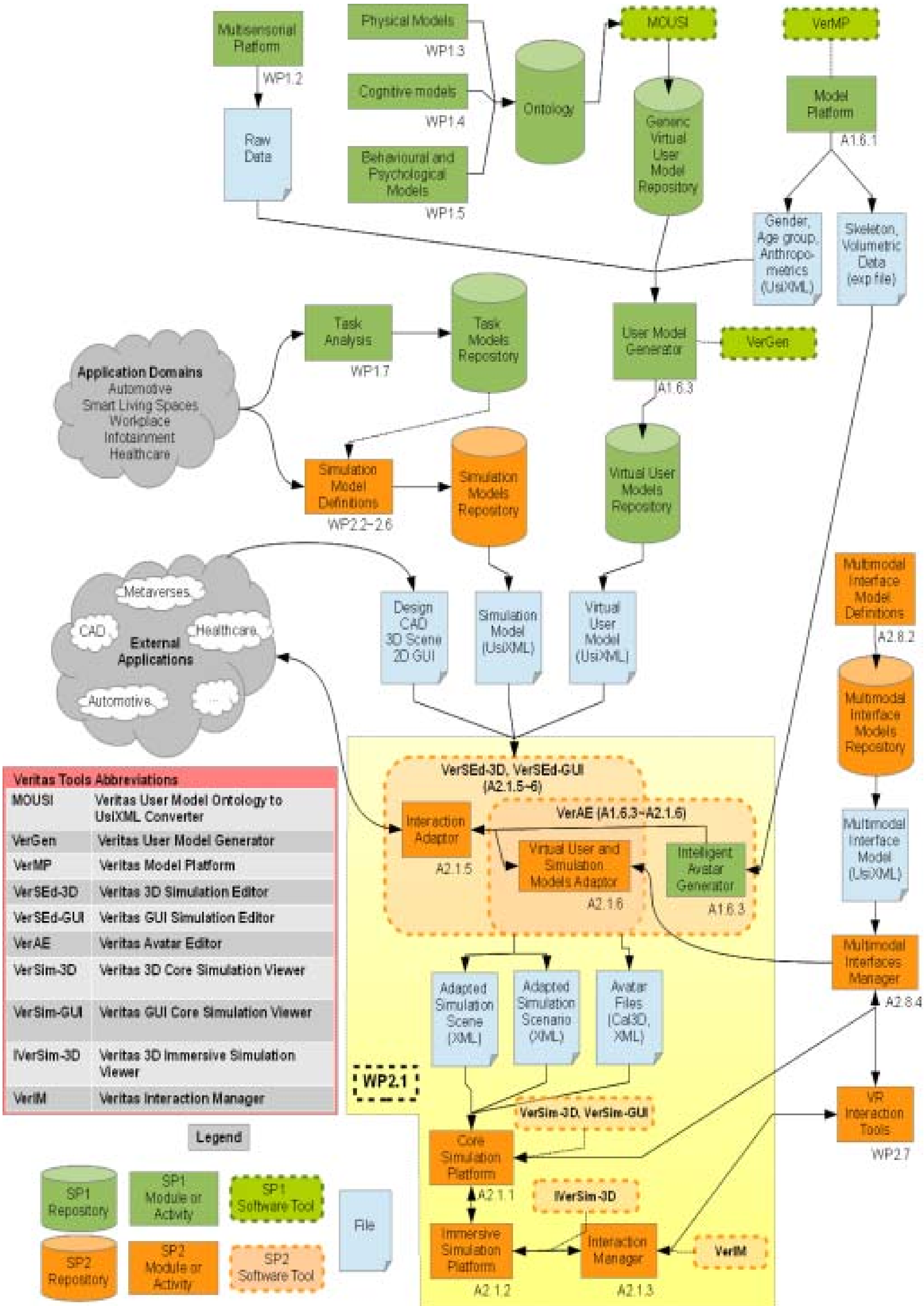

Figure 2: VERITAS Global architecture [33]

3.2 VERITAS tools

This section provides an overview of the VERITAS tools along with a brief description of operations. The information has been consolidated from the user manuals of each tool.[23-27]

3.2.1 Avatar Editor (VerAE)

Below, we describe the operations that can be performed with the editor.

- **Skeleton Conversion** - User can perform a conversion from Ramsis to the Veritas skeleton.
- **Alter height** – Alter weight - User can also alter height and weight of the input model. If the input model is not loaded from an .exp, the information of weight is not available.
- **Alter total Body Size** – Alter torso size - User can changes total body size. The maximum scaling factor is 2 and the minimum scaling factor is 0 in which the model returns to its original size. Additionally user can alter torso size. User has three torso scaling options: a. total torso, b. lower torso, c. upper torso. The maximum scaling factor is 2 and the minimum is 0 in which the model returns to its original size.
- **Cutting limbs** - Furthermore, user can select the limbs that he wants to remove. Except from that, user can set a smaller length for the desired limb.
- **Seamless Fix** - An automatic "seamless fix" algorithm is activated, when user selects the "Seamless Fix" checkbox which fixes the avatar if it is not in its initial values.

The edited model can be saved in cal3d .xml format. It is also supported mesh colorization. At the end The VerAE can import poses from the RAMSIS format and export cal3D skeletons in the required pose or as separate joint rotation data files.

3.2.2 VerGEN

The VerGEN is the user model generator of VERITAS toolbox. Creating new user models or make changes to existing ones is essential for later use with other software tools. As well as with VerGEN user can select a disability from a drop down menu and create a user model with different parameters.

3.2.3 VerMP

VERITAS demostrator V3.0 is a platform that creates new user models that are referred to automotive solutions.

3.2.4 VerSEd-GUI (VERITAS GUI Simulation Editor)

This tool introduces many physical simulation models and their most noteworthy features and gives to the end users a good idea of its actual way of use. Data structures and internal functionality are issues that managed carefully by a simple and easy to use user interface.

3.2.5 VerSEd-3D (VERITAS 3D Simulation Editor)

This tool is used to convert a 3D model of a design (e.g. Automotive, Workplace etc.) into a physical simulation model. The Simulation Model Adaptor performs the tasks of adapting. The design of a 3D scene whether it refers to an automobile, a building or equipment, when exported in any Standard, Pseudo-Standard or Proprietary 3D format, it still represents only the geometric entities of the designs. The features of the Simulation Model Adaptor are:

- Allocation of simulation parameters to the object
- Definition of Scene Rules for the simulation of this object
- Definition of Interaction Sets of Physical objects in a design
- Definition and parameters of interactive objects of the design
- Which objects are interactive
- Which primitive interaction tasks are supported by them
- What are the parameters of the interactive objects that affect interaction (degrees of freedom, mass etc.)
- Definition of interaction requirements and outcomes

3.2.6 VerSim-3D (VERITAS 3D Simulation Viewer)

This tool can simulate how a task would have been performed by an impaired person by simulating physical body movements in a specified simulated environment (scene). To perform a simulation you will need an avatar model, a user model, a 3D scene and a scenario.

3.2.7 VerSim-GUI (VERITAS GUI Simulation Viewer)

This tool is used to simulate the processed scenario files produced by the VerSEd-GUI. It is also needed one or more user models and the original desktop or web based application. The output of VerSIM-GUI is the simulation itself; either it is real time or automatic.

3.2.8 VerMIM

This tool is used to add Multimodal functionality in the rest of the VERITAS tools. The process is provided in section 4.7, presenting the process and steps to be followed as recorded in D2.8.2.

4 VERITAS and Design Methodologies

Having examined the basic methodologies and principles that focus on the user and the diversity among users in section 2 and each of the VERITAS tools in section 3, it is important to examine the design processes that were recorded in WP1.1, D1.1.1 (that is processes before the inclusion of VERITAS tools), for each respective domain and where VERITAS tools fit into those processes. On D1.1.1, the perceived benefits and constraints of VERITAS in the process were also recorded. This section presents the specific nuances in the design processes for each domain, which are then analysed in the next section.

4.1 Automotive

The task of a car or a motorbike design team usually consists of 3 main subtasks: the exterior design, the interior design, and the colour and trim design. In addition, also graphic design is an important aspect of the automotive design [12].The design process in the automotive industry is a long and complex affair with many steps and substeps (see table 1). It is also an industry that has long established practices and likely to resist the introduction of VERITAS tools, at least in a standard project.

Table 1: The automotive design process [12]

I. Design process	II. Product planning	III. Vehicle engineering
1. Concept generation 2. Specify target market 3. Identify customer needs, wants, problems 4. Vehicle description	1. Establish targets for vehicle: quality and environmental performance, styling, cost, 2. Construct clay models 3. Develop corporate business statement, potential sales and profit	1. Determine overall feasibility of vehicle: fit, function, component, compatibility 2. Develop prototypes 3. Verify design intent and adequacy
IV. Product engineering	**V. Process engineering**	**VI. Pilot run**
1. Focus on single vehicle 2. Design individual parts in detail 3. Develop prototypes 4. Conduct extensive testing of parts, components, systems in terms of durability,	1. Design production facilities, processes, tooling 2. Develop production scheduling and flow of materials 3. Design material handling	1. Train production personnel 2. Verify processes and tooling 3. Produce initial vehicles for testing

reliability, noise, ease of maintenance

From the above table it can be deduced that the development process of a new automobile involves phases that are inherent to the domain (e.g., there are separate phases for the vehicle design and engineering and for the inside of the vehicle, as well as a phase for planning and developing the manufacturing process). These are not covered by the more abstract processes described in the previous section. The participants surveyed in D1.1.1 expressed their doubts over VERITAS tools saving time and resources when incorporated into the existing process but overall did not think that it would be a problem. There was a strong belief that using VERITAS tools would lead to design compliance.

The D.2.2.2 work activity [14] focused on the automotive industry and virtual reality. That activity showed that the automotive industry has been familiar with similar software solutions of evaluation and that VERITAS tools could work mostly as an additional step in the existing process but not likely to replace existing practice:

In the automotive area commercial tools like RAMSIS have been used for years to evaluate new designs. Therefore users and engineers in the industry have experience using these tools. Furthermore these tools have been integrated into the engineering workflows. It can be assumed that these users do not want to replace completely their existing evaluation tools. Further it can be assumed that they do not want to implement complete new engineering workflows. Studies showed that the handling of virtual manikin is still a demanding, time consuming task and that ergonomic evaluation tools need more simulation functions. So it is a promising approach to use virtual reality with motion-capture techniques in combination with existing commercial tools. Furthermore a concept and workflow have to be developed to show how these tools can be used in praxis. (quoted from D.2.2.2, page 7)

4.2 Smart Living Spaces

Smart Living Spaces is a new domain compared to the other domains. The technology and infrastructure has only recently been advanced and become affordable enough in order to make ubiquitous computing a reality. Smart Living Spaces is a subset of ubiquitous computing, involving rooms or buildings where people live. There are few facilities worldwide dedicated solely to research in this area, so it is understandable that this domain is still in its infancy and there are no definite correct practices in regards to design. Interaction and experience design in such environments is an ongoing research pursuit. A smart living space can be defined as any electronic environment that is sensitive and responsive to the presence of people. Smart living spaces are populated with sensors, networks, mobile and embedded devices and are context aware. Smart living spaces often control the environment (such as heating, lights, windows and stories etc.) based on inferring algorithms. Such an environment is characterized by services that monitor the user's behaviour, anticipate, adapt and respond to his/her particular needs. Smart living spaces is a domain that many different disciplines meet and where newer technologies and interaction paradigms are being researched. Because of this, all four design guidelines categories in section 5.2 are specifically relevant to Smart Living Spaces.

D2.3.1 [15] presents the process steps of a modified user-centred design approach modified to include VERITAS (p. 29)

The VERITAS Smart Living Spaces Design Process is based on the UCD process presented in the previous section.

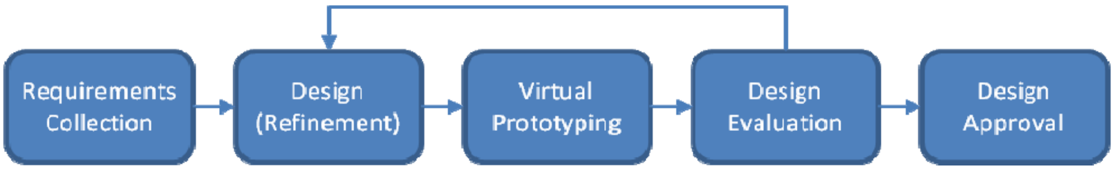

Figure 3: The VERITAS Smart Living Spaces design process [15]

The process steps include the following activities:

1. Requirements Collection

- Collection of end-user requirements
  - Constraints and context
  - Functional and technical
  - Usability and accessibility
- Configuration of decision support system for later design evaluation
  - Regulations, normative rules
  - Checklists
- VERITAS: Definition of User and Task models

2. Design (Refinement)

- Architectural design of building using 3D Design tool (CAS, Modeller, CAD, AEC)
- Engineering design of domotics solution using Smart Devices library, Device Network editor
- Outcomes: (Refined) Technical specifications of building and its technical infrastructure

3. Virtual Prototyping

- Export of 3D models to simulation using A2.1.4 data conversion plans/tools

    - Fidelity increasing from low to high over iterations
    - Static, non-functional base of prototype
- Functional virtual prototype by integration of domotics simulation
    - Placement of Devices in architectural 3D model
    - Definition of Device behaviour
- Integration of virtual User and Task models

4. Design Evaluation

- Application of VERITAS Development Support System for Smart Living Spaces with Designers and Engineers
    - Immersive building simulation
    - Smart Devices simulation
- User requirements evaluation
- If refinement is needed, go back to step 2, else proceed to step 5.

5. Design Approval

- Application of VERITAS Development Support System for Smart Living Spaces with Customer
- User requirements approval
- Preparation of implementation, i.e. construction of building

Figure 4 shows the overall design flow for Smart Living Spaces as used by the VERITAS project, as shown in D2.3.2 [34]. Following this design flow, a smart environment is developed in 6 consecutive design phases:

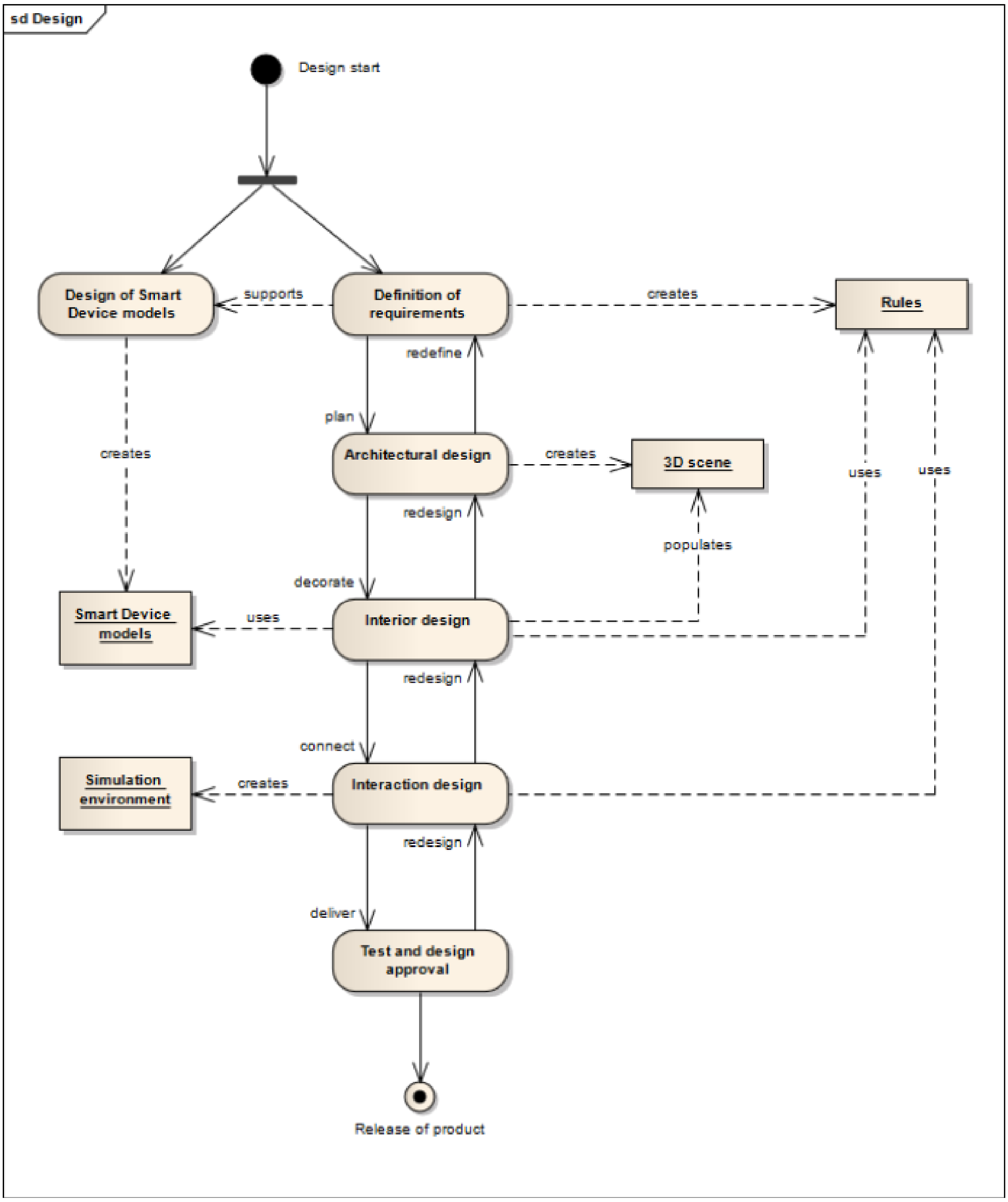

Figure 4: Design flow for Smart Living Spaces as used by the VERITAS project [34]

1. Design of Smart Device models: Creating the virtual models of the devices involved in the simulation scenario,

2. Definition of user requirements: Defining the requirements for a smart environment,

3. Architectural design: Designing the architectural aspects of the living area, e.g. the house, flat or room,

4. Interior design: Designing the interior of the living area. This includes the selection of goods and domotic devices.

5. Interaction design: Designing the interaction between devices and users

6. Test and Design Approval: Evaluation of the design(s).

Work activity D2.3.3 (Integrated Smart Living Spaces (SLS) System with the VERITAS simulation environment) [16], which describes the testing of two SLS prototypes into the VERITAS tools reports:

The integration of the VERITAS tools with the Smart Living Spaces appliances from Indesit represents a good experiment into the adoption of specific tools that could support a Design for All approach in the industrial design process. It is considered that they could constitute an additional tool in the process, to be used since the very early phases of the design development, and not only at the end of it, to evaluate a given design. Moreover, they could be used together with the User Centered Design methodology (UCD), and they shouldn't be meant to replace direct observation of the users in their context and user's involvement in the design process, as it happens in Participative Design. In fact the rich and insightful findings that can be gathered through User Centered Design methodology, give back much more than data, design guidelines or system requirements to the design process: it opens opportunity spaces for design and innovation beyond the first visible needs.

To conclude, it is suggested that the use of VERITAS tools needs to go together with UCD methodology and that VERITAS approach should go beyond the single impairment, aiming to a «Design for All» approach, while solving those particular design problems emerged from simulating specific impairments.

4.3 Office workplace

As technology becomes an increasingly important part of the activities carried out at work, innovative workplace design is no longer just a question of architecture in the sense of spatial arrangement and furniture. Instead of a linear and successive design process, it has become a process that simultaneously takes into account the physical space, the furniture, the technological support, the activities that are going to take place within the workplace and the accessibility and usability issues. The office workplace is a special domain where characteristics of smart living spaces and computer supported co-operative work are combined. The office workplace can be a standard PC configuration or it can be an office of the future, a true ubiquitous environment, with the blending of the physical and the virtual. For the latter, the set of generic guidelines regarding large displays, touch and gesture interfaces, as well as the mobile design guidelines are relevant to this domain.

As per D1.1.1, the design process of an office workplace has the following steps:

- Functional brief
- Design brief
- Design planning
- Conceptual design
- Detailed design
- Documentation

- Construction
- Occupancy

It is noted that participants in the survey regarding office workplaces expressed their concerns over additional costs piling up with the introduction of VERITAS tools in the design process. On the other hand, they expected that VERITAS tools can assist design compliance.

In the guidelines section, all the relevant guidelines and compliance standards regarding the office workplace are listed (taken from ID2.4.1 [20]).

4.4 Infotainment and Games

"Infotainment" as Wikipedia explains is "a neologistic portmanteau of information and entertainment, referring to a type of media which provides a combination of information and entertainment". For the purposes of this work, "infotainment" is used to denote the devices and applications that are aimed towards the delivery of information or entertainment. This means home media entertainment systems, such as a large screen or TV coupled with a media center or a modern gaming console which offers various entertainment services, as well as games. The purpose of this section is not to provide design guidelines for games or infotainment applications. It is rather to emphasize that this domain is the most "guilty" of exclusion of people with disabilities. Efforts are made towards accessible games (e.g. UA-Chess [39]), which are games designed to be accessible by all, in accordance to the Design for All philosophy. The key to such games, as indeed any universally accessible application is multi-modality. Mainstream games on the other hand usually include several options to facilitate users with various disabilities. ID2.5.1 [21] focuses on Metaverses (virtual environments) and reports the findings of evaluating several popular games and summarizes the issues faced by people according to the main classes disabilities

The domain of Infotainment is huge and encompasses many vastly different manifestations, spanning different industries and disciplines. It is impossible to pinpoint a particular methodology that suits every type of infotainment service. Instead, the emphasis should be placed on the fact that accessibility is notoriously missing from the gaming industry, where accessible games are a rarity and that any type of infotainment would greatly benefit from Design for All principles. Since the manufacturers of infotainment span across different industries (Gaming, TV and Movies, Automotive, Home Media, Web, etc.) it is unrealistic to consolidate each respective practice into one methodology. Nevertheless, it should be noted that the design guidelines in section 5 that are categorized by application domain are applicable to the infotainment domain, just as they are for most application domains.

4.5 Healthcare

Currently, systems have been created and optimized to handle acute illnesses, but most healthcare expenditure is due to chronic diseases, which are likely to increase in the near future. It is recognized that the incidence of these kinds of diseases can be reduced with proper early prevention, by means, for instance, of health promotion and citizen empowerment in the management of their own health. This requires a shift in the current health provision from an illness-centric to a patient-centric approach and the healthcare boundaries are widening from the hospital to the patient's homes. The patient of today is increasingly well-informed and motivated.

Healthcare is becoming ubiquitous, personal and mobile and will involve formal caregivers (medical professionals) but also and more often informal caregivers (relatives, friends, volunteers, etc.). [18]

Deliverable D2.6.3 [18] reports the design and development methodology used along with the introduction of VERITAS tools. Basing the observations on the user manuals of VERITAS tools and conducting a training to learn their use in the pre-pilot activity (see D3.7.1), it seems that VERITAS tools will bring some changes in the current methodology.

The methodology used to design PC@Home had three iterative phases, following the basic pattern of UCD:

- **requirement and design phase**, where the users and their context as well as the functional and non-functional requirements of the system are defined;
- **development phase**, where increasingly complex prototypes are built according to the functionalities defined;
- **evaluation phase**, where the prototypes are tested with users.

The results of the evaluation phase are then analysed, and may be used to refine the requirements, the user models or any other aspect of the previous phases.

VERITAS tools will have an impact on each phase of the methodology (see Figure 5) and it is expected also that such a strong involvement of end-users, as it is in the current methodology, will not yet be necessary, in other words with VERITAS tools a minor involvement of users will allow to reach the same quality of results.

In the Requirements engineering phase designers could use the VERITAS User Models (VUMs) in order to evaluate requirements that are identified in design sessions. Developers will use the VERITAS simulation platform to define scenarios that allow to evaluate and analyse specific contextual situations. This could be done by testing the scenarios with different user models.

Also in the Design phase there could be some changes: designers will evaluate preliminary mock-ups and design ideas by using the VERITAS user models (VUMs). These provide information about restrictions and possibilities of specific users. This approach will allow to create mock-ups much more adherent to the user's needs.

In the Development and UI testing unit phase developers will take advantage from the use of VERITAS simulation platform making tests on the functionalities of the application UI. Each specific module could be simulated and the usage of the particular UI could be tested with different user models. If in the design phase the designer used the tools to reach the best mock-up, it will be expected to obtain a successful outcome in this phase.

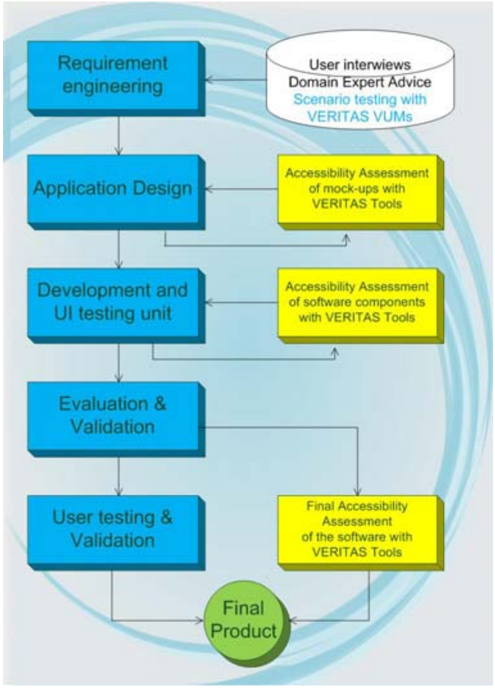

Figure 5: Design methodology used in D2.6.3 [17] as modified to include VERITAS tools in the process.

ID3.5.1 [22] describes the integration of VERITAS tools into discreet steps of the design process in the design refinement phase. Spanning the Application Design and UI testing phases of figure 4, the modified methodology includes a sub-phase of validating the prototype designs with the corresponding validation scenarios produced in the previous phase (requirements engineering / requirements definition). This phase includes the following steps (reproduced from ID3.5.1):

Step 1: Record an interaction session

Once the initial GUI (look and feel) is created for the specified application in this phase (refinement), an interaction session has to be recorded using the VERITAS GUI Simulation Editor (VerSEd-GUI) [24].

As described in [25], with this tool the user's activity is captured. After this, (second step) the tool will be used to proccess task models that produce, at the end, the validation scenario files.

After loading a task model file (according to VERITAS task model specification), the prerecorded user driven events can be directly connected to tasks during the processing phase. In this way, the developer can capture mouse and keyboard activity in a specified area of the screen during the recording phase.

Using the VerSEd-GUI the developer initiates the recording of time stamped input events along with screen captures during these events, and performs a session that covers the tasks described in the simulation model that have already been defined as an interaction workflow (see VERITAS D2.6.1 [26]) for the application, including key inputs which affect it, as well as the corresponding outputs that are affected by it.

Step 2: Matching of the recorded simulated scenario to the simulation model

When the recording is over, the developer marks the areas on the prerecorded user driven events corresponding to the UI elements involved in each task, and matches them to the objects described in the task model file (i.e. the models that have already been defined in VERITAS D2.6.1 [26] for the different healthcare applications) during the processing phase.

For every task defined in the model, the different events are associated with the images of the GUI that have been captured in Sub-Step 1.

The outcome of this process is a simulated scenario file that describes the user's activity on every simple task as defined in the tasks models (the interaction key path).

This is one of the most important stages of the methodology, being able to assign to every single event the interactions that are taking place when using the GUI.

Step 3: Replay the interaction using a user model with impairments

The last sub-step consists in evaluating the interaction using the different user models with disabilities and check if the interface is accessible.

To do this, the resulting task model created in Sub-Step 2 has to be exported as a scenario file ready to be reproduced in the VERITAS GUI Core Simulation Viewer (VerSim GUI) [27] using various virtual user models (covering the different type of users addressed by VERITAS).

The developer uses this tool to playback the user's activity in the application previously recorded by the VerSEd-GUI (VERITAS GUI Simulation Editor). By loading different user models, VerSim-GUI can simulate how a task would be performed if an impaired person had used a specific graphical user interface.

The GUI Core Simulation Viewer will apply filtering based on the impairments parameters that affect for instance, mouse motion path, mouse target position accuracy, key entry accuracy, speed of motion and mouse button press and release, visual representation of the GUI, delay in cognitive understanding of UI elements, etc.

4.6 Public Spaces

Public Space is an application domain that was chosen to be incorporated into the list of application domains VERITAS is being tested on. Public spaces are defined as spaces which are accessible to the public, such as roads, parks, public squares (open spaces) or public libraries, train stations, museums (which can be inside a buidling) etc. In the interest of this section, the domain is used to denote any ICT service, device or application that is available to the public in any kind of space, regardless of ownership (private or public). ATMs are an example of that but also vending machines, information kiosks and interactive displays in public spaces (such as airports or train stations, museum exhibits, interactive walls) etc.

The reason this particular domain was selected was for its obvious target group of users. By definition a public space should be available to all. This makes it ideal to employ the Design for All principles and thus explore the rich potential of the VERITAS framework in facilitiating the application of those principles (see also sections 5.2.1 and 5.4.6)

4.7 Adding multi-modal support: VerMIM

VerMIM was chosen to be presented in this section as it is a tool that facilitates the design and implementation phase and is of critical importance, since multimodal support is key in order to provide a truly accessible by all service. Work activity D2.8.2 [19] describes the methodology of adding the Multimodal Interfaces functionality to the rest VERITAS tools. The methodology steps are split into two main stages:

- **Adaptation stage:** this stage contains the user's assignment of alternative interfaces to the simulated environment objects and components, either 3D scene or GUI, e.g. the assignment of a speech recognition interface to a virtual telephone device. Moreover this stage requires the definition of the alternative tasks contained in the Multimodal Interfaces Models.

- **Runtime stage:** this stage contains the analysis of the Virtual User Model file and identification of the virtual user's affected modalities. It also contains the prioritization process on the selection of the alternative task sequences. The modality compensation and replacement process also takes place in this stage.

The two stages along with the tools involved and the actions that are performed are presented in table 2

Table 2: The two stages of adding and using the Multimodal Interfaces in the VERITAS applications [19].

Stage	Tools Involved	Sequence of Actions
Adaptation	VerSEd-3D, VerSEd-GUI	a. Manually assign the multimodal and alternative interfaces to the: • 3D virtual objects, if it is about 3D environment simulation (i.e. non-ICT products). • GUI components, i.e. buttons, text input boxes, alert message boxes, etc. b. Perform an automatic analysis of the loaded

<table>
<tr><th>Stage</th><th>Tools Involved</th><th>Sequence of Actions</th></tr>
<tr><td></td><td></td><td>Simulation Model and automatically produce alternative task sequences that use a variety of modalities, using the Multimodal Interfaces Models.

c. Manually define each alternative task of each produced task sequence.</td></tr>
<tr><td>Runtime</td><td>VerSim-3D,

VerSim-GUI,

IVerSim-3D &

VerIM</td><td>a. Automatically, perform an analysis of the Virtual User Model’s disability model and find the affected modalities.

b. Perform the modality compensation and replacement process. This process is defined by the presence or not of a real user in the simulation session:

☞ If automatic simulation, i.e. if not a real user is present, perform an analysis of the loaded Simulation Model and automatically produce alternative task sequences using the Multimodal Interfaces Models. Then sort the alternative sequences list, putting first the sequences that contain the most tasks which remain unaffected and run the first sequence. This process defines that the modality compensation is based on prioritisation rules and involves the tools: VerSim-3D and VerSim-GUI (the latter running in automatic mode).

☞ If immersive or interactive simulation, i.e. if a real user is involved, enable the interfaces that have been already defined in the adaptation process and run the default task sequence defined in the simulation model. If a task fails, repeat the process using now a task with another modality based on the multimodal interface models. This process defines that the modality compensation is based on modality replacement and involves the VerSim-GUI (running in interactive mode) and IVerSim-3D tools.</td></tr>
</table>

5 Guidelines

5.1 Introduction

This section of the deliverable presents a set of design guidelines, recommendations, warnings and where applicable, standards for the use of any designer or developer who works with VERITAS tools. These guidelines have been gathered from various deliverables of the VERITAS project, as well as from literature of the design discipline.

The first goal was to gather all findings from the various activities in VERITAS. Producing design guidelines from those findings proved to be a difficult task as the project is still ongoing and there are various technical issues to be sorted out before such results can be achieved. In order for more concrete and rigorous guidelines to be drawn, further testing in each application domain should continue. The guidelines found in section 5.3 vary in their scope, particularilty and applicability. In order to present a more useful framework, it was decided to include various guidelines that have been formed over the years of research and practice in domains and technological areas that were deemed relevant to the VERITAS project and the application domains being researched within the project.

5.2 Generic guidelines

This section presents design guidelines and principles that apply to all application domains. The focus is on Universal Design and its 7 principles, since those are the guiding principles that designers should strive to achieve Design for All and accessibility to everyone. The VERITAS framework is an effort to support these principles, so they should be the starting point of conceptual design. There is also a small section on colour, with some practical advice on its use in design, to avoid common pitfalls, as well as a few tips.

5.2.1 The 7 principles of Universal Design

The 7 Principles of Universal Design were developed in 1997 by a working group of architects, product designers, engineers and environmental design researchers, led by Ronald Mace at the North Carolina State University. The Principles "may be applied to evaluate existing designs, guide the design process and educate both designers and consumers about the characteristics of more usable products and environments."

1. Equitable use: The design is useful and marketable to people with diverse abilities

- Provide the same means of use for all users: identical whenever possible; equivalent when not
- Avoid segregating or stigmatizing any users
- Provisions for privacy, security, and safety should be equally available to all users
- Make the design appealing to all users

2. Flexibility in use: The design accommodates a wide range of individual preferences and abilities

- Provide choice in methods of use
- Accommodate right- or left handed access and use
- Facilitate the user's accuracy and precision
- Provide adaptability to the user's pace

3. Simple and intuitive: Use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level

- Eliminate unnecessary complexity
- Be consistent with user expectations and intuition
- Accommodate a wide range of literacy and language skills
- Arrange information consistent with its importance
- Provide effective prompting and feedback during and after task completion

4. Perceptible information: The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities

- Use different modes (pictorial, verbal, tactile) for redundant presentation of essential information
- Provide adequate contrast between essential information and its surroundings
- Maximize "legibility" of essential information
- Differentiate elements in ways that can be described (i.e., make it easy to give instructions or directions)
- Provide compatibility with a variety of techniques or devices used by people with sensory limitations

5. Tolerance for error: The design minimizes hazards and the adverse consequences of accidental or unintended actions

- Arrange elements to minimize hazards and errors: most used elements, most accessible; hazardous elements eliminated, isolated, or shielded
- Provide warnings of hazards and errors
- Provide fail safe features
- Discourage unconscious action in tasks that require vigilance

6. Low physical effort: The design can be used efficiently and comfortably and with a minimum of fatigue

- Allow user to maintain a neutral body position
- Use reasonable operating forces
- Minimize repetitive actions
- Minimize sustained physical effort

7. Size and space for approach and use: Appropriate size and space is provided for approach, reach, manipulation, and use regardless of user's body size, posture, or mobility

- Provide a clear line of sight to important elements for any seated or standing user
- Make reach to all components comfortable for any seated or standing user
- Accommodate variations in hand and grip size
- Provide adequate space for the use of assistive devices or personal assistance

5.2.2 Colour

A few considerations regarding colour are listed below. While colour is of course a major part of any design, this sub-section provides a few notes and guidelines that every designer should keep in mind. Additionally, since VERITAS covers issues with color-blindness and assorted visual disabilities, before tackling those issues by testing in VERITAS, the designer should ensure that some basic principles are followed.

A person with 'normal' colour vision is able to perceive over 7 million different shades of colour. But, only 8 to 10 different colours can be identified accurately, without prior training. About 8% of men and 1% of women are colour blind, most commonly being unable to discriminate between red and green.

At the periphery the eye is least sensitive to red, green, and yellow light and most sensitive to blue light. At the front of the eye, where colour vision is at its best, the eye is most sensitive to red and yellow and is least sensitive to blue

- Small blue objects tend to disappear on the screen, and this is especially true where the blue is pale
- Small changes in shades of blue are difficult to distinguish but the eye is sensitive to small changes in red
- Spectrally extreme colours should not be placed together
    - Thus, blue and red must never be placed together
    - Red, orange, and yellow can be viewed comfortably together
- Dark or dim colours should be used for the background and bright colours for the foreground
- Amount of colour: too many colours in a display increase search times, so they should be used conservatively. Excessive use of colour can result in *Colour Pollution*

Segmentation colour

Segmentation colour is a very powerful way of dividing a display into separate regions.

- Areas that need to be seen as belonging together should have the same colour

Design in grayscale first

According to Scott Klemmer [42] often people rely on colour as a crutch for making visual distinctions in designs. That is not necessarily a wrong approach but it should happen after the tools of typography and layout have been used. A good practical method to approach colour design is to design in grayscale first.

- Use luminance to distinguish between what's more and less important
- Add colour later, preserving the luminance distinctions, in order to provide additional redundant coding for salience

5.2.3 Design Guidelines for interaction modes and techniques

This section provides a set of guidelines independent of application domains. As explained in the introduction this was decided because these technologies and techniques are potentially related to all application domains. It was decided that the guidelines should concentrate on Large Displays, Mobile Devices, Touch-based interaction and gesture-based interaction (often cited as "natural interaction"). Mobile, touch and gestures are often interrelated, since most modern mobile devices (smartphones and tablets) feature a touchscreen that supports gesture interactions. The division of guidelines between those three categories is solely based on the focus of the guideline. However, the designer should note that a proper understanding of all three categories is needed; for example, guidelines regarding gestures are very important for mobile and touch interaction experiences. A brief description of these categories is also included.

Interaction with Large displays

One aspect of the current paradigm shift that is occurring through ICT technologies (introduction of smartphones, tablets, gesture-based interaction, The Cloud) is that the modern consumer of technology interacts with various monitor sizes, ranging from the 3-5 inch monitor of a smartphone (small), to the 10-12 inches of a tablet (medium), to the 15-22 of laptops (medium large) to the desktop monitor sizes. Monitor sizes do not limit desktop interaction size however, since the use of double or even triple monitors (supported easily through modern OS's) is becoming more and more affordable and common (large). Very large displays (projector or LCD based or multi-monitor clusters or VR installations) are also becoming more affordable and are expected to become a common feature in Ambient Intelligence environments. In every domain, including those presented here, Very Large Displays involve particular care in interface and interaction design. This is because while the advantages that they offer have been documented in various publications, the cause of these advantages has not been sufficiently studied. Research cited in Ni et al (2006) [31] finds definite correlation between display size and better usability, task performance, memory retention and decreased context switching. However, the causation of this correlation is not studied and the findings are explained empirically and intuitively. Similarly, there are reports of interaction challenges, which are based on user observance but there are no concrete solutions or guidelines to address every challenge. This is of course explained by the maturity of the technology where it is normal for techniques that will be obvious in a generation are still toyed with in research.

What is important to note is the need to include every user group, including people with disabilities in the ongoing research for Large Displays interaction, from a Design for All perspective. This means to ensure that simulations and evaluations performed by VERITAS (or VERITAS-type) tools are conducted before the development process. Gesture based interaction is specifically common among various Large Displays applications, as well as problems arisen by the incompatibility of desktop based interaction (such as drag and drop or selecting an object) translated into large displays. It follows that many of the design guidelines found under “Gestures” (5.3.4) are also applicable in this section.

Ni et al (2006) provide a comprehensive study of current research on Large Displays. Included in that study is a set of points of concern that should be taken into account when designing an application that uses Large Displays. These are directly quoted below. Note that the following issues also raises concerns regarding large displays that are consisted of a number of monitors next to each other, which presents some particular problems. Such a setup is very common in office workplaces or the home and thus were considered relevant and included in this guide. Every developer using VERITAS should design and rigorously test for the following issues:

- **Reaching distant objects**. As screen real estate grows, it is increasingly difficult for users to access objects scattered around on a wall-sized display especially when they tend to stay relatively close to a large display. For example, if a user seated in front of a large screen tries to drag an icon near the lower right corner to the recycle bin icon on the left, it will be a terrible experience to use a traditional drag-and-drop interaction paradigm. It is also a common problem with more modest multi-monitor configurations, since accessing an icon or window at a distance requires more cursor moving, which takes time and raises cursor-tracking issues. Reaching distant information becomes even harder with heterogeneous monitor configurations (e.g. a SmartBoard combined with a regular LCD panel plus a PDA).
- **Tracking the cursor.** With increased physical screen size, users employ higher mouse acceleration to traverse large displays. The faster the mouse cursor moves, however, the more difficulty users have keeping track of it. In addition, during meetings or presentations with large format display facilities, a speaker is likely to point a cursor at a target to direct audience's attention. Locating a stationary cursor, however, becomes increasingly problematic on large displays.
- **Crossing bezels.** Using multiple monitors is still a popular configuration to gain extra working space. Multi-monitors display bezels are beneficial in allowing users to organize multiple tasks onto different monitors. Problems occur, however, when users cross bezels. A windows or an image may be sufficiently large to occupy several monitors, creating visual discontinuity at bezels. When a cursor traverses across a bezel, there is normally a

discrepancy between its actual traveling course and what users may expect, since there is no virtual space underneath the bezels.

- **Managing space and layout.** Interaction with large high resolution displays imposes many space and layout management issues, especially when windowing systems are used. On desktop displays, various window or task management systems exist, such as Apple Exposé. Effectively handling space and layout on large format displays, however, is by no means trivial.
- **Transitioning between interactions**. Based on tasks a user is likely to perform, interaction with large displays can be categorized into two broad paradigms. For tasks involving dealing with detailed information, working up close to a large display is reasonable. There are other tasks, however, that are best performed from a distance, such as sorting photos and pages or presenting large drawings to a group. Also, large displays often feature touch screen capacity. Consequently, techniques allowing a smooth transition from up-close interaction to interaction at a distance and vice versa are needed.
    - *(taken from Ni et al, 2006)*

Mobile Interaction

Looking at the statistics of mobile device use, it is apparent that mobile devices are currently the most common electronic device: There are more than 6 billion mobile phone connections (2012), out of which "only" 1.1 are mobile-broadband devices. Mobile devices vastly outnumber the number of personal computers; in 2010 there were more than three times as many phones as personal computers in the world.[32] The International Telecommunications Union predicts that by 2014 the world will have more cell phone accounts than people on Earth at the current growth rate. While the market for personal computers continues to grow, mobile phone sales and mobile data usage is outgrowing their PC equivalents nearly 3 to 1. In the U.S. tablets with touchscreen interfaces grew by 400% in 2012. By 2014, 20% of the U.S. population will use touchscreens with "natural user interfaces" as their primary computing device.[43]

It is therefore apparent that mobile devices will be a vital part of any application domain, including all application domains presented in section 5.4.It was therefore decided to dedicate a section to this technology. This section provides basic concepts and design guidelines for mobile interaction.

Hinman (2012) [32] provides a set of guidelines and theoretical background for the design of mobile device experiences. The book (The Mobile Frontier) is a general-purpose guide that applies to any domain that involves the use of mobile devices and serves as an excellent starting point for designers, outlining basic concepts and the major issues of concern. It was used as the primary source for this section.

The following table summarizes the basic constraints and characteristics of mobile interaction that influence every design decision:

Table 3: basic constraints and characteristics of mobile interaction that influence design reproduced from [32]

Mobile Device	Mobile Environment	Mobile Human

constraints	constraints	constraints
Small form factor	Can be used in almost any environment	Easy to lose
T9 and/or QWERTY alphanumeric input	Can be stored in almost any environment	Language and metaphors aren't always appropriate for some cultures
Camera/video	Screen glare can occur in bright sunlight	Focus required for cognition
Battery operated	Sensitive to wear and tear (dropping in water, dust, etc.)	Alphanumeric input is challenging
Cellular, WiFi and Bluetooth network access	Use is prohibited in some environments	Socially awkward or unacceptable to use in some circumstances
Microphone	Unable to use because of lack of network connectivity	Small text and graphics are sometimes difficult to read
Speaker	Electricity is scarce in some environments	Difficult to hear in some contexts
Headphone jack	Financial constraints are based on location (roaming charges, data costs etc.)	Use places high demands on working memory
Sensors		
Accelerometer		

Task switching

Mobile devices are multipurpose and people use them everywhere (e.g., music player, voice calls, text messaging, etc.) The possibility of interruption during use is very high—either by the physical environment or other functions of the device. As a result, users of mobile devices are often in a state of juggling big and small tasks, a behavior known as task switching. Whether it's an incoming call or the arrival of a bus, users of mobile devices must often reshuffle what they're doing based on incoming information and changes in the environment.

The implication of this behaviour is that mobile experiences should be designed for partial attention, distractibility and interruption.

- The interface should avoid forcing users to dive deep into menu structures. Instead it should get people to the content and functionality they want intuitively and quickly.
- The interface should not attempt to present all possible menu options. Instead, it can allow users to "opt in" to information while simultaneously giving them the opportunity to intuitively dive more deeply into the content. That way, it is easy for people to pause and pick up an experience where they left off.

Cognitive Load

The more a user is distracted or interrupted, the more difficult it becomes for him to complete a task. People who seek refuge in a quiet place in order to write in a journal or read a book are in a sense increasing the capability of their working memory. The mobile context, however, is riddled with distractions and interruptions. Creating mobile experiences with an appropriate level of cognitive load is a sensibility most designers new to mobile must develop.

- Make every effort to **reduce cognitive load** and **opportunity cost** required
    - Cognitive load has to do with understanding the impact context has on a user's ability to focus (their working memory).
    - Opportunity cost has to do with understanding user motivation—why a user will choose to engage with a mobile experience based on the other options at their disposal.

Hinman notes that "it requires evaluating your work throughout the design process in a variety of mobile contexts". Evaluation of mobile device applications presents a particularly difficult problem, due to the inherent private nature of the interaction, which makes it unsuitable for observation without affecting the subject's behaviour.

- The VERITAS simulation tools are particularly suited to this task, particularly for ergonomic issues regarding the device. Testing for people with difficulties in their hands and fingers is especially warranted, as touch and gestures are the primary interaction modes of modern smartphones and tablets.
- Speech interaction and other multimodal support is critical for a large number of disabilities, including vision disabilities and motor-movement disabilities of the hands.

- Clear and simple is almost always better.
- Striving for intuitive menu options, screen layouts with low information density, and functionality that is edited to only the essentials are a few of the ways to ensure that the mobile design work reduces cognitive load and opportunity cost.
- Think one big idea per screen and remember that in mobile, clarity trumps density.

Minimise keystrokes.

- Avoid text entry wherever possible.
- Use selection menus or GUI widgets where the possible values are known (e.g., a calendar control for date entry, a list of frequently used contacts to select recipient of SMS or e-mail, controls that increase of decrease numeric values).

The top of the screen is most visible to people, because they tend to interact with the device by holding the device in the following ways:

- In their nondominant hand (or laying it on a surface), and gesturing with a finger of the dominant hand
- In one hand, and gesturing with the thumb of the same hand
- Between their hands, and gesturing with both thumbs
- Put the most frequently used (usually higher level) information near the top, where it is most visible and easy to reach. As the user scans the screen from top to bottom, the information displayed should progress from general to specific and from high level to low level

- Make the path through the information you present logical and easy for users to predict
- In addition, be sure to provide markers, such as back buttons, that users can use to find out where they are and how to retrace their steps
- Strive to make your application instantly understandable to people, because you can't assume that they have the time (or can spare the attention) to figure out how it works
- Make the main function of your application immediately apparent. You can make it so by:
- Minimizing the number of controls from which people have to choose
- Using standard controls and gestures appropriately and consistently so that they behave the way people expect
- Labeling controls clearly so that people understand exactly what they do
- Don't waste screen estate and user attention on processing secondary functions.
- Focus on the primary task and display only the content and controls that are relevant to the user at that moment
- Analyze what's needed in each screen. As you decide what to display in each screen always ask yourself, Is this critical information or functionality users need right now? If your answer is no, decide whether the information or functionality might be critical in a different context, or if it's not that important after all

Inputting information takes time and attention, whether people tap controls or use the keyboard

- If your application requires a lot of user input before anything useful happens, that input slows people down and can discourage them from using your app
- Balance any request for input by users with what you offer users in return
- Sstrive to provide as much information or functionality as possible for each piece of information people give you. That way, people feel they are making progress and are not being delayed as they move through your application
- Make it easy for users to input their choices

Touch-based Interaction

Touch based interaction is an interaction mode that has become widespread in ICT devices through the proliferation of mobile devices that feature a touchscreen, such as smartphones and tablets. As noted in the previous subsection regarding mobile devices they are also expected to be a vital component in any Ambient Intelligence environment of the future and highly relevant to the application domains presented in the next section (5.3). Therefore this section (and the next subsection – 5.2.3.4) should be treated as complementary to the Mobile devices section. Indeed, certain guidelines presented here were adopted from the same source and a few are repeated for the sake of organization, since they belong under both categories. They are however presented separately because they can be treated as generic guidelines for any type of touch-screen, including those found on public spaces installations or in any other context.

Optimize for generous touch targets

The MIT Touch Lab study of “Human Fingertips to Investigate the Mechanics of Tactile Sense” [40] found that the average human finger pad is 10–14mm and the average fingertip is 8–10mm. This means that the minimum touch target that ensures that most users will be comfortable with is 10mm.

- A minimum touch target of 10mm X 10mm is a good estimate/rule of thumb to apply to all touchscreen designs. Hinman says: “for desktop designers, this will feel ridiculously large—toy-like even! But have faith, it’s important to make touch targets easy for users to engage with”

Support users’ ability to switch views—landscape to portrait and back again

Having to consider every element of your application in these two sometimes radically different layouts is like designing for two devices. The designer should put an effort to keep the experience consistent in each view, allowing for a seamless user experience when switching views.
The limited screen estate and the limited credit on the number of physical actions needed to complete one task (“don’t make me swipe and touch too often”), should inform the designer to create a very simple information architecture and an elaborate interaction design pattern with a minimal number of actions.

- This goes hand in hand with the economic rule of user interaction design: Minimize input, maximize output.
- Since the smallest touch point for each operation is a circle of the size of a male index finger tip, it is strongly recommended to avoid including a myriad of features in the tight frame. Instead the designer should focus on the essential elements.
- Don’t waste screen estate and user attention on processing secondary functions.
- Focus on the primary task and display only the content and controls that are relevant to the user at that moment
- Analyze what’s needed in each screen. As you decide what to display in each screen always ask yourself, Is this critical information or functionality users need right now? If your answer is no, decide whether the information or functionality might be critical in a different context, or if it’s not that important after all
- Make the main function of your application immediately apparent. You can make it so by:
- Minimizing the number of controls from which people have to choose
- Using standard controls and gestures appropriately and consistently so that they behave the way people expect

The top of the screen is most visible to people, because they tend to interact with the device by holding the device in the following ways:

- In their nondominant hand (or laying it on a surface), and gesturing with a finger of the dominant hand
- In one hand, and gesturing with the thumb of the same hand
- Between their hands, and gesturing with both thumbs

Smartphones are often used one-handed. Touchscreen interfaces must not only be aesthetically pleasing, but also should be organized for the fingers, especially the thumb. It’s the finger that gets the workout and the reason why most major interface elements are located at the bottom of the screen instead of the top.

- Smartphone orientation and navigation control placement:

  Ideal placement for primary navigation controls relative to the device orientation. For portrait orientation place the primary navigation elements at the bottom of the screen. For landscape orientation, placement of the primary navigation controls would be better on a vertical column on the right side (for a right-handed user) or the left side (for a left-handed user),where the thumb can reach comfortably.

- Tablet orientation and navigation control placement:

  Curling up. Tablet experiences that encourage the “curling up” user stance opt for navigation at the top and consider incorporating horizontal gesture controls

  The clipboard. For tablet experiences in which the user will often be holding the tablet like a clipboard, consider placing the navigation at the top where it’s easy to see.

  Multitasker.For active tablet experiences where the user will likely be multitasking with other objects or devices, opt for placing the primary navigation at the top and/or the bottom. Tablets used in this configuration are often resting on tables/desks/hard surfaces making placement along the bottom of the screen a viable space for navigation and controls.

VERITAS tools for the evaluation of reachability

The above recommendations regarding the placement of navigation controls overlaps with recommendations for gestures (see section 5.2.3.4) as it concerns both layout considerations and usability considerations regarding gesture control. Therefore:

- Test various postures and orientations with different VUMs to establish the most likely (in some cases, it could be the only) posture to be adopted by the respective user.
- Test with various VUMs for the reachability of the interaction zones for every orientation that succeeds in the previous step.

Scrolling

A thing that seems to work better on touch-based mobile devices than on desktop computers is scrolling: it's easier to scroll using fingers than using the mouse, and people expect to be scrolling a lot

- Therefore, the lower part of the screen (including the footer) tends to be more accessible than on the desktop
- The footer can be used in order to avoid scrolling back up to the top of the page

Gesture-based Interaction

This section is concerned with gesture interaction. Gesture interaction can be divided into two major categories: touch-based gestures, where the user inputs gestures by directly touching a touchscreen and hand motion gestures (usually) that are recognized and interpreted by the system via cameras or sensors. An example of the touch-based gesture interaction would be operating a smartphone or tablet. An example of hand gestures would be Microsoft's Kinect system or Nintendo's Wii. The inclusion of this interaction mode was deemed necessary as gesture-interaction from both categories is becoming very widespread and is relevant to all application domains. The argument regarding mobile and touch interaction is also true of gesture interaction but hand gesture recognition through cameras is an interaction mode that will be seen across various applications and domains in the future. The Infotainment and Games domain is the most obvious, having been the domain that made body gestures popular to the public. But gesture interaction is employed in other domains as well. For example installations in public spaces, such as the Paximadaki [28], a game that was installed in a public space, for the advertising of traditional food products was operated via (full body) gestures. Another example is the "Creative Crete" installation at the Heraklion airport, developed by FORTH, which features various applications to travelers, from playful interaction walls to travel information and media galleries operated by hand gestures [35].

A few basic concepts and concerns are listed below, along with respective advice and warnings, gathered from various sources ([32][36])

Advantages

- Direct, "natural" interaction
- Screen real estate (no need for menus)
- Enjoyable, playful user experience

Disadvantages

- Poor visibility and discoverability
- Non-existing signifiers

  A basic issue with gestures is that unlike GUI elements, such as a button that looks clickable or arrows attached to scroll bars that indicate the directions it can move, gestural interfaces have few or no visual affordances. They are largely invisible, and this is why discovery of gestures can be a difficult obstacle for users to overcome

This is not a problem with gestures mimicking an equivalent gesture in the real world: flicking or sliding a digital page, rotating an image, etc. The problem is with unnatural or arbitrary gestures which have no equivalent in the world. For example, a simple and familiar gesture such as “swipe” if performed on a message in the email application on the iPhone will prompt to delete that message. This gesture is very useful, fast and satisfying but the problem is that there is no way to find out about it apart from accident or someone informing you.

This can be somewhat balanced by the users’ willingness to “play” with the exciting technology but defining new gestures is a risk. It can be compensated with on-screen tips, tutorials or signs.

- Lack of established guidelines for gestural control

  The novelty of the technology also means that there is little in the literature regarding usability guidelines towards gestures. The bulk of the existing literature is pointing out problematic aspects of this modality and its potential pitfalls but in the sense of actual guidelines to adhere to the advice is limited to more abstract suggestions rather than established practice that overcomes these concerns.

- Inconsistencies between major developers (Apple, Google, Microsoft)

  As any new technology, gestural control is not consistent across major developers. Practically, this means that different developers use different gestures to perform similar actions or use similar gestures to perform entirely different actions. Inconsistencies can also occur across different applications of the same developer. For example, the “delete message” swipe gesture mentioned above for the iPhone will not work on calendar or call lists.

  It is unreasonable to expect that all developers will mutually agree to use gestures uniformly. Instead, the truth of the matter is that we have to be patient for the technology to reach its maturity and users becoming more familiar with established practice that should converge among developers, at least regarding common tasks and operations.

Recommendations

With these issues in mind some recommendations are:

- Avoid associating different actions with the standard gestures users know. Just as important, avoid creating custom gestures to invoke the actions users already associate with the standard gestures
- Use complex gestures as shortcuts to expedite a task, not as the only way to perform a task. Although most users know the more complex standard

gestures, such as swipe, or pinch open, these complex gestures are not as common

- Try to ensure that there is always a simple, straightforward way to perform an action, even if it means an extra tap or two. Simple gestures allow users to focus on the experience and the content, not the interaction.
- In general, avoid defining new gestures. When you introduce new gestures, users must make an effort to discover and remember them.
- Monitor and evaluate popular applications to find patterns of common gestures for common tasks.
- Use Double duty gestures
    - o The “tap” gesture does double duty in the Trip Advisor application (an application for planning trips, providing travel information, including maps) for the iPad. Depending on the context, “tap” either initiates an interaction or displays a preview of information about an active element. It’s a clever way to build functionality into a well-understood gesture

VERITAS tools for the evaluation of hand gestures

The above recommendations are applicable to any category of gestural interfaces. A special mention however should be made about the problems gestures performed without touching, most notably by hand, might entail.

Such gestures, can be tiresome after prolonged use. This is something that can be an advantage in some context, such as “exergames” (exercising and gaming). But in other contexts it can mean the exclusion of use to a large number of people. People with arm-related disabilities is one obvious group but it also includes elderly people that tire easily or even people recuperating for example from an illness.

- Use VERITAS tools to test whether the hand or body gestures are feasible by people with disabilities. This involves testing VUM with various conditions on the hands, testing the line of sight between the various users and the sensors/cameras but also testing for fatigue after prolonged use. This is especially relevant in large displays or interaction walls operated from a distance.

5.2.4 Generic Guidelines for using VERITAS tools in any application domain

This sections provides guidance into initiating the usage of VERITAS tools. These are not design guidelines per se but rather a list of advice and things to look out for when using the VERITAS tools. More specifically a set of guidelines is defined for this process:

- A working prototype of the application needs to be developed before testing with VERITAS tools
    - o The working prototype could be created in any prototyping tool as long as is functional
    - o Functional prototypes should be able to present the appropriate feedback on simulated user actions (e.g. mouse, key events)

- It is critical to select the appropriate VUMs for your application target user population
- If alternative designs target alternative user categories a prototype for each user category must be developed and tested
- The target user population should be properly matched with the VUMs created for evaluation
- If designing for all VUMs should be created for all the applicable for the application user population
- Appropriate task models must be defined for all the tasks of the prototype to be evaluated
- Each task model should decompose the sub-tasks into ones that model single actions
- All task models must be evaluated in conjunction to all VUMs
- Keep track of the evaluation results and save evaluation output so as to compare results with future designs
- VERITAS tools reduce touch events to mouse events therefore test results of touch designs need further analysis
- When designing for multi-touch the tester should be aware that VERITAS tools reduce multiple touches to sequentially occurring mouse events
- When designing for gestures the tester should be aware that VERITAS tools doesn’t support multi-touch gestures
- When simulating using VERITAS tools the tester should be aware that each VUM may require more than one simulation in order to get the medium of results
- When simulating using VERITAS tools the tester should be aware that some VUMs may require immersive simulation
- VUMs that are related with vision disabilities always succeed. It is strongly recommended to use the immersive simulation mode so as to judge personally the resulted from the tools output.
- When simulating with vision disabilities many representative VUMs must be created. Different percentage of users selected for creating the VUM may result to simulation results that have radically different results.
- It is a good practice to create VUMs that are on the extremes of each user category. This will provide sufficient data for conducting critical analysis and will also provide feedback about the worst case scenario.
- It is a good practice to always have a user with no disabilities mapped into a VUM so as to be able to compare with your target user population.
- The GUI evaluation of the prototype that will employ mixed reality (usage of physical – digital object) will only produce results for the digital part of the application.
- When creating a prototype that will employ mixed reality the space where the application will be deployed should be also be designed in 3D and evaluated separately using the appropriate VERITAS tools
- When creating an application for mobile devices (e.g. a tablet) it is a good practice to create a prototype running on a Desktop PC so as to conduct the assessment.

- When creating an application for mobile devices (e.g. a tablet) it is strongly recommended to persist the same device resolution as the one used by the tablet.
- When creating an application for mobile devices (e.g. a mobile phone) it should be noted that VERITAS tools will only evaluate the interface and not the affordances of the mobile devices
- When designing for alternative screen sizes please have in mind that different captures should be taken for each supported by your application screen resolution.
- When designing for alternative screen sizes it is recommended to evaluate the prototype in a single (mostly used) resolution and then conduct additional evaluations on the final prototype.
- For analyzing the output of the simulations VERITAS tools provide both graphical reports by the simulation tool and also include a tool for analyzing the log files produced by the simulation.
- When simulating the accessibility of a physical device (e.g. the design of a gas hob) VERITAS tools will check only the UI representation of the build in device controllers and not the affordances of the device itself. A mixed evaluation is required to accomplish both.
- When designing multimodal interfaces the VERITAS workflow is altered and additional steps are required
  - o When designing multimodal interfaces the developer should manually assign the multimodal and alternative interfaces to the 3D virtual objects, if it is about 3D environment simulation (i.e. non-ICT products).
  - o When designing multimodal interfaces the developer should manually assign the multimodal and alternative interfaces to the GUI components, i.e. buttons, text input boxes, alert message boxes, etc.
  - o When designing multimodal interfaces the developer should perform an automatic analysis of the loaded Simulation Model and automatically produce alternative task sequences that use a variety of modalities, using the Multimodal Interfaces Models.
  - o When designing multimodal interfaces the developer should manually define each alternative task of each produced task sequence.
- When designing 3D spaces the developer should create a functional – compliant with VERITAS 3D space to be simulated.
- When designing 3D spaces VUMs are mapped to avatars using your space at runtime
  - o VERITAS tools provide an avatar editor that the anthropometric information provided by the VUM can be properly adjusted
- When designing for public spaces it is vital that the developer take into account the diversity of the end user population
- For alternative input methods (e.g. hand tracking) the GUI simulation supports typical UI operations such as selection, dragging, single – dual click etc.
- For alternative input methods (e.g. hand tracking) the developer should adapt the interaction expected by the application to the one that VERITAS tools support for evaluation.
- When designing for cognitive impairments the appropriate option should be selected on the simulation

- When conducting immersive evaluation a number of alternative aspects of your interface should be manually checked, such as:
    - Visibility of available UI elements
    - Visibility and readability of functions – textual descriptions
    - Main/peripheral vision
    - Graphics – animations
    - Distinction between functional and nonfunctional elements of your interface
    - Colour contrast
    - etc.
- A way of manually recording detected issues should be determined before conducting immersive evaluation
- The simulation stops when the first error occurs.
- When a simulation fails the prototype should be recreated in order to test subsequent point from the one where the error occurs. Alterative a large tasks could be decomposed into smaller ones so as to be simulated concurrently.
- Alternative user models with the same disability but different degrees should be tested in simulations. If the majority of the VUMs fail to successfully finish a task it is a good indication that major redesign of this task is required.
- During simulation, when a VUM with severe disabilities fails this doesn't necessarily means that a redesign should occur. In most of the cases small improvements of the prototype could result in a successful reevaluation.
- Paper based designs can be also evaluated with VERITAS tools as long as properly prepared (scanned – imported into the appropriate software and interconnected with the appropriate user functions)
- VERITAS tools could also be used in conjunction with actual users. For example VERITAS tools could be used to fill-in a user based that needs some test subjects so as to be complete. Additionally VERITAS tools could be used to compare the results of user based vs VUMs based assessments.
- VERITAS tools could be used in the context of hybrid approaches. For example conduct initial design iterations with VUMs and subsequent ones with actual users.
- VERITAS tools could be used to validate or complements the results of heuristic evaluations conducted by usability experts.
- VERITAS VUMs represent approximations of actual user models resulting from anthropometric measurements.
- When conducting immersive simulations with VERITAS tools for visual disabilities, the mouse pointer is mapped to the direction of virtual user's site. Use the mouse to simulate end user's visual behavior and not for producing events. In the same context functionality of the UI should be evaluated in conjunction to the user's field of view (e.g. what the user sees when staring at a specific location of the interface).
- When conducting immersive simulation with VUMs representing motor impairments, VERITAS tools introduce the appropriate jitter to the tester's movements so as to mimic VUM interaction capabilities. Do not be tempted to exaggerate this effect because it will result to not valid simulation results.

- When conducting an immersive simulation with VUMs representing motor impairments do not try to correct mouse trajectory. Use the UI naturally.
- VUMs can also be used to present concurrent disabilities. Experiment with this feature for simulating users that may have more than one disabilities. For example elderly uses often combine motor and visual disabilities.

5.3 Domain - specific guidelines

The following section explores 6 different application domains and outlines the major concerns and challenges associated with each. Findings and insights from tests conducted in VERITAS tools are presented, where available. There are some preliminary findings and conclusions in the Healthcare, Smart Living Spaces and Infotainment domains. It should be noted that these are not domain-specific guidelines per se, since most of them would be applicable to any domain.

5.3.1 Automotive

The automotive industry has traditionally been one of the forerunners in human factors and ergonomics research, along with the aviation industry. Simulations, both virtual and physical of the vehicle's interiors and the driver's cockpit have been used for decades. This research not only focuses on usability but also safety and there is a considerable amount of guidelines and established practice within the industry that makes this part of the report redundant. Instead, the focus here is on the integration of the VERITAS tools with the tools already used (e.g. RAMSIS) and the need to include more than "average" models to the test and evaluation phases of current practice.

For the integration of Virtual User Models created in VERITAS for the use with software used by the automotive industry see sections 3.2.1 to 3.2.3 of this document. The process of integration is described in detail in D2.2.2_VR [14] and D2.3.1 [15].

- Use the VERITAS avatar editor and generator to create and modify virtual user models to allow for testing for accessibility and usability for people with disabilities.
- Pay specific attention to motor impairments and issues of fatigue

5.3.2 Smart Living Spaces

The recently emerged domain of Smart Living Spaces is now becoming a reality after the technology and infrastructure that can make the vision a reality have become available and affordable (for example the proliferation of mobile devices that are internet-capable) to conduct research. As noted before Smart Living Spaces is a subset of ubiquitous computing, involving rooms or buildings where people live. Repeating the definition of section 4.2, a smart living space can be defined as any electronic environment that is sensitive and responsive to the presence of people. Smart living spaces are populated with sensors, networks, mobile and embedded devices and are context aware. Smart living spaces often control the environment (such as heating, lights, windows and stories etc.) based on inferring algorithms. Such an environment is characterized by services that monitor the user's behaviour, anticipate, adapt and respond to his/her particular needs. Smart living spaces is a domain that many different disciplines meet and where newer technologies and interaction paradigms are being researched. Because of this, all four design guidelines categories in section 5.2 are specifically relevant to Smart Living Spaces.

The newer interaction methods and modalities (such as touch or gesture) that characterize modern computing devices is an exciting area but it also presents severe (new) challenges to people with disabilities.

On the other hand, this domain is tightly coupled with architecture, which has traditionally been at the forefront of accessibility and universal design (see 5.2.1). The combination of the two disciplines in domotics (home automation) presents a field where experts from architecture and the building industry come together. In such a domain, VERITAS is almost ideally suited for the task of testing designs and finding problems.

From D2.3.3 [16]:

The integration of the VERITAS tools with the Smart Living Spaces appliances from Indesit represents a good experiment into the adoption of specific tools that could support a Design for All approach in the industrial design process. It is considered that they could constitute an additional tool in the process, to be used since the very early phases of the design development, and not only at the end of it, to evaluate a given design. Moreover, that they could be used together with the User Centered Design methodology (UCD), and they shouldn't be meant to replace direct observation of the users in their context and user's involvement in the design process, as it happens in Participative Design. In fact the rich and insightful findings that can be gathered through User Centered Design methodology, give back much more than data, design guidelines or system requirements to the design process: it opens opportunity spaces for design and innovation beyond the first visible needs.

To conclude, it is suggested that the use of VERITAS tools needs to go together with UCD methodology and that VERITAS approach should go beyond the single impairment, aiming to a «Design for All» approach, while solving those particular design problems emerged from simulating specific impairments.

First evaluation results and insights from VERITAS testing

From D3.2.1:

As presented previously the assessments conducted using VERITAS simulation environment has produced a number of accessibility issues. The most important of those were (a) the need to make textual representations more readable, (b) increase the size of buttons and texts within buttons (c) the need to make distances between buttons larger so as to decrease the option of false selections. These exact issues were also identified by the 1st iteration of assessment with beneficiaries. This 1st iteration has produced some other issues that could be identified as recommendations by the beneficiaries (in some cases beneficiaries could not identify the function of a control button. This mainly occurred in buttons with no textual descriptions). These issues were not identified by the tools as expected (usability issues).

5.3.3 Office workplace

The office workplace is a special domain where characteristics of smart living spaces and computer supported coperative work are combined. The office workplace can be a standard PC configuration or it can be an office of the future, a true ubiquitous environment, with the blending of the physical and the virtual (such as CS OFFICE [41]). This section presents design guidelines for both scenarios.

Standard office design guidelines and recommendations

Deliverable ID2.4.1 [20] lists a set of guidelines, standards and recommendations regarding the workplace environment, drawn from various sources (ISO, ADA, Australian standards), compiled mainly from a list of guidelines from the European Agency for Safety and Health and Work and by the University of Sydney. These are reproduced here.

Lighting and Sound

- "Ordinary" visual tasks should be in range 300 to 400 lux [320 lux (task) and 160 lux (Background)] [UTS guidelines].
- For more demanding visual tasks, including proof reading and working from poor quality photocopies, 600 lux is suitable [UTS guidelines].
- Older workers may require stronger lighting [UTS guidelines].
- Glare should be minimised [UTS guidelines].
- Illumination should be even between adjacent areas [UTS guidelines].
- The recommended decibel range for office work is 55 to 65 dBA [UTS guidelines].

Furniture and Storage

- The maximum acceptable load to be lifted in the seated position is 4.5 kg [UTS guidelines].
- All pieces of furniture should be placed so that workers do not have to twist or reach while carrying items weighing over 4 kgs. It is advisable to have a secondary work space outside the maximum reach area, so that people have to stand up and move around to reach items that should not be lifted whilst sitting [UTS guidelines].
- Workers should not over-stretch in order to reach objects located beyond maximum reach [UTS guidelines].
- Heavy items should be stored on shelves around waist level. Frequently used items should not be stored near floor level or above shoulder height [UTS guidelines].
- Workers should not have to repeatedly use poor spinal postures when sideways reaching and leaning down to a drawer unit [UTS guidelines].
- Workers should avoid excessive bending or reaching to gather or store items on shelves [UTS guidelines].

Visual Display Unit (VDU)

The orientation of the VDU should guarantee a normal body and head posture and ease of viewing [UTS guidelines]. The chin should be tucked in towards the chest and aligned with the spine rather than poking forward or upwards (EASHW guidelines).

- The VDU should be rotatable and tiltable, to be easily adjustable [UTS guidelines].
- The VDU should be placed at an appropriate height above the work surface where the top line of text is just below eye level (15 degrees) [UTS guidelines].
- For people wearing glasses, the VDU should be positioned low enough so that they do not have to raise their chin to look at the screen [EASHW and UTS guidelines].
- The VDU should be positioned at a comfortable reading distance from the operator (350mm to 750mm) (EASHW guidelines).
- For workers wearing glasses, the monitor distance from the user should match the focal length of the spectacles [UTS guidelines].
- No more than six colours should be simultaneously displayed [UTS guidelines].
- Alternative light control options should be investigated to reduce glare from the work environment [UTS guidelines].

Document Holders

- A document holder should be used, so that the source material is not positioned flat on the desk or in a position to the extreme side of the monitor. Reading a document at such angles requires prolonged bending and twisting of the neck and therefore generates greater prolonged muscle tension [UTS guidelines].
- The document holders should be placed at a comfortable viewing distance in line with the screen, should be stable and free from vibration [UTS guidelines].

Keyboards

- The keyboard should be separate from the screen to allow both of them to be independently adjusted [UTS guidelines].
- The keyboard design (either split, compact, "Internet" or "ergonomic") should be selected according to the best match to the hand size, finger reach and keying style of the users [UTS guidelines].
- The primary part of the keyboard to be used (i.e. alpha or numeric), should be directly aligned in front of the body [UTS guidelines].
- The monitor and keyboard should be aligned and directly in front of the worker so that they do not twist to reach the keys (EASHW guidelines).

- The keyboard should be located in close proximity to the body to avoid over reaching to key (EASHW guidelines). The worker should not have to overstretch the fingers to reach shift and function keys [UTS guidelines].
- The shoulders should be relaxed when the hands are resting on the keys with the upper arms hanging naturally and the lower arm at approximately 90 degrees (EASHW guidelines).
- The wrists should be straight and in line with the forearm whilst keying or using the mouse, to avoid excessive bending to the side or upwards (EASHW guidelines).
- Laptop screens and keyboards should not be used for prolonged periods, as they cannot be optimally adjusted. If this cannot be avoided, it is advisable to use a standard keyboard and mouse connected to the laptop and to place the laptop screen so that the top line of text is just below the eye line [UTS guidelines].

Mouse Controls

- The slope and shape of the mouse should allow the wrist to be aligned with the forearm without an angle to either side [UTS guidelines].
- The incline of the mouse should guarantee minimal bending up of the wrist [UTS guidelines].
- The mouse should be at the same level and as close as possible to the keyboard to avoid stretching the arm out to the side or across the desk (EASHW guidelines).
- Controls that allow a variety of finger movements instead of holding a position on a button should be preferred, as they allow better blood flow to the muscles and prevent fatigue [UTS guidelines]. A scroll wheel may be employed, for example during web searches [UTS guidelines].
- If extensive mouse use is required, it is advisable to provide for easy alternation between the left and right hand [UTS guidelines].
- The possibility to adjust mouse speed via the control panel may reduce the need to maintain a tense grip to control excess movement [UTS guidelines].

Chairs

- The chair should maintain the curves of the spine by providing adequate support to the lower back curve. The backrest should be sufficiently padded and contoured to fit and support the small of the back [UTS guidelines].
- A chair should be adjustable in height whilst seated and should be stable under normal operating conditions at all heights. It should have backrest adjustable in height and tilt whilst seated on the chair and should allow close access to the desk [EASHW and UTS guidelines]. A chair should allow alternation between a semi-reclined and upright posture throughout the day, e.g. when on the phone [UTS guidelines].
- The backrest width should not impede keying posture by causing the arms to be held out to the side [UTS guidelines].

- Chairs should move easily across floor surface, to avoid extra strain on the upper limbs in pulling and pushing the worker towards or away from the desk [UTS guidelines].
- Glides are recommended if chairs are on linoleum or similar floors, as castors may present a hazard by rolling too freely. Lockable castors may be used on linoleum floors. These are free rolling when there is no weight on the chair, and lock in position when weight is applied [UTS guidelines].
- If the feet are not flat on the floor when sitting, then a stable footrest should be used (EASHW guidelines).

Desks

- The desk top size should have an adequate width and depth to allow for correct posture at the keyboard [UTS guidelines]. Elbows should be level with, or slightly higher than keyboard while typing (EASHW guidelines).
- The desktop should easily accommodate all tasks and there should be sufficient space for source documents. The following are the minimum desk top sizes: for mixed tasks e.g. computer and clerical - 1500 X 900mm, for single tasks e.g. computer only - 1200 X 900mm [EASHW and UTS guidelines].
- If the height of keyboard desks is fixed this should be in the range of 680 mm to 710mm (Australian Standard 3590.2-1990). A higher work area should be used for layout, sorting and collating of documents (Australian Standard 3590.2-1990).
- The tops of tables should be in the height 660 to 760 mm above the ground. The tops of work surfaces should be in the height 710 to 865 mm above the ground [ADA 2010].
- The desk top and supporting frame should have a maximum thickness of 30mm to allow for adequate leg clearance [UTS guidelines].
- The underside of the desk should be free from obstruction to the knees through items such as under desk CPU holders and drawer units. The minimum clearance for legs to allow close access to work tasks are: minimum depth 550mm, minimum width 800mm (EASHW guidelines and Australian Standard 3590.2-1990).

Equipment positioning on desktop

- The items most frequently handled should be within easy reach whilst sitting and under 4kgs [EASHW and UTS guidelines].
- The less frequently used equipment and materials should be placed within a distance reached by the outstretched arm [UTS guidelines].
- The position of source documents should be in line with or close to the monitor and around eye level to avoid excessive twisting or bending of neck (EASHW guidelines).

Phones

- Telephones should be positioned on the non-dominant side to allow pick up and holding in the non-dominant hand while writing or keying with the dominant hand [UTS guidelines].
- When phone is frequently answered while keying or writing, a phone head set should be used [UTS guidelines].

Office Accessories and Non Routine Processes

- Non routine processes involving prolonged tasks such as stapling, hole punching, flipping through heavy lever arch files, guillotining, handling of heavy reference texts and large mail outs should only be performed for short intervals, at a relaxed pace [UTS guidelines].

Smart Office characteristics

Such an environment presents many opportunities for innovative CSCW applications, taking advantage of the new technologies and the advancement of social computing which opens new avenues of collaboration. Such an environment should support teleconferences and remote meetings, which very often feature a type of Large Display. Therefore, special attention should be given to design guidelines regarding Large Displays.(see section 5.2.3.1)

5.3.4 Infotainment and Games

The domain of Infotainment is huge and encompasses many vastly different manifestations, spanning different industries and disciplines. It is impossible to pinpoint a particular methodology that suits every type of infotainment service. Instead, the emphasis should be placed on the fact that accessibility is notoriously missing from the gaming industry, where accessible games are a rarity and that any type of infotainment would greatly benefit from Design for All principles. Since the manufacturers of infotainment span across different industries (Gaming, TV and Movies, Automotive, Home Media, Web, etc.) it is unrealistic to consolidate each respective practice into one methodology. Nevertheless, it should be noted that the design guidelines in section 5 that are categorized by application domain are applicable to the infotainment domain.

ID2.5.1 [21]focuses on Metaverses (virtual environments) and reports the findings of evaluating several popular games and summarizes the issues faced by people according to the main classes disabilities. Designers and developers should take these into consideration before starting the design process.

a) sight

- the blind cannot orient themselves in the visual virtual worlds, the only option are text based MUDs. However, these can be difficult for the readers to process.
- user with deteriorated sight usually have the option to zoom in the world and most of the control panels, in same games the size of the control panels is static and a other zooming tools must be used

b) hearing

- sounds are not one of the primary sources of information and playing without them does not impair the player (in contrast to action games like First person shooters)

c) movement

- most of the games can be controlled by solely the mouse or the keyboard. The gameplay usually expects a fast response though and the games can become difficult to play with some specialized control device.

d) cognitive abilities

- games usually have a high cognitive difficulty and are demanding

These issues should all be considered during design and development of any infotainment application or game.

- Use VerSEd-3D (VERITAS 3D Simulation Editor) and VerSim-3D (VERITAS 3D Simulation Viewer) to check against these issues (excluding cognitive abilities issues as dependent on context and irrelevant to the 3D environment).
- Provide alternative modalities where appropriate. Sound is inconsequential to games designed for visual navigation and gameplay but is the most important modality for blind people

First evaluation results and insights from VERITAS testing

From D3.4.1

The evaluation of tasks focused on 2D GUI widgets showed that the size of buttons, menu items and interactive labels (e.g. radio button labels) should be increased, because the simulated VUMs had difficulties to press and release mouse buttons in the specified area (motor impairment simulation). In some tasks there was a possibility to correct the interaction, but in some cases such miss caused changes that prevents in task continuation (e.g. pop-up menu disappear when the correct menu item is missed by mouse click). Some issues were also observed for clicks at the sidebar panels that might be undocked by drag&drop interaction and such interaction was the result of unsuccessful mouse press and release. In case of tasks for interaction with 3D objects the main issue was again the size of manipulators, which should be increased.

Initial conclusions for hearing impairment

We simulated and perform actions manually over Prismix. As designer we feel sensations and modifications over Prismix as we have hearing impairments. Feeling are nice because we note how important is stimuli for people with hearing impairments.

Perceptions that we observe are:

- We need to develop more interesting colors to compensate no hearing advices
- We need to record sounds that help in reading rules

Initial conclusions for visual impairment

We simulated and perform actions manually over Prismix. As designer we feel sensations and modifications over Prismix as we have visual impairments.

Perceptions that we observe are:

- We need a bigger size in text font, with visual impairment is difficult to read
- We need to develop more interesting colors to compensate visual impairment defects
- We need to add attractive colors (in text font) to attract user visually to menu options
- With visual deformations, buttons for selections must be most bigger than now.
- We need to add “sounds” that advice user that is checking correct button (it has special importance for user with macular impairment that, they can’t see where is focused mouse icon).

As presented previously the assessments conducted using VERITAS simulation environment has produced a number of accessibility issues. The most important of those were (a) the need to make textual representations more readable, (b) increase the size of panels and panel buttons and (c) panel images were not readable during immersive simulations with severe visual disabilities. These exact issues were also identified by the 1st iteration of assessment with beneficiaries. This 1rst iteration has produced two more issues not identified by the tools. This was more or less expected as these issues are usability problems of the game that could not be identified by VERITAS tools.

5.3.5 Healthcare

Current systems have been created and optimized to handle acute illnesses, but most healthcare expenditure is due to chronic diseases, which are likely to increase in the near future. It is recognized that the incidence of these kinds of diseases can be reduced with proper early prevention, by means, for instance, of health promotion and citizen empowerment in the management of their own health. This requires a shift in the current health provision from an illness-centric to a patient-centric approach and the healthcare boundaries are widening from the hospital to the patient’s homes. The patient of today is increasingly well-informed and motivated.

Healthcare is becoming ubiquitous, personal and mobile and will involve formal caregivers (medical professionals) but also and more often informal caregivers (relatives, friends, volunteers, etc.).[18]

Based on the above, applications that involve healthcare should meet the following requirements:

- Person-centered health management (at home and away from home)
- Tele-monitoring and self-management of chronic diseases
- Appropriate support systems for care personnel

It should be noted that part of that vision of healthcare from home overlaps with Smart Living spaces in the context of ambient assisted living (AAL), which effectively is a combination of the two domains. Therefore, any developer working on any of the two domains should look into both sections.

Unobtrusiveness

- Systems should be completely invisible to the users.
- The physical condition of the assisted person should be sensed in by environmental sensors that can read situations and act proactively with minimal human intervention.
- Such sensors can be attached to walls in rooms and their equipment for collecting data about the behavior of the person living in the smart healthcare environment.
- Use VERITAS VerSed-3D and VerSim-3D in order to test placement of sensors within the environment. Test placement with various VUMs varying significantly the height of avatars.

The following section is based on the work presented in D2.6.2 [17] and D2.6.3 [18], which described the design, development and testing through VERITAS of three different types of healthcare applications. The common theme between these applications (apart from the domain) is that they were specifically designed to cater for the needs of elderly users and people with visual disabilities, such as colour blindness.

“From the very beginning developers tried that the application would require the minimum interaction of the system with the older people and people with special needs, in order to achieve high usability and accessibility levels”. [17]

The mobile application presented employs several UI themes that have been implemented in order to cover all users’ needs and preferences. Specifically four different themes have been developed and applied to the application’s UI. The design choices translate into guidelines thusly:

The first theme is applicable for elderly users without visual impairments:

- Primary colours are arranged in the colour space of green and grey.
- Avoid colour combinations like green and red due to the fact that they can cause problems in reading for people with colour blindness.
- A brightly coloured background for text increases readability.

Some users have problems with bright backgrounds: These users report of overstraining and tired eyes while reading.

- Allow for easy selection of UI themes

- Use dark colours for the background and set the text and other UI elements to light colours to increase contrast.
- For users with specific eye-sight disabilities such as deyteranopia and protanopia the third theme has been designed in orange colours.
- Offer the ability to enlarge fonts to the user's preference

First evaluation results and insights from VERITAS testing

From D. 3.5.1

In order to extract a complete and accurate insight of the needs of a user when assessing accessibility with VERITAS tools, it is essential to test applications with several VUM (including variations of each of them) and to perform both immersive and non immersive simulations. Otherwise, the designer might deduce wrongly what the user would perceive and what they would or not be able to do. Objective feedback (from non immersive simulation) is essential to get valuable feedback on the physical interaction of users, the duration of tasks, the comparisons with optimal users, etc.

Subjective feedback provided by the immersive simulation functionality critically enriches the designer experience, letting the designer experience on his own. Regarding the actual design of the Remote monitoring application, the main conclusion extracted is that, even though the design can be extensively improved, the application reaches acceptable levels of accessibility, meaning that users would probably be able to complete the tasks, but the satisfaction with the easiness of use and look and feel would not reach the high levels that designers would desire.

Below there is a list of elements that need to be improved in further designs, according to results extracted from the assessment with VERITAS tools:

- Bigger font and higher contrast is essential
- Revise the colour of the UI, it is not the best selection
- Revise colour and size of icons
- Revise the distribution of content on the screen:
  - Keep the main functions of the tool within the central part of the GUI
  - Keep text content clearly associated to corresponding buttons, or viceversa
  - Whenever alarms or reminders need to be shown, keep them in the central part of the UI, to assure that users with low vision impairments are able to perceive them
  - During a specific task, don't spread the content all over the screen, since users with low vision impairments won't be able to see everything at once, and therefore it will be difficult for them to understand what is happening.
- Increase the distance (clearly delimitate) between hot areas, to assure that users with motor impairments (such as tremor on Parkinson disease, or even standard old users which movements are slower and imprecise) fail to click the correct ones

- When radio buttons are used, the corresponding text should be clickable as well

These results underline the idea that assessing accessibility must be of high level priority in the healthcare domain, where achieving compliance and adherence to treatments and recommendations is essential for the success of applications. Therefore, it is mandatory that solutions are accessible and easy to use, providing a total satisfaction of the user. Both assessments with real and virtual users raised the need of bigger fonts and content, higher contrast, better distribution of content and better limits and definitions of hot areas in order to allow better interactions.

5.3.6 Public Spaces

Public spaces are defined as spaces which are accessible to the public, such as roads, parks, public squares (open spaces) or public libraries, train stations, museums (which can be inside a buidling) etc. In the interest of this section, the domain is used to denote any ICT service, device or application that is available to the public in any kind of space, regardless of ownership (private or public). ATMs are an example of that but also vending machines, information kiosks and interactive displays etc.

The three basic parameters that concern this section particularly are:

Discoverability

Services provided in public spaces first and foremost need to be discovered in order to be used.

- Building the prospective space and its immediate surrounding environment into a 3D model will make it possible to run various tests through VERITAS.
- The VerSim-3D should be used in order to test the visibility of the installation/kiosk from various angles, including the points of entry to the room. Additionally, should the space where the installation will be placed be obscured at first glance, the 3D model should provide substantial cues for sign and advertisement placement, as well as their ideal properties (height, color, size, etc) in order to be noticeable by the majority of users.
- Consider the use of audio/speech to alert and attract users to the service/application, as it is the only way to alert people with vision disabilities. Be careful of the appropriateness of the use of sound depending on the context of the surrounding environment (noise levels, social context – no noise in most hospital areas etc.)

Accessibility

It should go without saying that the public space services should be accessible. This involves all contemporary knowledge on accessibility that lies in the domain of architecture and urban planning but it also involves the complete accessibility of IT services to all, since by definition it is made available to all citizens.

- This means
    - adhering to the universal design principles listed in 5.2.1 and more to the point that
    - the design and development team should work closely with the team designing the actual space.
- Test for the accessibility of any public space application or service through the 3D Editor and Simulation.
- The list of VUMs tested should be exhaustive, covering all disabilities
- Provide auditory feedback where necessary (e.g., ATM beeping to retrieve card)
- In order for the public space application or service to be accessible to all do not use a touchscreen as the primary interaction channel, since it will exclude blind people and people with severe visual problems from using it.
- Provide controls with haptic properties (such as buttons with braille captions).

Privacy

Privacy and confidentiality concerns are a major point of research in the new information society and especially relevant for the new emerging paradigm of Ambient Intelligence. It is beyond the scope of this deliverable to list privacy and security concerns as well as practices. Instead, the focus is on the inclusion of people with disabilities to the group of users concerned with privacy. For example, an application that ensures privacy for people with acute vision may not offer the same privacy to a blind user. Sound is less private channel of interaction compared to the visual and more prone to accidental disclosure, unless headphones are used.

- Always provide a section in the application that outlines the privacy policy of the system used. Make sure the information is available multi-modally.
- Consider the possibility of providing headphones to users. Test the placement of headphone rest in VERITAS.
- If the services used can be considered sensitive, consider positioning the primary output channel (ie display) from view through placement.
    - For example, an ATM screen is hidden from view by the person using it. The same principle may apply in other cases. But:
    - Test in VERITAS for various VUMs (including tall, short and sitted – on a wheelchair - avatars)

5.4 VERITAS project Task Examples

Deliverable 2.8.4 [37] provides a table that lists a set of indicators to measure the usability of common VERITAS project tasks, suitable for assessing any simulation outcome in the VerSim-3D (VERITAS 3D Simulation Viewer). They are applicable to most application domains that involve three-dimensional environments (real and virtual) and are therefore reproduced here separately.

Although usability and acceptability indicators and their measurement are in general mostly task independent, i.e., performance and satisfaction (task success, task completion time, error/accuracy, learnability, frustration, trust, etc.), in the following table we describe the indicators for a few exemplary VERITAS project tasks.

Table 4: indicators for a few exemplary *VERITAS* project *tasks.*

Task	Comment on indicators
Walk	Indicators for the usability of an interface to complete the task «walk» are: Task success: User has arrived at the end sate (i.e., user has arrived at the target location) Task completion time: Speed (e.g., meter per minute) to move from start location A to target location B Errors/accuracy: For example, the number of times the user left a predefined path. Efficiency: Number of user actions with the interface (e.g. steps, button presses, navigation commands, etc.) to successfully arrive at the target location B. Learnability: Analyze a specific performance metric; E.g., task completion time, number of errors, number of actions. If after repeating the task "x" times the user shows no improvement, the user has learned as much as he can and there is not much room for improvement. The difference between first and last trial will indicate how much learning must occur until maximum performance is reached. Self-reports: usability score (SUS), user satisfaction (USE)
See	Indicators for the usability of an interface to complete the task «see» are: Task success: User has arrived at the end sate (i.e., the user has identified "x" items, written words and images at a given time). Task completion time: Speed (e.g., number of recognized items per minute) to identify items. Errors/accuracy: Number of items the user could not identify. Efficiency: Number of user actions with the interface (e.g. steps, button presses, navigation commands, etc.) to successfully identify items. Learnability: Analyze a specific performance metric; E.g., task completion time, number of errors, number of actions. If after repeating the task "x" times the user shows no improvement, the user has learned as much as he can and there is not much room for improvement. The difference between first and last trial will indicate how much learning must occur until maximum performance is reached. Self-reports: usability score (SUS), user satisfaction (USE)

Hear	Indicators for the usability of an interface to complete the task «hear» are similar to the task «see» Task success: User has arrived at the end sate (i.e., the user has identified “x” items, spoken words and sounds at a given time). Task completion time: Speed (e.g., number of recognized items per minute) to identify items. Errors/accuracy: For example, the number of items the user could not identify. Efficiency: Number of user actions with the interface (e.g. steps, button presses, navigation commands, etc.) to successfully identify items. Learnability: Analyze a specific performance metric; E.g., task completion time, number of errors, number of actions. If after repeating the task “x” times the user shows no improvement, the user has learned as much as he can and there is not much room for improvement. The difference between first and last trial will indicate how much learning must occur until maximum performance is reached. Self-reports: usability score (SUS), user satisfaction (USE)
Grasp – Door handle	Indicators for the usability of an interface to complete the task «grasp – door handle» Task success: User has arrived at the end sate (i.e., one action away from using the door handle) Task completion time: Time (e.g., in seconds) until end state is reached. Errors/accuracy: For example, the number of failed attempts to reach the end state in a given time (e.g. 1 minute). Efficiency: Number of user actions with the interface (e.g. steps, button presses, navigation commands, etc.) to successfully reach the end state. Learnability: Analyze a specific performance metric; E.g., task completion time, number of errors, number of actions. If after repeating the task “x” times the user shows no improvement, the user has learned as much as he can and there is not much room for improvement. The difference between first and last trial will indicate how much learning must occur until maximum performance is reached. Self-reports: usability score (SUS), user satisfaction (USE)
Pull – Door handle	Indicators for the usability of an interface to complete the task «pull – door handle» are

	similar to the task «grasp – door handle» Task success: User has arrived at the end sate (i.e., user has «moved» the door to a predefined position or angle) Task completion time: Time (e.g., in seconds) until end state is reached. Errors/accuracy: For example, the number of failed attempts to reach the end state in a given time (e.g. 1 minute). Efficiency: Number of user actions with the interface (e.g. steps, button presses, navigation commands, etc.) to successfully reach the end state. Learnability: Analyze a specific performance metric; E.g., task completion time, number of errors, number of actions. If after repeating the task "x" times the user shows no improvement, the user has learned as much as he can and there is not much room for improvement. The difference between first and last trial will indicate how much learning must occur until maximum performance is reached. Self-reports: usability score (SUS), user satisfaction (USE)
Sit – car seat	Indicators for the usability of an interface to complete the task «sit – car seat» Task success: User has arrived at the end state (i.e., user is seated in the car seat) Task completion time: Time (e.g., in seconds) until end state is reached. Errors/accuracy: For example, the number of failed attempts to reach the end state in a given time (e.g. 3 minutes). Efficiency: Number of user actions with the interface (e.g. steps, button presses, navigation commands, etc.) to successfully reach the end state. Learnability: Analyze a specific performance metric; E.g., task completion time, number of errors, number of actions. If after repeating the task "x" times the user shows no improvement, the user has learned as much as he can and there is not much room for improvement. The difference between first and last trial will indicate how much learning must occur until maximum performance is reached. Self-reports: usability score (SUS), user satisfaction (USE)

6 Roadmap & Standardisation

6.1 Introduction

This section presents the vision, the roadmap, the activities, the challenges and the results so far of VERITAS towards standardization of processes and guidelines that will lead to a more efficient and robust dissemination of knowledge and a more accessible Information Society. The content of this section has been based on the VUMS cluster meetings reports, and the VERITAS Standardisation White Paper (ID4.5.4).

First, there is a brief presentation of what actually constitutes a design guideline and a standard. Since design guidelines were presented extensively in the previous section, more focus is given to the standardisation activities in the VERITAS project.

The ongoing effort towards standardization is done in collaboration with the VUMS cluster, a cluster of projects that have a common scope and share similar areas of research, in an effort to synchronize research and knowledge and "join forces" in the promotion of standards and guidelines produced. The activities of the cluster meetings are summarized and the current status of the various activities is reported.

Finally, a glossary of terms is provided in the appendices of this deliverable, as well as a comprehensive list of existing standards relevant to VERITAS.

VERITAS demonstrates undoubtedly the first attempt towards simulated accessibility evaluation via the use of virtual reality and realistic modeling of virtual humans with disabilities. However, due to the fact that this particular research domain is highly interdisciplinary, ranging from medical analysis, to user modelling, ICT, realistic simulation and virtual reality, there are several areas identified, where innovative research could provide groundbreaking results and lead to embedded and context aware accessible designs for ALL. Below the most prominent technologies are briefly discussed.

- Dynamic virtual user modeling
- Real-time on-the-move simulation and interaction optimization
- Smart adaptive interfaces
- Seamlessly operating products
- Holistic cognitive-behavioural-motor modelling

In this context VERITAS is contributing towards standardisation of state of the art technologies of today but also could play an important part in future activities towards standardisation actions and mainly in relation with the aforementioned application domains. At the same time taking also into account that the AmI infrastructures ranging from "AmI at home", "at work" or even "on the move" are being currently a hot topic in the European market, VERITAS takes the first step by introducing virtual user modeling for the simulated accessibility evaluation of ICT and non-ICT products in virtual environments and is thus expected to boost research, development and hopefully standardization in the field of embedded accessibility designs.

6.2 Guidelines and Standards

Nowadays, guidelines and standards play a key role in the adoption of (computer) technologies by industries and society. In essence, they constitute a rapidly evolving medium for transferring established and de facto knowledge (know-how) to various interested parties. For instance, designers and developers, in various application domains, require guidelines and standards in order to achieve consistency and user-friendliness of user-interfaces, especially in cases where complex and rapidly evolving technologies are employed.

The term "guideline", in the present context, entails all forms of abstract or concrete recommendations that can be used to design interactive software. Guidelines can be expressed as general and domain independent recommendations (Smith and Mossier, 1986) or platform-specific style guides (Open Software Foundation, 1993; Microsoft, 1995; Apple Computers, 1992; IBM, 1992) or experience-based usability heuristics (Henninger et al., 1995; Henninger et al., 1997). Guidelines can be embedded in reference manuals and standards, or can be part of the corporate culture and practice of an organisation (i.e., customised corporate design wisdom).

Definition of "guideline"

The following definition of guideline is adopted in the context of this deliverable: "any design and/or evaluation principle to be observed in order to get and/or guarantee the usability of a user interface (UI) for a given interactive task to be carried out by a given user population in a given context" (Vanderdonckt, 1999).

The role of guidelines can be summarised in the four points below. A more elaborate description can be found in ID4.5.4:

- (a) Raising awareness of concepts:
- (b) Assisting in design choices:
- (c) Offering strategies for solving design problems:
- (d) Supporting evaluation:

Definition of "standard"

The term "standard" refers to a "document, established by consensus and approved by a recognised body, that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at achievement of the optimum degree of order in a given context" (ISO/IEC Guide 2:1996, Definition 3.2).

Characteristics of Standards

According to the World Standards Services Network (WSSN), standards:

cover several disciplines: dealing with all technical, economic and social aspects of human activity and covering all basic disciplines such as language, mathematics, physics, etc.;

are coherent and consistent: standards are developed by technical committees which are coordinated by a specialized body, and ensure that barriers between different areas of activity and different trades are overcome;

result from participation: standards reflect the results of joint work involving all competent parties concerned and are validated by consensus to represent all relevant interests: producers, users, laboratories, public authorities, consumers, etc.;

are a living process: standards are based on actual experience and lead to material results in practice (products – both goods and services, test methods, etc.); they establish a compromise between the state of the art and the economic constraints of the time;

are up to date: standards are reviewed periodically or as dictated by circumstance to ensure their currency, and therefore evolve together with technological and social progress;

have a reference status: in commercial contracts and in court in the event of a dispute;

have national or international recognition: standards are documents which are recognized as valid – nationally, regionally or internationally, as appropriate;

are available to everyone: standards may be consulted and purchased without restriction.

VERITAS and Relevant Standards and Guidelines

Categorisation of Standards (from ID4.5.1)

Industrial standards cover the following objectives:

- Safety (Saf),
- Usability (Use),
- Quality (Qua),
- Measurements and dimensions (Dim),
- Testing (Tes).

The most relevant objective for VERITAS is ”Usability” with focus on “design for all” and “accessibility” for the targeted population (elderly, disabled) with special needs.

Standards may include stipulations at quite different levels. One can distinguish between:

- Definitions, taxonomies, ontologies (Def);
- Procedures and processes (Proc);
- Characteristics and properties (Prop).

The first group of stipulations tries to establish a common language and a common understanding. It supports communication in a specific field. It demarcates a “world” by including and excluding and explains it. All standards include such elements, for instance the Scope of the standard. This is the lowest level as far as restrictions to a product itself are concerned. Work within VERITAS and the VUMS cluster showed the need of such standards i. e. in the fields of human models. (see 6.5 below)

The second group defines how things have to be done. Procedural standards have gained particular importance during the introduction of a total quality management in several areas ranging from industry to healthcare. They do not define the product itself, but they can describe the way how to create and test it. This type of standards best fits the approach of VERITAS. The project supports the way of designing and developing products and does not define the products themselves. Section 4 of this deliverable presents the design and development process including VERITAS tools, adopted in different application domains.

The third group is the most restrictive one. It fixes the product’s properties and characteristics, e. g. by specifying dimensions, colours, material. As far as an end-user product is concerned, this type of stipulations is not always favourable, because they restrict the individuality of the product, thus potentially hindering the creation of unique selling propositions. They are however necessary if it comes to technical interfaces. Those require precise specifications in order to work properly.

In this context different scopes of standardisation are related to VERITAS, which are characterized by the following list:

- General characteristics / properties of products in the application domains;
- Accessibility of products in the application domains (Access);
- Development and engineering processes in the application domains (Process);
- Development/engineering tools in the application domains (Tools);
- User characteristics of ageing and disabled users (User);
- Simulation in usability and accessibility engineering (Simu);
- User modelling (Model).

The order of topics is not random. The sequence follows increasing importance and specificity for the core activities of the project’s tasks and objectives.

Existing standards on general characteristics and properties of products are of low interest for VERITAS. They are application domain specific and normally do not take into account, what VERITAS is aiming at: the needs of special user groups.

Accessibility standards in certain application domains do exist. In particular the accessibility in the World Wide Web has been an issue in standardisation and shows quite good progress. Most of their stipulations are not the main focus of VERITAS. They are frequently guidelines, determining the characteristics of an interface rather than the development process.

Procedural standards in the application domains are relevant for VERITAS as long as they are related to the accessibility engineering process in the individual application domains. VERITAS does not intend to establish new development and engineering processes per se. It rather tries to fit into existing processes as long as they allow for the integration of simulation and VR based accessibility engineering. Therefore this type of standards establishes a kind of interface to existing processes, which VERITAS has to take into account. The same holds true for the tools used in the application domains.

User characteristics of ageing and disabled users are as well an input of VERITAS as an output. VERITAS intends to rely on existing taxonomies and data from literature. In case data for specific disabilities do not exist, the Multi-Sensorial Platform will be used to measure the user characteristics. Therefore VERITAS tries to use existing standards and will investigate, whether and how to be involved in standardisation in this scope.

Simulation in usability and accessibility engineering is the core task of VERITAS. The area is under research. In particular the simulation of special needs is a challenge here. Standards in that field would be highly relevant but are not expected to exist. VERITAS has to develop during the runtime of the project a position whether the elaborated results are suited for standardisation and where such initiatives have to be placed. See standardisation activities below for further discussion.

This scope is of high relevance for the project, because user modelling has been the main topic of the first year's work of VERITAS. The project has gained experience in the required processes and VERITAS user models are already available. So User Modelling is a promising candidate to incorporate VERITAS results into standardisation initiatives.

6.3 Application Design Guidelines from VERITAS

Section 5 of this deliverable presents a set of guidelines. These are not exhaustive, nor definitive. The target is to enrich them through further testing of applications with VERITAS tools. The application domains chosen and the technologies used are a new combination and as such few guidelines exist yet and fewer still regarding designing for people with disabilities. Furthermore, the deliverable presents the methodologies followed by the VERITAS partners in the design and development phases and how VERITAS tools fit into those.

Further usage and testing of the VERITAS tools should yield a comprehensive framework of development that could form the basis of a new process for the various domain industries that will include accessibility early on.

6.4 Standardization activities

This section summarizes the standardization activities conducted in the time frame of the Project. This activities are more extensively described in D.4.5.2.

VUMS standardisation activities

The following projects form the VUMS cluster (Virtual User Modeling and Simulation):

- GUIDE
- MyUI
- VERITAS
- VICON
- VAALID

The main output from these workshops was the following:

Following the proposals of the European Commission and experts involved in the proposal evaluation process a cluster of 4 projects GUIDE, MyUI, VERITAS and VICON, starting early 2010 and working on “Embedded Accessibility” was formed. The VAALID project joined this cluster as well. The cluster is named VUMS cluster as an acronym for “Cluster on Virtual User Modeling and Simulation”. The cooperation of the four projects is based on a Memorandum of Understanding on concertation and clustering, which is part of the individual Descriptions of Work (DoW) of the cluster projects. This MoU covers collaboration in the fields of interoperability, standardisation, dissemination and ethics of the cluster projects.

It also states that the cluster projects will make their software platforms interoperable in an appropriate way and that in particular VERITAS, VICON, MyUI and GUIDE, will harmonise standardisation activities and support each other in activities concerning international mainstream standardisation organisations such as W3C, ISO/IEC, ITU, ETSI, CEN, or CENELEC.

Results of VUMS workshops

The activities of these workshops lead to the creation of a common glossary of terms that was compiled after discussion between projects, in order to achieve common understanding and facilitate interoperability. This glossary of terms also serves the same purpose in communicating with the various national and international standardisation bodies (such as ISO) and other groups (such as Cloud4All, AccessForAllWorkingGroup).

6.5 Virtual User Models

Virtual User Models are the main focus of the VUMS cluster workshops. VERITAS has contributed to the work conducted by providing a detailed description of what a virtual user model should include and how it is to be structured. It is a very important part of the standardization activities, since a standardized virtual user model would obviously facilitate in the adoption of VERITAS tools or similar tools.

Part of the workshop discussions also revolved around the extensibility of these user models or how current virtual models employed in various application domains can be extended to accommodate the characteristics and variables of people with disabilities. For example, the automotive industry is already using simulation tools (such as RAMSIS) to test ergonomical issues. Such tools do not account for people with disabilities, so a standardized extension of the virtual models would be most beneficial. An open user profile repository would make an impact. A standard should apply to a range of complexity of user models. It seems useful to start with defining syntax and taxonomies (ontologies) for user models. The target standard shall definitely not include specific user models. It should provide a helpful framework for cooperation and interoperablility.

Concept of the VUMS User Model (from D4.5.4d)

- Providing interfaces for interoperability
- Declarative approach
- Set of variables describing the user
- Machine and human readable presentation
- Flexible structure that adapts to user needs and applications
- Open standard living in the internet

Structure of the VUMS user model

- A taxonomy of variables
    - Anthropometrics: Physical dimensions, proportions, and composition of the human body
    - Motor parameters
    - Strength parameters
    - Dexterity/control parameters
    - Affective parameters
    - Interaction related states
    - Hearing parameters
    - Visual parameters
    - Cognitive parameters
    - Equilibrium
    - Others

Descriptors for variables

This is a list of descriptors for the variables that describe the user that was shared with the VUMS partners.

- Name: The name of the variable
- ID/tag: The tag to be used for defining the specific variable in a user profile
- Description/definition: A description/definition of the variable
- Unit: the measurement unit of the variable
- Value space: The value space of the variable (character/string, enumeration, list/vector, integer, float, set)
- How to measure/detect: Refers to techniques/devices used to measure the value of the variable (e.g. goniometer, tape measure method, etc.)
- Reference/source: Literature references where information regarding the variable can be found
- Relations: Statistical correlation to other variables, function of others, dependency of others
- Source project: The name of the project of VUMS cluster that introduced the variable
- Supported/used by Project: The name(s) of the project(s) of VUMS cluster that use the variable in their user profiles.
- Comment: Comments concerning the variable (status, cross-references and others)

The VERITAS user modelling methodology is being built based on four major building blocks that are the following: (a) Task Models, (b) Abstract User Models, (c) Generic Virtual User Models and (d) Virtual User Models (implemented in VERITAS as personas).

6.6 Roadmap

The VERITAS roadmap has been formulated based on the VERITAS standardization activities. The contribution of design guidelines formulated in the context of this deliverable to the roadmap is twofold. Initially design guidelines could be employed in the future as design guidance for producing accessible products targeting the VERITAS application domains. Furthermore the guidelines themselves can be employed within the VERITAS tools to provide runtime ergonomic knowledge to designer and developers as long as produce reports based on the formal definition of design guidelines. The complete Roadmap of the project is more extensively described in D.4.5.2.

7 Discussion and Conclusions

This deliverable presented an analysis of the conclusions drawn by the rounds of testing of the VERITAS framework and tools. Its primary aim was threefold:

to identify the design and development processes as they were shaped during this round of testing and briefly present them according to application domain, consolidating the processes of each respective work group.

To consolidate design guidelines and recommendations as they emerged during testing with existing design guidelines from practice and expert advice. These were presented according to application domain and generic guidelines.

To summarize the roadmap so far and suggest/present the vision of the future

The overall conclusions drawn at this stage suggest the following:

The VERITAS framework and tools need tweaking and overcoming certain problems but the successful employment of the tools in real case studies across various application domains suggests that they offer a viable and feasible solution for the inclusion of Design for All principles into the current design and development processes.

The initial findings are too few to extract specific guidelines at the moment but long-term usage and dissemination of knowledge gained certainly holds a lot of promise.

7.1 VERITAS weaknesses

Several work activities have identified weaknesses and shortcomings of various VERITAS tools. For example D2.3.3 (p. 39) [16] or D2.1.1 (p.107) [38], which are presented in this section. The scope of this section is not to list all shortcomings of the VERITAS tools but to draw attention to the recommendations of other work groups and emphasize the need to overcome them.

7.1.1 Software problems

From Smart Living Spaces, D2.3.3:

During the development and the first pilot iteration several issues were observed based on developers' and users' experiences.

- The VerSimCore API does not provide sufficient support for a service oriented decoupling of the actual simulation. VerSimCore developers have included new calls for deeper access but have been limited by the used libraries as e.g. Delta3D or Cal3D. These have encapsulated functionalities which could not been accessed without changing the source code. This was not foreseen initially. The online coupling could be realized nevertheless but is brittle and sensitive towards further development.
- The VerSimCore simulation is not really real-time capable in terms of simulation but also in terms of feeding end-point data via a real time tracker

- The VerSimCore engine is not ready to simulate geometrically correct intermediate steps (and never has claimed) only the end state is significant in terms of the result.
- No real time changes of the scene can be made as the only correct and reliable description is via the task and scene files.
- The end user asked for play back, slow motion, step play, and rewind of the simulation which is not easily possible.
- The task and the scenes are coupled so tight that they cannot be exchanged easily.
- The task and the user model are also coupled too tight.
- The tool chain of VerSimCore has still room for improvement as it is very difficult to use the VerSimEd-3D GUI as reloading the file readjusts the initial position of objects each time the files are loaded.
- The first person view needs a floor projection to be able to perceive open and closing of nearby objects in order to evaluate the design.
- First person view in wheelchair modes needs a proper collision model
- The latency and the overshooting for the visual impairments in the first person view are too high. So only static views are really usable.

The observation of no. 1, 2, 3 and 4 lead to the conclusion that, although fully functional, the coupling does not meet the users' expectations and is too slow. One could try now to optimize further the throughput of the simulation but we believe specifically considering no. 5 it would be more beneficial to substitute the actual real simulation with pre-computed animations which can be loaded independently and played back and forth as needed. The no. 6 and 7 lead to the conclusion that the task, scene and user configurations are heavily dependent. It would make no sense to offer end user the choice of different entities on the fly, but the scene creator has to provide complete configuration file sets which are offered as sessions. This additionally simplifies the 2D control interface to a simple list of prepared scenarios.

No. 8 suggests to focus on the 1st person view as the creation of the scenarios is very time consuming and error prone. No 9 increases the need for hardware and a multiwall projection system which also needs a very powerful computer or a cluster of computers. No. 10 and no. 11 suggest an effort which is worthwhile but probably out of the project's time frame for the evaluations.

The conclusions that have been drawn in regard to the above described issues are the following:

1. Integrate the VerSimCore as animation files which can be paly back forth. To do this the core simulation of the virtual human has to be captured in an animation file format as VRML.

2. Focus on the 1st person view: To do so the collision has to be integrated and the visual impairments have to be optimized (eventually a shader).

We are optimistic that both points can be achieved until the end of the project. For the second iteration of the pilot for the designer point 1 will be realised.

Work activity D2.1.1 provides a table summarizing the list of problems encountered and the comments suggesting solutions.

Table 6 (reproduced from [38]): Limitations of simulating the avatar model in conjunction with the respective virtual user model parameters.

Simulation engine limitation	Type	Associated VUM parameter	Comment
Application of different dynamics specs to a joint for opposite moving directions is not possible	Motor / Dynamics	upperLimb-> pullForce, pushForce, inForce, outForce, shoulderTorque, elbowTorque, lowerLimb-> flexionTorque, extensionTorque	The declared values are mixed using the formulas **Σφάλμα! Το αρχείο προέλευσης της αναφοράς δεν βρέθηκε.** and **Σφάλμα! Το αρχείο προέλευσης της αναφοράς δεν βρέθηκε.** in order to provide a region-specific factor for the limb and increase the stability of the simulation.
Missing of a physics-based method.	Motor / Dynamics / Gait	-	This limitation has no negative impact on VERITAS simulation scenarios.
Reproduction of an approximation of the virtual user's gait cycle.	Motor / Gait	-	Exact reproduction of the user's gait cycle cannot be achieved because the VUM file lacks of specifying gait cycle angle data. The simulation engine copes with this matter by using and adapting the needed data from the respective bibliography.
Limb tremors are not supported	Motor	-	In 3D physical environments, tremors may result in instability issues and most importantly they can affect the evaluation result by succeeding or failing "by mistake". There are, however, plans for supporting the hand tremor simulation in GUI simulation sessions.
Prosthetics simulation not supported.	Motor / Anthropo-metrics / Assistive devices	-	Amputee users with prosthetics are not currently supported by the simulation engine. Although the Veritas Avatar Editor can export CAL3D models with missing limbs, the prosthetics simulation is an area that needs further investigation, before implementing such kind of planners.

Simulation engine limitation	Type	Associated VUM parameter	Comment
Wheelchair simulation not supported yet.	Motor / Assistive devices	-	A wheelchair motion planning is under development.
Automatic accessibility assessment when simulating vision impair-ments is not supported	Vision	-	There are not any criteria for providing a “success” or “failure” result when simulating a user having vision deficiency. Even if the virtual user’s field of view is severely blocked by blinding spots, there is not any known formula to justify if he/she can see the environment. Additionally a “can been seen” or “cannot been seen” result is compromised by the user’s perception and his/her experience regarding the environment.
Visual acuity simulation is not modelled correctly for 3D environments.	Vision	visualAcuity	Visual acuity simulation is based on a global image blurring method, i.e. all the scene objects are blurred the same not taking into account their distance from the avatar. There are some vision impairments where such filtering is not correct, such as Myopia, especially for 3D design evaluation.
Glare sensitivity requires a fast CPU.	Vision	glareSensitivity	A fast CPU is required for filtering large frames in real time.
Blind spots cannot be generated at specific positions on the field of view.	Vision	blindSpotArea, blindSpotSize, blindSpotOpacity, blindSpotCount	Blind spots’ locations are computed in a random way. Thus, precise placement on the avatar’s field of view is not allowed.
Automatic accessibility assessment for hearing impairments is not supported	Hearing	-	Speech recognition systems have been implemented as part of Multimodal Interfaces Manager (WP2.8) they must not be used for this kind of purpose, because the modelling that applies to them does not apply in the same way for the human brain.

Simulation engine limitation	Type	Associated VUM parameter	Comment
VUM parameters form support in filtering high pitch sounds	Hearing		The provided VUM files include audiogram parameters that reach 8KHz (8KHz is considered enough for proper voice sampling), so the simulation engine has not enough information to perform filtering on higher frequency bands (although it is supported), e.g. for high pitch sounds.
Lack of speaking simulation.	Speaking		Speech simulation is totally absent. The problem is not so in the generation of speech from text, but in what purpose this speech serves. The problem does not reside in synthesising the speech from text, but understanding its meaning, i.e. mental consideration of the phrase before and after it has been spoken. So, because this problem has a perceptual nature, it has been avoided.
Cognition simulation is not supported properly.	Cognitive		Cognition simulation is currently defined by using the delay factors (mentioned in **Σφάλμα! Το αρχείο προέλευσης της αναφοράς δεν βρέθηκε.**) before and during an action. Later implementations will include models from the ACT-R software **Σφάλμα! Το αρχείο προέλευσης της αναφοράς δεν βρέθηκε.**.

Deliverable 3.5.1 reports:

The designers found that the various functions in VERITAS system are not very well integrated but think also that there are not too many inconsistencies.

Participants to the pilot with developers showed little differences in their opinions on how VERITAS tools are easy to use, in general it seems that the tools are quite easy.

The state of the generation of the VUMs was not always clear: some parameters seem to be a bit unclear with respect to how the model is affected when changing the values.

Loading an existing model is very easy in developers' opinion but not so easy is editing it. A missing functionality in VerGen, when defining a virtual user model, seems to be a more efficient generation of pre-configured user models. All the designers highlight that the tool don't provide enough feedback to evaluate whether the user models fit their design goals, in particular designers would prefer the tool to give more details when changing a parameter value, in terms of what is the impact of the change on the user model.

For what concern the functionalities of VerSEd-GUI when defining the parameters for the simulation scenario it would be useful to improve the configuration mode of the areas of interaction with the user with disabilities. One designer noticed that he missed the ability to specify expected reaction times in the interactions (since some of them are time-dependent).

During the second iteration of the pilot with designers the participants had some problems with the VerSIM-GUI in trying the simulations with users with different disabilities.

Assessing a simulation of different task modalities and modifying parameters of a simulation is not so intuitive, it needs a bit of study of the user manual.

In designers' opinion missing functionalities are the following: a greater feedback of the VerSIM-GUI results, a better simulation of physical disabilities and an improvement of the immersive simulations to match the real user.

Most of the participants to the pilot with developers highlighted that the feedback of VerSIM-GUI in case of an error is not completely adequate.

In conclusion, some work could be done to improve the capability of the simulation of physical disabilities and immersive simulations to match the real characteristics of the users. VERITAS tools are a valuable instrument especially to test mock-ups, although most of the designers think that learning to use this system is not very intuitive; when trained, they found using VERITAS tools quite easy so that they would improve their performance in the design and development.

From VERITAS D3.4.1:

The following are some of the general restrictions:

- Each redesign requires a re-recording of the interactions and adaptation of the simulation models to match the new designs, regardless of the extent of changes made to the UI, whether these changes are minimal or extensive.
- Visual and Hearing accessibility issues can only be tested in an interactive manner, because the system cannot truly automatically simulate the recognition of visual and auditory stimuli. This is a technological limitation that is understandable, since machine learning algorithms required to perform a task by understanding what is displayed on screen or what is output on the speakers are still some years off.
- Cognitive simulation offers an entry level accessibility assessment but for the same reasons as those regarding vision and hearing simulation, cannot fully cover the accessibility assessment requirements in an automatic manner.
- Some interactions, e.g. dragging of UI elements, scrolling to an indefinite position cannot be fully supported due to the unknown final state of the interaction. For example, in the 3D UI elements of Second Life, the Veritas

system can't encode the final state of the elements in a rotate action, since this is dependent on user location and thus UI element size.

- In general, the system must be used by a usability expert or a UI designer well trained in usability engineering, in order to be fully exploited.
- The results of the simulations make certain assumptions on the aptitude and prior knowledge of the use cases by the virtual users that need to be taken into account when comparing with results by actual users. The system assumes that the virtual user knows both how to use the UI design and perform the tasks perfectly with the only restrictions taken in to account being those introduced by impairments, whereas, as we witnessed in the pilot sessions with beneficiaries, there are further delays and errors that may occur in actual testing due to the user's imperfect understanding of the tasks and the UI designs' layout.

Defining the interaction areas.

The current version of the VerSEd that records the interaction areas of GUIs is currently marking the areas based on absolute pixel co-ordinates. This is inflexible since not all GUI layouts are based on absolute pixel values (e.g. fluid web pages) and the final appearance and size of a GUI can be different across different devices, screen resolutions and monitor sizes. This means that each simulation ran by VERITAS will be completely accurate and valid for the specific proportions of the device and environment. This may be negligible in some cases but testing a GUI that could run in a tablet or a desktop PC will be substantially different.

- In order to avoid this potential pitfall designers and developers should test their interfaces with different resolutions, screen sizes and test whether these variations all check out.

7.2 VERITAS strengths and potential

7.2.1 Extracting guidelines and standards from evaluation/simulation sessions?

Guidelines constitute a rapidly evolving medium for transferring established and de facto knowledge (know-how) to various interested parties (e.g., designers and developers require guidelines for achieving accessibility and usability). The simulation and evaluation environment of VERITAS can prove very valuable for transforming knowledge stemming from the evaluation sessions into Guidelines. Some results in that direction have been included in section 5.4 and in some cases throughout section 5.2 and 5.3.

The simulation itself, via a large number of automatically generated user models, can be proven of great significance for testing the practical exploitation and therefore the usefulness of guidelines.

7.2.2 Virtual User Models as an extension of Personas

The Virtual Models supported by VERITAS could be seen also as an extension or evolution of the concept of personas. Personas are fictional user profiles, constructed by a design team to serve as a reminder and as a means to increase empathy towards the final user. Personas are complete with a picture, biographic details and even personal details and preferences that may have no actual bearing to the design process per se but are actually very helpful in order to make the persona “real” to the designer. Personas are supposed to represent “typical” end users or stakeholders. Of course, such a thing as a typical user does not exist but rather the persona encompasses traits found among the majority of users (such as age, profession, financial status, family status, etc.). Typically, more than one persona is used during the process. The main advantage of personas is that they provide a constant reminder to developers about users and their needs, especially useful when interaction with real users is not feasible or is sporadic.

The Virtual User introduced by VERITAS could very well serve as giving the persona a (virtual) corporeal body that can also be modified to represent any group of users and any kind of disability and special groups.

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Appendix

Standards relevant to VERITAS

Standard	Year	Title	Objective/ Scope	Level of stipulation	Short description	Relevance for VERITAS
ISO 9241-20:2008	2008	Ergonomics of human-system interaction Part 20: Accessibility guidelines for information/communication technology (ICT) equipment and services	Use/ Access	Proc	ISO 9241-20:2008 is intended for use by those responsible for planning, designing, developing, acquiring, and evaluating information/communication technology (ICT) equipment and services. It provides guidelines for improving the accessibility of ICT equipment and services such that they will have wider accessibility for use at work, in the home, and in mobile and public environments. It covers issues associated with the design of equipment and services for people with a wide range of sensory, physical and cognitive abilities, including those who are temporarily disabled, and the elderly. [1]	
ISO/IECTR 15440:2005	2005	Information technology Future keyboards and other associated input devices and related entry methods	Use/ Process	Def	ISO/IEC TR 15440:2005 is aimed at both the users and manufacturers, and intends to present the user requirements regarding keyboards and associated devices and methods, at time of its publication.	

					ISO/IEC TR 15440:2005 covers ■the different input requirements catering for national and international practices and support of cultural and linguistic diversity; ■the recognition of requirements regarding comfort of use (for any user, including children, elderly and disabled people), and improved user productivity related to inputting data; ■enhancements of keyboards and related input devices and methods required for new emerging phenomena such as Internet, multimedia, virtual reality; ■virtual input requirements; ■labelling issues (soft [LCD] and hard, permanent and temporary labels), function symbols and icons. [2]	
ISO/IEC TR 19766:2007	2007	Information technology Guidelines for the design of icons and symbols accessible to all users, including the elderly and persons with disabilities	Use/ Access	Def	ISO/IEC TR 19766:2007 provides recommendations relating to the design of icons to support accessibility by the elderly and people with disabilities. These recommendations assist accessible implementation of all icons for users. While these recommendations were developed to meet the needs of the	

					elderly and people with disabilities, they can also provide greater accessibility to a wider range of users in a variety of different contexts. ISO/IEC TR 19766:2007 introduces a set of attributes and operations that can be implemented as features of graphic icons to make the functionality of these icons accessible to the widest possible range of users. Textual attributes are emphasized because they can be rendered in various alternate modalities. ISO/IEC 11581-1 provides guidance on the graphic aspects of icons. Specific renderings of these attributes (or of icons in general) are not dealt with as part of ISO/IEC TR 19766:2007. [3]	
ISO 9241-171:2008	2008	Ergonomics of human-system interaction -- Part 171: Guidance on software accessibility	Use/ Access	Def	ISO 9241-171:2008 provides ergonomics guidance and specifications for the design of accessible software for use at work, in the home, in education and in public places. It covers issues associated with designing accessible software for people with the widest range of physical, sensory and cognitive abilities, including those who are temporarily disabled, and the elderly. It addresses software considerations for accessibility that complement general design for	

					usability as addressed by ISO 9241-110, ISO 9241-11 to ISO 9241-17, ISO 14915 and ISO 13407. ISO 9241-171:2008 is applicable to the accessibility of interactive systems. It addresses a wide range of software (e.g. office, Web, learning support and library systems). It promotes the increased usability of systems for a wider range of users. While it does not cover the behaviour of, or requirements for, assistive technologies (including assistive software), it does address the use of assistive technologies as an integrated component of interactive systems. It is intended for use by those responsible for the specification, design, development, evaluation and procurement of software platforms and software applications.[4]	
ISO/IEC 24751-1:2008	2008	Information technology Individualized adaptability and accessibility in e-learning, education and training Part 1: Framework and reference model	Use/ Access	Def	ISO/IEC 24751 is intended to meet the needs of learners with disabilities and anyone in a disabling context. ISO/IEC 24751-1:2008 provides a common framework to describe and specify learner needs and preferences on the one hand and the corresponding description of the	This standard is not too relevant with the goals of VERITAS. However, it proposes a process for matching digital resources to user's needs and preferences. Some of the steps of

					digital learning resources on the other hand, so that individual learner preferences and needs can be matched with the appropriate user interface tools and digital learning resources [5]	the proposed process could provide guidance to VERITAS on how the Virtual User Models could be used by a simulation platform.
ISO/IEC 24751-2:2008	2008	Information technology Individualized adaptability and accessibility in e-learning, education and training - Part 2: "Access for all" personal needs and preferences for digital delivery	Use/ Access	Prop	ISO/IEC 24751-2:2008 provides a common information model for describing the learner or user needs and preferences when accessing digitally delivered resources or services. This description is one side of a pair of descriptions used in matching user needs and preferences with education delivery (as described in ISO/IEC 24751-1). ISO/IEC 24751-2:2008 discusses the basic principles adhered to in developing this model for describing personal needs and preferences. It explains: the rationale for using a functional approach to describing needs, possible methods of creating a personal needs and preference statement, the major groupings of needs and preferences within the standard, the use of different needs and preferences statements in different contexts, how needs and preferences can be ranked with respect to priority, and the use of generic and application-specific	VERITAS may include a subset of the stated in the standard user needs and preferences related to disabilities to the structure of the Virtual User Models.

					needs and preference specifications. It contains the information model for ISO/IEC 24751-2:2008, including the attribute, allowed occurrence and datatype of each element. It defines and describes how the terms in the information model should be used. Conformance to ISO/IEC 24751-2:2008 is discussed. Conformance is dependent on the role played by the conformant technology. Conformance requirements for both education delivery applications and alternative access systems are explained. ISO/IEC 24751-2:2008 provides ■a consolidated list of all the terms defined in ISO/IEC 24751-2:2008, sorted in French alphabetical order, ■the ISO French language equivalent terms and definitions, and ■the codes representing the gender of the French terms. The vocabulary codes, values and associated rules of application are defined. An informative list of recommended default values for the learner preferences and needs is	

					provided. It lists existing bindings of the IMS Learner Information Package Accessibility for LIP - Version 1 [ACCLIP] that serves as the reference specification for ISO/IEC 24751-2:2008. It describes information scenarios for applying ISO/IEC 24751-2:2008 and gives informative implementation examples. Use of ISO/IEC 24751-2:2008 will assist in matching individual learner needs in a computer mediated learning environment with the necessary user interface and resources needed to meet those needs.[6]	
Web Content Accessibility Guidelines (WCAG) 2.0	1999	The Web Content Accessibility Guidelines (WCAG) documents explain how to make Web content accessible to people with disabilities. Web "content" generally refers to the information in a Web page or Web application, including text, images, forms, sounds, and such. WCAG is part of a series of	Use/ Access	Prop	Web Content Accessibility Guidelines (WCAG) 2.0 covers a wide range of recommendations for making Web content more accessible. Following these guidelines will make content accessible to a wider range of people with disabilities, including blindness and low vision, deafness and hearing loss, learning disabilities, cognitive limitations, limited movement, speech disabilities, photosensitivity and combinations of these. Following	The Delivery Context Ontology itself constitutes a vocabulary of terms describing different types of devices. This vocabulary can be used in the Abstract User Models as well as in the Virtual User Models wherever special requirements

		accessibility guidelines, including the Authoring Tool Accessibility Guidelines (ATAG) and the User Agent Accessibility Guidelines (UAAG). Essential Components of Web Accessibility explains the relationship between the different guidelines.			these guidelines will also often make your Web content more usable to users in general. WCAG 2.0 success criteria are written as testable statements that are not technology-specific. Guidance about satisfying the success criteria in specific technologies, as well as general information about interpreting the success criteria, is provided in separate documents. See Web Content Accessibility Guidelines (WCAG) Overview for an introduction and links to WCAG technical and educational material. WCAG 2.0 succeeds Web Content Accessibility Guidelines 1.0 [WCAG10], which was published as a W3C Recommendation May 1999. Although it is possible to conform either to WCAG 1.0 or to WCAG 2.0 (or both), the W3C recommends that new and updated content use WCAG 2.0. The W3C also recommends that Web accessibility policies reference WCAG 2.0.[7]	have to be defined for a user concerning the interaction with various devices.
http://www.w3.org/TR/2004/REC-CCPP-struct-vocab-20040115	2004	Composite Capability/Preference Profiles (CC/PP): Structure and Vocabularies 1.0	Use/ Process	Proc	This document describes CC/PP (Composite Capabilities/Preference Profiles) structure and vocabularies. A CC/PP profile is a description of device capabilities and user	VERITAS may use the user preferences specified by the standard, especially those related to

					preferences. This is often referred to as a device's delivery context and can be used to guide the adaptation of content presented to that device. The Resource Description Framework (RDF) is used to create profiles that describe user agent capabilities and preferences. The structure of a profile is discussed. Topics include: •structure of client capability and preference descriptions, AND •use of RDF classes to distinguish different elements of a profile, so that a schema-aware RDF processor can handle CC/PP profiles embedded in other XML document types. CC/PP vocabulary is identifiers (URIs) used to refer to specific capabilities and preferences, and covers: •the types of values to which CC/PP attributes may refer, •an appendix describing how to introduce new vocabularies, •an appendix giving an example small client vocabulary covering print and display capabilities, and •an appendix providing a survey of existing work from which new vocabularies may be derived. [8]	disabilities, for the development of the Abstract and Virtual User Models.

IMS Access For All Personal Needs and Preferences Description for Digital Delivery Information Model	2004	Composite Capability/Preference Profiles (CC/PP) is a specification for defining capabilities and preferences (also known as 'delivery context') of user agents. CC/PP is a vocabulary extension of the Resource Description Framework (RDF). Delivery context can be used to guide the process of tailoring content for a user agent. The CC/PP specification is maintained by the W3C's Ubiquitous Web Applications Working Group (UWAWG) Working Group	Use/ Access	Prop	This part of the Access For All Specification provides a common information model for describing the learner or user needs and preferences when accessing digitally delivered resources or services. This description is one side of a pair of descriptions used in matching user needs and preferences with digital delivery. This model divides the personal needs and preferences of the learner or user into three categories: a) Display: how resources are to be presented and structured; b) Control: how resources are to be controlled and operated; and, c) Content: what supplementary or alternative resources are to be supplied? This part of the Access For All Specification is intended to meet the needs of learners with disabilities and of anyone in a disabling context. The purpose of this part of Access For All Specification is to provide a machine-readable method of stating user needs and preferences with respect to digitally based education or learning. This part of Access For All	This standard provides a machine-readable method of stating user needs and preferences with respect to digitally based education or learning. Some of the stated user needs may also be used out of the scope of e-learning, describing the limitations in interaction of the user with the environment (ex. there are attributes like “speech-rate”, “pitch” and “volume” concerning screen readers). The description of such user needs, as it is proposed by the standard, may be used in the development of VERITAS Abstract and Virtual User Models.

					Specification can be used independently, for example to deliver the required or desired user interface to the learner/user, or in combination with Access For All Specification Digital Resource Description to deliver digital resources that meet a user's needs and preferences. This document is based upon the original ISO/IEC 24751-1:2008 Information technology Individualized adaptability and accessibility in e-learning, education and training Part 2: "Access For All Personal Needs and Preferences for Digital Delivery". The ISO/IEC 24751-1:2008 document was a further development of the original IMS GLC Access For All Learner Information Package Specification, July 2003. The key changes from the ISO/IEC equivalent document are (note that these changes are documentation in nature and the technical solution is faithfully reproduced): a) The ISO/IEC Annex A has been removed and the subsequent appendices renumbered. This annex consisted of the French equivalents; b) The ISO/IEC Section 6 and 7 have	

					been combined into a new Section 6 to contain all of the formal description of the information model. Also, this model is described using the Unified Modelling Language representation as defined in the IMS GLC Specification Note 07: UML Profile for Platform Independent Model Descriptions of Specifications for Data Models.[9]	
ETSI EG 202 116	2009	Major revision of ETR 116, Human Factors guidelines for ISDN terminal equipment design to include provision for elderly and disabled users. The content of ETR 029 and ETR 166 will be revised and merged into the final document.	Use/ Access	Proc	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	ETSI EG 202 116 contains definitions of user characteristics, including sensory, physical and cognitive abilities. These definitions may be used in the development of the VERITAS Abstract User Models, in order to express how the disabilities are connected with the sensory, physical and cognitive abilities of the user. Additionally, ETSI EG 202 116 describes how user abilities are changing over years. This information could

					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. 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].	be used in the development of VERITAS Generic Virtual User Models representing users of different age groups.

					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. [10]	
ETSI EG 202 132	2004	Human Factors (HF); User Interfaces; Guidelines for generic user interface elements for mobile terminals and services MMI in Mobile telecoms	Use/ Access	Prop	The aim of this work is to widen and simplify end user access to mobile information and communication devices and services. The document will be based on consensus and best practice, addressing key issues from the end user's perspective. It will provide guidance to ETSI, manufacturers and service providers on possible and beneficiary options to harmonize generic UI elements for mobile ICT terminal devices and services, on the basic level, without limiting their options to use the user experience of brand-specific user interface implementations as a competitive edge. In order to support the trend toward mobile access to ICT for all, basic needs and goals of	

					users of mobile telecommunication terminals and services will be examined in detail, taking into account all users (e.g. novice users, professional users, the mobile worker, young, elderly and disabled people). Based on this analysis, a core set of common user interface solutions of key functions will be identified and recommended for harmonisation, without restricting the ability of market players to further develop their devices and services. Also, negative aspects of such a harmonisation will be considered. The work will address areas such as basic call handling and safety-critical functionality, configuration and access to network-based functionality and services (including some professional application areas), most common and basic symbols and icons and specific support for the young and elderly users. Results of work performed by ETSI TC HF through other STFs under the eEurope 2002 Initiative will be considered and included in order to make an implementation-oriented practical impact. [11]	

ETSI EG 202 325	2005	Human Factors (HF); User Profile Management	Use/ Process	Prop	Effective user profile management will be critical to the uptake and success of new and advanced communication services and it is therefore important to focus on the users' requirements in this area. The objective of the work item is to produce an ETSI Guide (EG), establishing a set of guidelines relevant to users and their need to manage their user profiles for personalisation of services and terminals to provide efficient communications. The ETSI Guide will describe a conceptual framework in which user profiles can be considered. The following key areas are addressed: The user profile concept. Administering sub-profiles that reflect users' lifestyles and different situations. The benefits of user profiles to different parties. Scenarios in which user profiles may bring benefits. Administering automatic activation of sub-profiles. [12]	EG 202 325 provides guidelines relevant to users' needs to manage their profiles for personalisation of services and terminals. VERITAS may follow some of these guidelines for the better management of the Virtual User Models.
BS EN 1332-4:2007	2007	Identification card systems. Man-machine interface. Coding of user requirements for people with special needs	Use/ Tools	Proc	Identity cards, Cards, Interfaces, Ergonomics, Identification methods, Data elements, Integrated circuit cards, Objects (programming language), Tags (data processing), Length, Coding (data conversion), Colour codes, Position, Amplification,	BS EN 1332-4:2007 provides a set of detailed definitions of user needs (such as preferred speech output rate, requirement for

					Frequencies, Programming languages, Conformity, Disabled people, Aids for the disabled [13]	specific type of fonts, etc.), including people with special needs, for example the aged, minors, people with disabilities, those with learning difficulties, first time users, those not conversant with the local language. These user needs may be used in the VERITAS Abstract User Models, presenting this way how user needs are connected with the disabilities.
ISO 11228-2:2007	2007	Ergonomics - Manual handling - Part 2: Pushing and pulling	Use/Tool	Proc	ISO 11228-2:2007 gives the recommended limits for whole-body pushing and pulling. It provides guidance on the assessment of risk factors considered important to manual pushing and pulling, allowing the health risks for the working population to be evaluated. The recommendations apply to the healthy adult working population and provide reasonable protection to the majority of this population. These guidelines are based on experimental studies of push-pull tasks and associated levels of musculoskeletal loading, discomfort/pain, and	ISO 11228-2:2007 provides structured information illustrating the maximum acceptable forces concerning pushing/pulling for the 90% of the healthy adult working population, according to different parameters (gender, pushing/pulling distance, frequency, etc.). Additionally, many other

					endurance/fatigue. Pushing and pulling, as defined in ISO 11228-2:2007, is restricted to the following: whole-body force exertions (i.e. while standing/walking); actions performed by one person; forces applied by two hands; forces used to move or restrain an object; forces applied in a smooth and controlled way; forces applied without the use of external support(s); forces applied on objects located in front of the operator; forces applied in an upright position (not sitting). ISO 11228-2:2007 is intended to provide information for designers, employers, employees and others involved in the design or redesign of work, tasks, products and work organization.[14]	comparative tables are provided (ex. population subgroup profiles varying in age and gender and reflecting elderly working population (50-64 years)). This information could be taken into account during the development of the VERITAS Generic Virtual User Models.
EN ISO 24502:2010	2010	Ergonomics - Accessible design - Specification of age-related luminance contrast for coloured light	Use/ Tools	Prop	This international standard specifies age-related luminance contrast of any two lights of different colour seen by a person at any age by taking into account the age-related change of relative luminous efficiency of the eye.This basic international standard provides a method that can be applied to the design of visual signs and displays. It applies to visual	ISO/DIS 24502 provides a comparative analysis concerning the age-related spectral luminous efficiency (age is defined in decade). This information is pretty useful when there is need for the

					environments in which the spectral radiance is known or measurable and viewed under the moderately bright light level called photopic vision. It does not apply to those which are seen under a dark environment called mesopic and/or scotopic vision. NOTE 1 This document specifies the luminance contrast for people from 10 yrs to 70 yrs of age who have had no medical treatment or surgery on their eyes throughout their life. For people younger than ten years old or older than 80 years old, this document may apply by estimating the age-related spectral luminous efficiency by extrapolation .NOTE 2 This document does not apply to visual signs and displays seen by people with colour defects who have different spectral luminous efficiency from people with normal colour vision. [15]	development of User Models representing a population group of specific age and could be taken into account during the development of the VERITAS Generic User Models.
WHO ICF	2002	International Classification of Functioning, Disability and Health (ICF)	Dim/ User	Def	The International Classification of Functioning, Disability and Health, known more commonly as ICF, is a classification of health and health-related domains. These domains are classified from body, individual and societal perspectives by means of	WHO ICF provides classifications related to body functions and structure, and a list of domains of activity which may be used during the

					two lists: a list of body functions and structure, and a list of domains of activity and participation. Since an individual's functioning and disability occurs in a context, the ICF also includes a list of environmental factors.[16]	development of the VERITAS Abstract User Models.
UsiXML	2007	USer Interface eXtensible Markup Language) is an XML-based markup language for defining user interfaces on computers	Use/ Tools	Proc	The UsiXML language was submitted for a standardisation action plan in the context of the Similar network of excellence and of the Open Interface European project. For this purpose, the Université catholique de Louvain has been accepted by W3 Consortium for entering its academic initiative . Recently, in the context of the HUMAN project, UCL is responsible to enrich the UsiXML language by modeling aspects into abstractions that are general (e.g., more detailed modeling aspects of graphical UIs in general) but also in order to address aspects that are specific to Advanced Human Machine Interfaces (AHMIs). Therefore, the main goal was to enrich UsiXML in order to become able to describe, specify any AHMI involved in the HUMAN project in a way that will become standard at various organisations. Of course, it is	One of the requirements of VERITAS is the formal and detailed description of multimodal interfaces as well as user tasks. On the other hand, UsiXML provides meta-models that describe in detail the design of multimodal user interfaces, while it also supports task modeling. Consequently, UsiXML could be used in VERITAS for the development of multimodal user interfaces and task models.

					likely that some parts of UsiXML will be transferred to standardisation and not the entire language since the goal of the standardisation consists of extracting the best aspects of existing UIDLs. The next section details the various standardisation actions that have been introduced and in which we participated thanks to the HUMAN project. These actions would not have been made possible without the support of the HUMAN project and the EU. [17]	
ETSI TS 102 747	2009	Human Factors (HF);Personalization and User Profile Management;Architectural Framework	Use/Tools	Prop	The work will build on results from STF265 on User Profile Management. With the goal of obtaining maximum benefits for users, profiles would not be limited to cover today's ICT market, but would also embrace ubiquitous services and applications, and be able to communicate with a wide range of devices in digital homes/buildings. The deliverable will be a Technical Specification (TS) on issues related to networks, terminals and SmartCards. The intended readers of this deliverable are profile providers, telecom companies and device manufacturers who will implement and provide the underlying infrastructure and	VERITAS may follow some of the recommendations provided by this standard (ex. those concerning privacy) for the management of the Virtual User Models.

					architecture of network and devices necessary to achieve the user profile management concept described in EG 202 325 Human Factors (HF); User Profile Management. [18]	
ETSI TR 102 068	2002	Human Factors (HF); Requirements for assistive technology devices in ICT	Use/ Access	Proc	A technical report giving guidance on the needs of older and disabled people for assistive technology devices and the requirements for the interconnection of such devices to ICT systems. The report considers devices for user interface input (eg key presses) and output (eg display content) as well as speech and video transmission. It reviews available transmission technologies (eg bluetooth and DECT) and requirement on the transmission protocols. [19]	ETSI TR 102 068 describes user sensory, physical and cognitive disabilities and correlates them with assistive devices. VERITAS may use this information in the development of the Abstract User Models, which describe the disabilities, in order to correlate the disabilities with assistive devices.
ETSI ES 202 746	2010	Human Factors (HF);Personalization and User Profile Management;User Profile Preferences and Information	Use/ Tools	Def	This STF will standardize a rule definition language for defining automatic activation of profiles, a set of components (including attributes, operations and relations) and a common terminology related to user profile management. The work will build on results from STF265 on User Profile Management. With the goal of obtaining maximum benefits for users, profiles would not be limited to cover today's ICT market, but	VERITAS may include the user preferences specified by the standard, especially those related to disabilities to the structure of the Virtual User Models.

					would also embrace ubiquitous services and applications, and be able to communicate with a wide range of devices in digital homes/buildings. The deliverable will be an ETSI Standard that will standardize: - objects (including settings, values, operations and relations) related to user profile management; - rule definition language for defining automatic activation of profiles; - common terminology. [20]	
BPMN	2008	Business Process Modeling Notation (BPMN) is a graphical representation for specifying business processes in a business process model.	Use/ Tools	Def	A standard Business Process Modeling Notation (BPMN) will provide businesses with the capability of understanding their internal business procedures in a graphical notation and will give organizations the ability to communicate these procedures in a standard manner. Furthermore, the graphical notation will facilitate the understanding of the performance collaborations and business transactions between the organizations. This will ensure that businesses will understand themselves and participants in their business and will enable organizations to adjust to new	BPMN may be used for the graphical notation of the VERITAS Task Models.

					internal and B2B business circumstances quickly.[21]	

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