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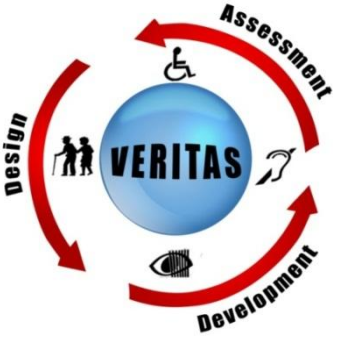

VERITAS

Virtual and Augmented **E**nvironments and **R**ealistic User **I**nteractions **T**o achieve Embedded **A**ccessibility Design**S**

247765

UCD design revision manual

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Workpackage No.	**W1.1**	Workpackage Title	**User groups, benchmarking and the industrial needs**
Activity No.	**A1.1.4**	Activity Title	**VERITAS UCD methodology**
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14	Revision of document to begin developments towards D1.1.3 – UCD Design Revision manual

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Abbreviations list

Abbreviation	Explanation
A	Activity
CARD	Collaborative Analysis of Requirements and Design
D	Deliverable
DoW	Description of Work
HCI	Human Computer Interaction
ICT	Information and Communication Technology
ID	Internal Deliverable
ISO	International Standards Organisation
PDA	Personal Digital Assistant
PICTIVE	Plastic Interface for Collaborative Technology Initiatives through Video Exploration
TAF	Task Analysis Framework
UCD	User Centred design
UI	User Interface
UML	Unified Modelling Language
UR	User Requirements
USID	User Sensitive Inclusive Design
UX	User Experience
SySML	Systems Modelling Language
WP	Work Package

Executive Summary

This is the third deliverable to be prepared in the context of the VERITAS project within the first work package namely, W1.1: “User groups, benchmarking and the industrial needs”. It presents the user centred design (UCD) methodology to be followed throughout the whole VERITAS design and development process, the ethical framework that it is situated within and the applications of the UCD framework up till month 18 of the VERITAS project by all VERITAS partners. This is the final revision of the deliverable in line with the growth of the project.

The first part of the document will outline the general UCD approach (Section 1.1) and defines the user groups involved in the VERITAS design and development process (Section 1.2). These are the VERITAS designers and developers who build the VERITAS applications and tools, and the two user groups: end users using the VERITAS tools and VERITAS beneficiaries, who are users with impairments (in vision, hearing, motor movements, cognition, speech) and older people. The involvement of users in each stage in the VERITAS process is seen as a particular challenge due to the large scope of target end users that need to be involved. Section 1.3 introduces methods to be applied in VERITAS to allow a UCD process. These methods are grouped according to the main stages: Requirements engineering, early and later design and development stages of VERITAS, Evaluation of designs and developments, and a preliminary plan for the pilots in VERITAS. The pilot planning (WP3.6) is outlined in detail within D3.6.1. All methods recommended to be applied in the respective stage of the VERITAS process (e.g. requirements engineering) are listed and described briefly. In addition, guidelines as to how to choose appropriate methods by designing and developing partners of VERITAS are provided. These guidelines are supplemented by tables showing in a systematic manner the different objectives, advantages, disadvantages of each method as well as required amount of participants and costs to facilitate decision making processes, especially considering the five different application areas of VERITAS (automotive, health care, smart living, workplace and infotainment). Each method is described in detail in Section 1.4 extending on the objectives, advantages, disadvantages of each method and providing details on the procedure of performing the method, helpful tools, other specifications of each method and further aspects requiring attention.

The second part of this document (Section 2) shows how the UCD approach is applied within VERITAS. Here, it is specified which UCD method will be used in the different work packages and activities of VERITAS. Again, this Section is grouped into the main stages of the project. Within these stages, the application of UCD method is distinguished according to the three user groups involved, and as defined earlier.

The third part of the deliverable (Section 3) is taken from D4.1.4 and discusses the ethics of applying the UCD design methods. This allows partners to understand the general ethical procedure and associated tasks and the general legal framework that surrounds those tasks.

The fourth part of the deliverable (Section 4) covers the application of the VERITAS UCD methods within the project to evaluate the applicability of the approach. This section presents feedback from 23 activities conducted up till month 18 and looks ahead to see if there are any further concerns for the UCD in the VERITAS project.

The last part outlines the product life-cycle of VERITAS (Section 5), encompassing its launch and exploitation as foreseen in SP4. It also outlines certain evaluations following the dissemination of VERITAS presented through market research and user experience research, e.g. of the end users when designing using the VERITAS tools.

1 VERITAS UCD approach

The overall VERITAS UCD approach will be applied to the development of the VERITAS tools as well as the development process of the five different VERITAS application areas: automotive, health care, smart living, workplace and infotainment (see Figure 1).

With respect to people with disabilities each application area contains special requirements and structures that need to be regarded within the particular user centred development process (cf. understanding UCD processes for people with special needs: Thimbley, 2008; Newell et al., 2010). The VERITAS tools support the designers and developers of the accessible applications during the development process of the particular application.

This document depicts the entire VERITAS UCD approach and contains the design guidelines to be applied during the development of the VERITAS tools as well as the accessible applications. All VERITAS products shall be developed and defined accordingly.

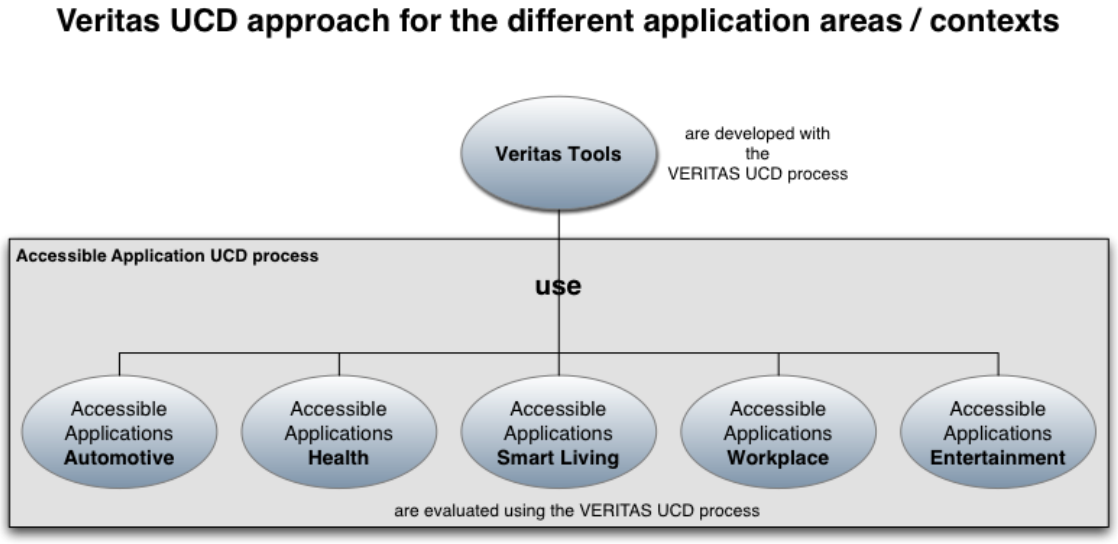

Figure 1 VERITAS UCD approach for the different application areas/ contexts.

1.1 Introduction

This is an extensive document that presents numerous UCD approaches that are tailored towards different environments for each Work Package leader. For those who wish to quickly find their relevant UCD approaches in this document, Table 17 shows the methods to be used by stage of the project, Table 19 breaks down the methods by SP and Table 20 and Table 21 provide an overview of the UCD methods broken down by WP. After reading these documents, partners will be able to identify the relevant methods that they should read up on and find them in section 1.4.

The User Centred Design (UCD) is made up of several steps to support designers and developers in every phase of the development process to consider the usability matter in the final system or product. The involvement of the target user in every phase of the development is the essential base of this design approach (Dix et al., 2003; Carroll, 2002; Bevan & Curson, 1999; Abras et al., 2004). This involvement is carried out by talking directly to the users, allowing them to test the applications and therewith to test and confirm that their requirements are being achieved. This approach aims at creating applications that do not only fulfil the functional needs of their user, but are also easy to use and accessible (Mao et al., 2001; Williams, 2009).

The users of the VERITAS tools are designer and developers that aim to design systems that shall be used by people with disabilities and elderly people. The VERITAS tools themselves shall provide a utility for designers and developers of products, and consist of usable tools that provide a good user experience to the designers.

The main objectives of this approach are to design and develop useful applications with respect to the user requirements identified. This increases the quality of the final system.

1.1.1 Human-centred design process for interactive systems

In order to be able to show that the VERITAS UCD process is a valid user centred design process we mapped it to the UCD approach defined through ISO 13407.

Figure 2 shows this standard for “Human-centred design processes for interactive systems”, which will be outlined in more detail in the following.

According to the ISO 13407 and the figure presented before, the following steps must take place for a thorough UCD methodological framework:

Identify need for user-centred design - Users are a fundamental element to take into consideration in the design process. The user determines the success or the failure of a system. Despite the fact the application designed and developed presents huge functionalities, great reliability and many other characteristics would not be sufficient if the user did not want to use them.

Understand and specify the context of use - The knowledge of the specific context in which services and product will be used is crucial. Information related with the environment where the systems is going to be used helps the designers and developers to be specific about the needs and requirements of the final system. Not only the environment itself must be known but also the hardware associated to that environment in terms of usefulness and availability (e.g. determining the peripheral devices the target user will use considering his

[lack of] technical experience). The outcome of this phase gathers the required characteristics in order for the user to use the system.

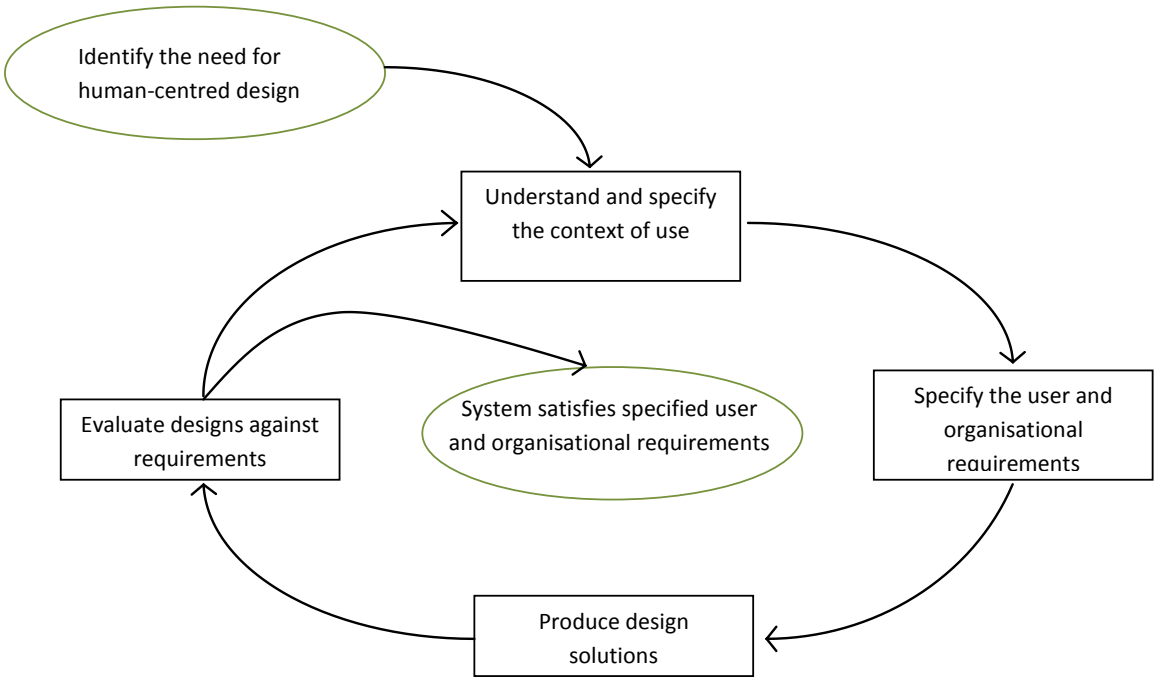

Figure 2 Human-centred design process for interactive systems (ISO 13407).

Specify the user and organizational requirement - While the previous phase did not deal with specific functionalities or deeper technical issues, this phase does consider several requirements, namely:

- Required performance of the new system against operational and financial objectives.
- Relevant statutory or legislative requirements, including safety and health.
- Cooperation and communication between users and other relevant parties.
- The user's job (including the allocation of tasks, user's well-being, motivation).
- Task performance.
- Work design and organization.
- Management of change, including training and personnel to be involved.
- Feasibility of operation and maintenance.
- The human-computer interface and workstation design.

Produce design solutions - The design solution is done considering all the information obtained in the previous phases, as well as that provided by the study of the state of the art and the experience. This process takes into consideration the following elements:

- Use existing knowledge to develop a design proposal.
- Make the design solution more concrete using simulation, models, etc..

- Present the design solution to users and allow them to perform tasks.
- Alter the design in response to the user feedback and iterate this process until human-centred design goals are met.
- Manage the iteration of design solutions.

Evaluate designs against requirements - Evaluation is not a final step in the design and development process. In UCD the evaluation is present in every step of the life cycle. By including it along the entire development process, the cost of changes at a late or final stage can be limited. By means of the evaluations there will be a feedback process put in place so that the design can be improved. Besides, a continuous analysis of the objectives is done, so that up-to-date information about the goals' status is obtained. The evaluation provides additional information regarding extra needs, new requirements, usability test, etc.

System satisfies specified user and organizational requirements - Once the evaluations are completed and the user requirements are successfully implemented and signed of through iterative evaluations, the final system will be ready. The evaluation results obtained should be written down in a report, where the objectives, the context, the methods and a summary should be described.

1.1.2 Enhanced Waterfall model of the VERITAS UCD process

Figure 3 shows the VERITAS UCD model and how it is defined according to the ISO 13407 standard described above. The first phase of the VERITAS UCD model is concerned with the gathering of all necessary requirements for the development of the VERITAS applications and tools. Therefore, the requirements of VERITAS end users (designers and beneficiaries) and the software applications are identified in the first stage and the different application scenarios are taking into account (see Figure 1). The present document further specifies the user groups of VERITAS (see Section 1.2).

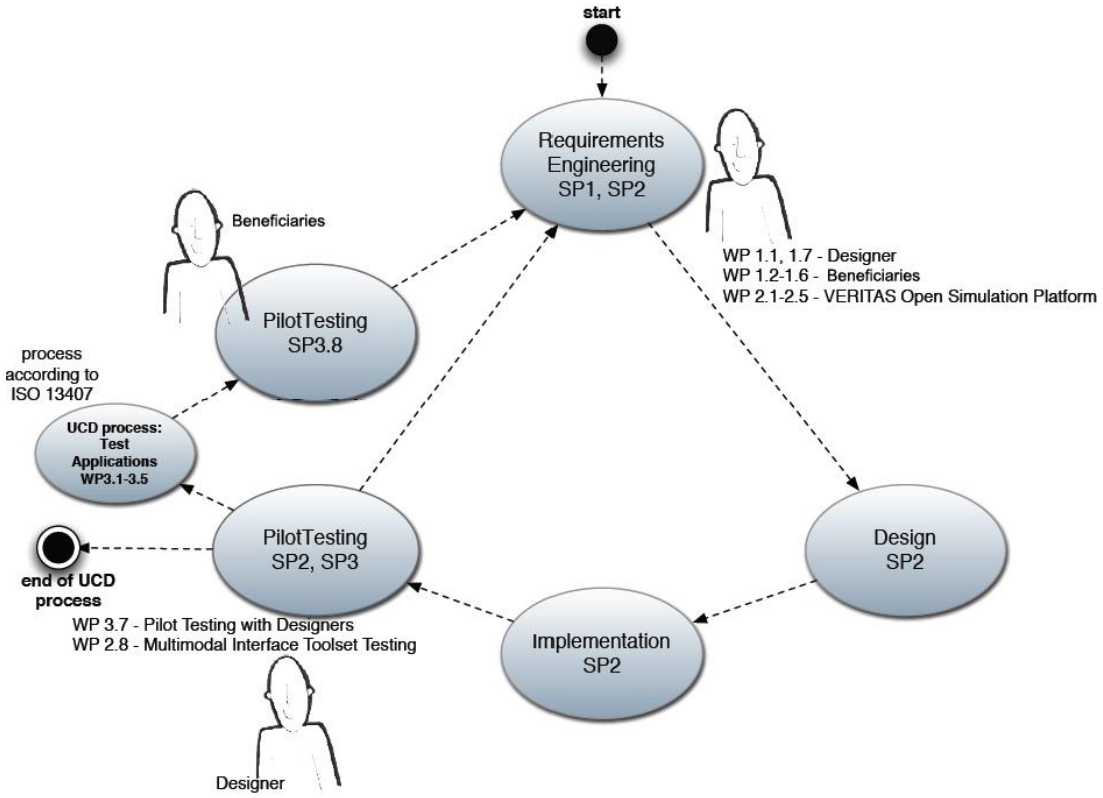

Figure 3 VERITAS model and its relation to the ISO 13407 UCD Model.

The design of the VERITAS applications is informed by the collected information of the requirements engineering process and the state of the art in research. Design solutions at this stage should be evaluated in formative evaluations with the relevant VERITAS end user groups. Feedback in this phase evaluates the gathered requirements and iterates the design process. Implemented VERITAS systems and tools are further evaluated both in formative evaluations but also in summative evaluations which are provided through the development of test applications and their testing in Pilots with the end users of the VERITAS project in later stages of the overall developmental process. Each of the test application again is designed, developed and evaluated according to the ISO 13407.

Even though, VERITAS process includes several iterative steps, the development of VERITAS tools is rather a streamlined process based on an enhanced waterfall model that iteratively integrates users and requirements than a strict realisation of a UCD model as depicted in ISO 13407. A waterfall model, from its origin, is a software development process in which the different phases of conception, initiation, analysis, design, development, testing and maintenance are sequential (Royce, 1970). The progression from one phase to the next is steadily downwards, like a waterfall (see Figure 4). In the original model, no iterations between and within the different stages of the software development process were considered. The model was modified in various

ways to include important and necessary iterations and evaluations and to reduce the risk of errors to occur in later stages of the development process.

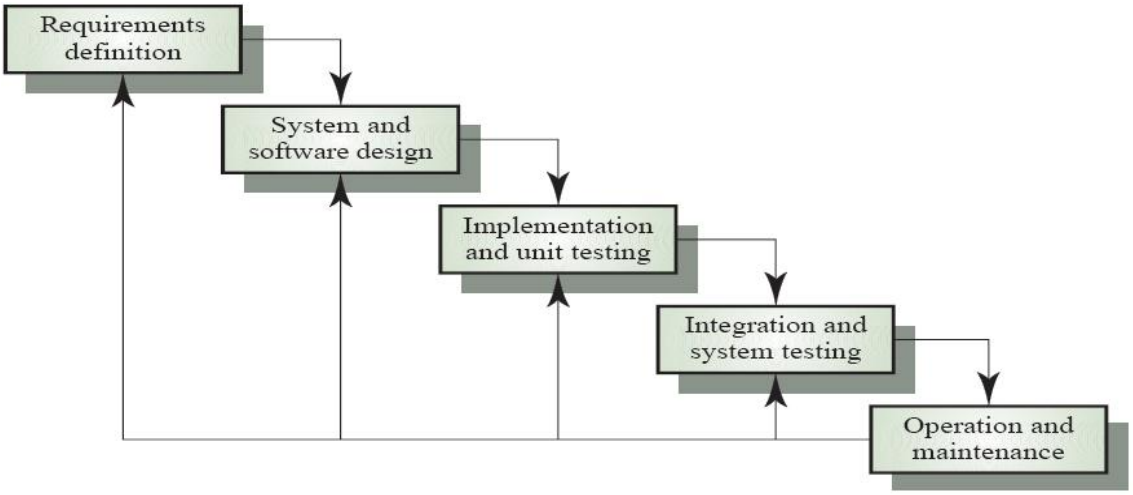

Figure 4 Waterfall model of software development (cf. Royce, 1970).

The VERITAS UCD model suggested here is therefore an enhanced waterfall model, combining a sequential design and development process with the benefits and necessary iterative steps and evaluations of ISO 13407 as described above. Figure 5 depicts this UCD model of the VERITAS development process. The process covers the usual steps of a development process and maps the particular step to the subproject and work packages defined by the VERITAS project.

The VERITAS UCD methodology encompasses formative and summative evaluations in all stages of the development process. The user-centeredness of the VERITAS approach is given through the integration of the both end users groups (end users and beneficiaries) throughout the depicted process (cf. also Rubin, 1994; Schneiderman, 1998; Schneiderman & Plaisant, 2009). The addressed users depend on the stage of the development process and involve different types of the VERITAS end users (see further Section 1.2).

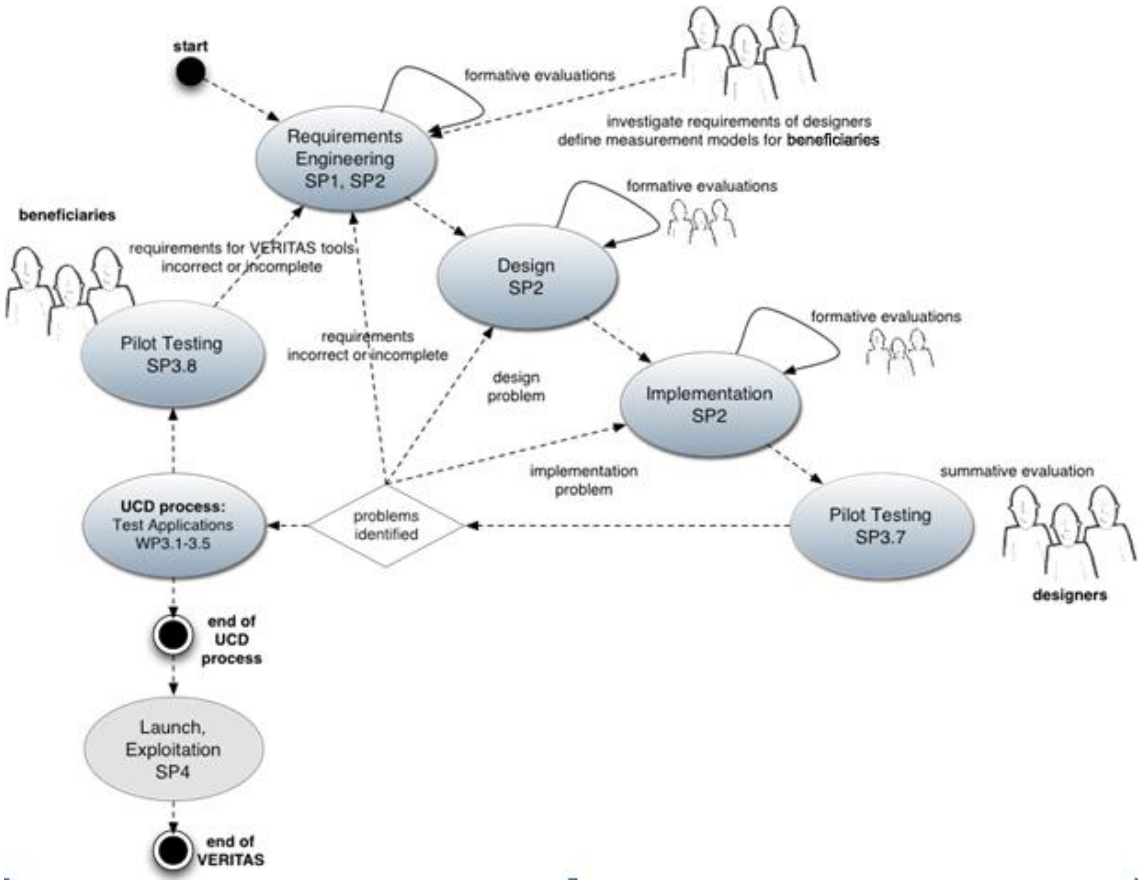

Figure 5 VERITAS UCD approach: Enhanced waterfall model.

1.2 Participant definition of the VERITAS engineering process

The VERITAS development process involves different types of participants addressed within the project.

Beneficiaries – The end users targeted by the designers designing with the VERITAS tools. The end users are people with disabilities or elderly people.

Designers – People using the VERITAS tools and simulations to design products for the “beneficiaries”.

VERITAS application developers – People developing the VERITAS architecture, applications as well as the final tools.

1.3 Methods for a UCD process in VERITAS

Several UCD methods can be carried out in different phases of the VERITAS development process, grouped to the stages: requirements engineering, design and development, pilot testing with VERITAS end users (designers/developers and beneficiaries) and the evaluation of extracted needs, tasks, scenarios, designs, concepts, and systems in the different phases of this process. It is

specified in the following, which methods would be appropriate for the extraction of requirements, for early and later designs and developments of VERITAS tools and applications, and for usability tests involving experts and end users (here: end users and beneficiaries) throughout the whole VERITAS project process. Ideally, the process of designing and developing systems and tools should be iterative to solve most problems users might have, e.g. with the usability of a software system, to minimise costs and to increase the success of the project in terms of the functionality, accessibility, efficiency, user acceptance and user satisfaction regarding the final developments of VERITAS.

One method that can be applied at any stage of the development process are (local and distributed) workshops to manage for instance the collaboration between partners and within diverse VERITAS work packages and activities, but in particular to involve end users in the evaluation of the VERITAS project and its outcome regularly and at several project stages. Workshops in VERITAS involving end users are user workshops and user forums (cf. VERITAS 1st Pan-European User Forum, Prague, Czech Republic), but also focus groups, which are described in detail in Section 1.4.5. During user workshops, potential end users of VERITAS are presented with the concept of the project. They are invited to discuss first results in depth with the designer and developer of VERITAS tools and applications. End users invited to the workshops are encouraged to utter their opinions and concerns regarding the project and its activities. In addition, participants can contribute to the project online, in online forums. The gained feedback informs developing partners on how to improve the outcomes of VERITAS to better match the needs of the end users.

The main purpose of workshops is briefly described below and shown in of the VERITAS project process.

Table 1 that follows. Details on the objective, planning and conducting workshops can be found in Section 1.4.21.

Workshops are a great opportunity for brainstorming, interactive learning, problem solving, as well as, building and fostering relationships, both between the partners of VERITAS, and as opportunity for a discourse with the VERITAS end users, at any stage of the VERITAS project process.

Table 1 Workshops in VERITAS

Method	Main Objectives	Advantages	Disadvantages	Amount of end users	Costs
Workshops ➢ Qualitative results	➢ Allow brainstorming, interactive learning	➢ Provide a corporate view when there are representatives of all WPS and	➢ Group dynamic might make some participants	Ideally not more than 10 partners per	Low - High

Method	Main Objectives	Advantages	Disadvantages	Amount of end users	Costs
	and problem solving of within activities and between the VERITAS partners	As related to the discussed topic. ➢ Workshops encourage co-operation between partners/participants. ➢ Different points of views get heard. ➢ Certain issues might get resolved easier when all responsible partners are present. ➢ Ideas are discussed, that encourages creativity. Partners can build on the thoughts and ideas of others.	anxious. They may be afraid to speak up and voice their opinion. ➢ Time commitment is required by each partner.	session	

1.3.1 Methods for the requirements engineering and evaluation

To design and develop VERITAS tools that are effective, efficient and satisfying to the users requires, as a first step, an in-depth understanding of the VERITAS users, their tasks and the different application contexts (here: automotive, infotainment, office workplace, healthcare, smart living). The following UCD methods are recommended to be used within the VERITAS project for the collection of users' requirements (cf. Heinila et al., 2005; Rauterberg, 2003). In particular questionnaires, interviews, surveys, focus groups, observations inside the real work context and task analysis are highly recommended to requirements gathering partners in this early stage of VERITAS. The next sections first present the methods which could be applied here and then provides guidance to all partners of VERITAS on how to select appropriate methods considering this stage of the process by taking into account which targets are followed, what quality of results is expected, the advantages and disadvantages of each method, the amount of required participants, as well as general costs.

1.3.1.1 Overview over requirements engineering methods

Methods for the requirements engineering are listed below and supplemented by a short description. Each suggested method is described in detail within Section 0.

Questionnaire - Set of pre-defined questions for gathering user's responses, in order to generate statistical, and to a certain extent, qualitative data.

Interviews - Method to obtain relevant information from the user, based upon the interaction between one interviewer and one user at a time. The interviewer asks the user a set of questions that can be more open-ended. The results obtained from the questions provide subjective and more detailed information.

Survey - A series of questions consisting mainly of closed-end answers (multiple-choice) used to identify patterns among a large number of people.

Focus groups - Target users are brought together for a discussion session where they can share their opinions and ideas about a specific issue proposed by the chairman. These meetings should repeat until the answers obtained become repetitive. This method brings out the main opinions, ideas and attitude regarding a specific matter.

Contextual Inquiry - Method that combines the observations and the interviews and is carried out at the user's environment. The interviewer goes to the user's place of work to learn about his work and understand better the user's needs. The information obtained should be gathered not only through the observation but also by means of interviews, in order to clarify some ambiguous points.

Task Analysis -This method aims to better understand what people are doing and why do they do specific actions to perform a particular task.

Participatory design - Method to carry out the design of an application by involving the user in the process and thereby support the identification of user needs.

1.3.1.2 Guidelines for selecting methods for the requirements engineering

Prior to the selection of a suitable UCD method for the extraction of requirements and their evaluation, responsible partners have to identify the wider and smaller context - considering also the five VERITAS application areas - from which requirements, relevant to the respective VERITAS tools and systems, have to get extracted, as well as, the VERITAS users. Depending on the general conditions particularly for VERITAS project, different UCD methods can be applied. Parameters for selecting appropriate methods comprise

amongst others also the amount of available potential users, budget and available time in the respective project.

To gain a better understanding of the target user group(s), their preferences, attitudes or opinions (Newell et al., 2010; Newell & Gregor, 2000), the following methods: *interviews*, *questionnaires*, *surveys* or *focus groups* should be applied.

The first three methods gather information of the VERITAS users individually, whereas focus groups aim to gain information from users through group discussions (Krueger & Casey, 2000; Fern, 2001). These four methods further differ with regard to the kind of results that can be gained through them. Interviews and focus groups gather rich qualitative data about a rather small sample of users. These methods are in particular suitable to capture users' individual thoughts, experiences and opinions (Rauterberg, 2003).

Questionnaires and surveys have their strength in collecting quantitative information about a large scale of end users. Quantitative data is in general easier to collect and analyse, and has the potential to collect representative data of the population under investigation. Even though qualitative data is often criticised for not being generalizable, highly subjective, complex and time-consuming to analyse and process, it can provide in-depth insight into specific behaviours of participants, their feelings or thoughts about a system, product or usage scenario (Heinila, 2005; Heinila et al., 2005; Kramer et al., 2000; Maguire, 2001). To evaluate the requirements identified to match the actual needs of the users of VERITAS, observational methods can be applied collecting data by monitoring the behaviour of either end users or beneficiaries in case studies or field studies. This is foreseen in many activities of VERITAS related to the design and development of applications, and in particular within the pilot test in WP3.7 and WP3.8.

Table 2 outlines the main objective of each of these four methods and displays their advantages and disadvantages, expected costs and approximately required amounts of end users as participants on one sight.

Table 2 Questionnaires, interviews, surveys and focus groups as methods for the requirements engineering of VERITAS

Method	Main Objectives	Advantages	Disadvantages	Amount of end users	Costs
Questionnaires ➢ Quantitative and Qualitative results	➢ Information regarding some specific issues (e.g. knowledge about area, demographic data) with prefixed possible answers. ➢ Prompt the participants by asking direct questions.	➢ Appropriate technique for large samples (huge amount of target users can be reached) ➢ Answer's objectivity ➢ Systematic analysis possible presents a good relation information-cost ➢ Much data can be acquired in short time ➢ User facilities are provided concerning when and where to answer it	➢ Response rate is very low unless the questionnaire is distributed by mail ➢ Reliability of the answers is not very high ➢ No personal contact with users ➢ Truthfulness of the answers uncontrolled ➢ It may be user's inhibition answering some questions ➢ Less flexible than interview ➢ Method should measure the variable that is intended to be measured	Min. 10 per area under investigation	Low
Interviews ➢ Qualitative results	➢ Gather information that has not been gathered through fixed question from face to face session with the user ➢ Duration per interview: approx. 45 - 60 minutes	➢ Users' preferences and attitudes can be obtained ➢ More detailed information can be gathered from the user than through questionnaires ➢ More adaptability of questions to context and user responses than through questionnaires ➢ Very effective for high level evaluations (e.g. getting information regarding the users' preferences, impressions and attitudes) ➢ High response rate ➢ Great reliability of the data collected ➢ The user's real needs of information can	➢ Many economic and personal resources are needed to carry out the interviews ➢ Possible lack of objectivity and bias (e.g. interview effect that interviewee tries to please the interviewer and responds in her/his favour) ➢ Difficult to apply to disperse populations	Approx. 5-7	Medium

Method	Main Objectives	Advantages	Disadvantages	Amount of end users	Costs
		be known ➢ It is possible to solve user's doubts during the interview due to the direct relation between the interviewer and the user ➢ Very useful method for users with low cultural level and with difficulties to express their ideas in writing ➢ Useful method to find not foreseen problems in the design phase			
Surveys ➢ Quantitative results	➢ Quantitative information regarding users' preferences, habits, attitudes, etc. ➢ Duration to fill out the survey: approx. 5 - 10 minutes	➢ Less biased (no interviewer effects) ➢ Less tendency to lie since anonymous (in particular in large online studies) ➢ Objective measurement ➢ Easy to apply ➢ Useful in describing the characteristics of a large population (larger samples feasible; statistically significant results) ➢ Can be administered from remote locations using mail, email or telephone ➢ Many questions can be asked about a given topic giving considerable flexibility to the analysis ➢ Flexibility in how questions are administered (face-to-face, phone, email, etc.) ➢ Standardized questions make measurement	➢ It forces the researcher to develop questions general enough to be minimally appropriate for all respondents, possibly missing what is most appropriate to many respondents, as it relies on standardization, ➢ Large sample needs to be available and has to reply ➢ Survey research as opposed to interviews can seldom deal with "context"	Large scale of participants	Low

Method	Main Objectives	Advantages	Disadvantages	Amount of end users	Costs
		more precise (uniform definitions upon the participants are enforced) ➢ Usually high reliability			
Focus groups ➢ Qualitative results	➢ Information from the user by means of an open discussion among a few users lead by a moderator ➢ Users are asked to share their opinions, thoughts and ideas about a specific subject ➢ Duration: approx. 1-2 hours per focus group session	➢ Moderator in face-to-face session can motivate the discussion and engage participants to reveal their opinion ➢ New thinking about a topic can be stimulated through group discussion (more in-depth and intense form of discussion) ➢ Trustworthy naturalistic data that also lead to important insights about human behaviours by allowing all participants to say anything they would like in front of the whole group ➢ Rather natural discussion that evolves a well-designed guide encourages group members to relax, open up, think deeply, and consider alternatives	➢ Evaluation of the gathered "discussion data" is rather complicated ➢ It is possible to gauge a groups' overall reaction to educational materials, but not on an individual basis. ➢ Focus groups do not produce reliable data on topics that produce extremely strong feelings ➢ No generalizations possible ➢ Not objective ➢ Moderator needs to be experienced	Approx. 6-12	Medium

A further qualitative technique is the *contextual inquiry*: the direct observation of users' behaviour in their real environment. This methods helps designers and developers of VERITAS applications to better understand the needs of the end users in either their work environment (designer and developers using the VERITAS applications) or life environment (VERITAS beneficiaries), as well as end users' preferences (e.g. for certain tools, products, functions) or problems in everyday lives (cf. Creswell, 1998). Contextual inquiry however is very time consuming and gained results can differ highly between the five VERITAS

application areas. Advantages and disadvantages of this method are outlined in Table 3.

Table 3 Contextual inquiry as method for the requirements engineering in VERITAS

Method	Main Objectives	Advantages	Disadvantages	Amount of end users	Costs
Contextual Inquiry ➢ Qualitative results	➢ Understanding users needs, preferences for certain tools or real life problems by observing them in their work context ➢ Duration: several hours up to several days per user	➢ Direct measurement of behaviour, no biased report of intentions or narratives ➢ More valid (user behaviour less prone to lies)	➢ Step from data collection to design requirements is hard; requires experience and expertise ➢ Requires long times of observations ➢ Blind to cognitive or affective variables ➢ Data is not generalizable	Approx. 3	Medium

To better understand what people are doing in their everyday work life (end users) or at home (beneficiaries), which different actions they perform to fulfil a certain task and why and how they perform these actions, requires the conduction of a *task analysis*. Task analysis is a process where the behaviour of performing a particular task or job is analysed and described in its elemental steps (tasks, sub-tasks and operations, sequences of tasks, different task environments, etc.) (Hackos & Redish, 1998; Kirwan & Ainsworth, 1992; Shepherd, 1985; 1989). Task analysis helps to understand existing systems and how information flows within them (Crandall et al., 2006). Designers and developers of VERITAS tools and application can then adopt this understanding, build on it and improve the functions needed to accurately perform certain desired tasks. This method also provides knowledge as to which tasks the different users of VERITAS wish to perform. Identified tasks need be addressed in the development and design of the VERITAS applications and tools. However, the time required to fulfil activity increases with the complexity of the task and the degree of detail in analysing it. Therefore, after a task has been identified, a conscious decision has to be made upon the level of detail to which this task will be decomposed into lower level subtasks. For further information see task analysis on Section 1.4.13. Table 4 subsumes key information on this method.

Table 4 Task analysis as a method for extracting task requirements in VERITAS

Method	Main Objectives	Advantages	Disadvantages	Amount of end users	Costs
Task Analysis ➢ Qualitative	➢ This method aims to better	➢ Can reveal	➢ Can be time consuming	➢ Min. 5 expert	➢ Low - Medium

Method	Main Objectives	Advantages	Disadvantages	Amount of end users	Costs
results	understand what people are doing and why do they do specific actions to perform a particular task	new information that is exploitable in the software design	➢ Needs expert users to be observed (complete tasks need to be covered) ➢ Observations of expert users obtain the risk to oversee problems specific to beginners	users	

Participatory design (PD) refers to a set of principles which places the user at the forefront of the design effort and is most applicable when seeking to extract user needs (D5.5.2 Guidelines on UCD requirements extraction, OASIS). Even though this method helps understanding the needs of the VERITAS users and supports the identification of related tasks, it is easy to be applied and has the important benefit to increase the overall acceptance of the system to be developed, which provides a significant extra effort within this phase of the VERITAS development process (cf. Muller, 2003; Schuler & Namioka, 1993). More information on participatory design can be found in Section 1.4.7, a summary of its main characteristics is displayed in Table 5.

Table 5 Participatory design as approach within the requirements engineering of VERITAS

Method	Main Objectives	Advantages	Disadvantages	Amount of end users	Costs
Participatory Design ➢ Qualitative results	➢ Users are involved in the design process of an application (e.g. in making a paper prototype) ➢ Duration: Approx. 1-2 hours per session	➢ Better understanding of final users needs and tasks that need to be fulfilled ➢ Opportunity for users to influence design decisions ➢ Increase users' acceptance of the final system through inclusion of user ➢ methods are easy to apply	➢ Time intense ➢ Availability of target users (e.g. users with disabilities, ethical approvals)	➢ Approx. 3-5 per session	➢ High

Each of these UCD methods listed in Table 5 is described in detail in Section 0. In addition to the extraction of requirements, criteria for the evaluation of the

identified requirements need to be defined and tested. To evaluate the requirements identified to match the actual needs of the users of VERITAS, observational methods can be applied collecting data by monitoring the behaviour of either end users or beneficiaries in case studies or field studies. This is foreseen in many activities of VERITAS related to the design and development of applications, and in particular within the pilot test in WP3.7 and WP3.8.

1.3.2 Methods for the design and implementation of VERITAS systems and their evaluation

The methods presented in this subchapter can be used within the VERITAS project for the design of tools and applications (Sections 1.3.2.1 and 1.3.2.2), and to evaluate identified design solutions (Sections 1.3.2.3 and 1.3.2.4). The suggested methods are recommendations to the designers and developers of VERITAS applications and tools at this stage of the project. The following sections first present the methods which could be applied here and then provides guidance on how to select appropriate methods considering this stage of the design and development process by taking into account, amongst others, which are the expected outcomes and their quality, the advantages and disadvantages of each method, the amount of required participants as well as general costs.

1.3.2.1 Overview over methods for the early and later stage of the VERITAS design process

Methods for the early and later stage of the VERITAS design and development process are listed below and supplemented by a short description. Each suggested method is described in detail within Section 0.

User Involvement in the design/development process

- **Participatory design** - Method to carry out the design of an application by involving the user in the process. Participatory design is a very useful method for the design phases where the user participates actively. For example developers, designers and users work together to design an initial prototype.
- **Co-Discovery Method** – Method to identify usability and usage problems in collaboration with others, and to discover additional user needs.

Developing Models to be tested with end users:

- **Prototyping** - Prototyping models of the final product that allow to test attributes of the final product by using them.

- **Paper prototypes** – This method helps explore early problems in the design by allowing the user to express his/her ideas with minimal costs and high effectiveness.
- **Storyboarding** - This method aims to show the relation between the system inputs (users' actions) and the system outputs. It is used to demonstrate the interfaces of the system to users, as well as the context of use of the application. The outcome of this method is a prototype of the interaction design.
- **Card Sorting (Information visualisation modelling)** – This method consists of a group of experts in a specific area (e.g. designers/developers for ICT and non ICT-products for older people) identifying relevant concepts related to this area and categorize them based on several relations identified. The final result is the generation of intuitive categories and structures related to the topic discussed.
- **Wizard of Oz** – Method to observe the usage and effectiveness of a concept of a computer application or user interface by the end users, rather than to measure the quality of an entire system.

1.3.2.2 Guidelines for selecting methods in an early and later design and implementation stage

Prior to the selection of a suitable method for the design and development process, responsible partners have to identify the wider and smaller context - considering also the five VERITAS application areas – for which they design, as well as the target VERITAS users. Depending on the general conditions for a particular VERITAS project, different UCD methods can be applied. Parameters for selecting appropriate methods comprise for instance the amount of available potential users, budget and available time in the respective project.

Participatory design (PD) refers to a set of principles which places the user at the forefront of the design effort and thereby helps avoiding failings in the design that have been previously experienced of this particular type of user (e.g. mobile phones for older users). In general, participatory design comes at the cost of significant extra effort on the part of the designer, so as to involve the end users of a system as close as possible in the design and development of the system. However, PD as a design process is scalable and flexible, and can be broken down into smaller stages. PD is not necessary for systems with only a small proportion of user interaction, but is highly recommended to be applied when it comes to novel technologies that extend aspects of an interface beyond what is known and familiar (e.g. novel sensor techniques). More information on Participatory design can be found in Section 1.4.7 and in Table 6.

Table 6 Participatory design as approach within the design and development of VERITAS applications and tools

Method	Main Objectives	Advantages	Disadvantages	Amount of end users	Costs
Participatory Design ➢ Qualitative results	➢ Users are involved in the design process of an application (e.g. in making a paper prototype) ➢ Duration: Approx. 1-2 hours per session	➢ Better understanding of final users needs and the tasks that need to be fulfilled ➢ Opportunity for users to influence design decisions ➢ Increase users' acceptance of the final system through inclusion of user ➢ Easy to apply method	➢ Time intense ➢ Availability of target users (e.g. users with disabilities, ethical approvals)	➢ Approx. 3-5 per session	➢ High

To capture and identify user problems (e.g. usability issues and concerns) at an early stage of the design and development process in VERITAS, the implementation of the *co-discovery (*also *co-participation)* method is recommended too. For the purpose of this method, two or more end users (end users or beneficiaries) are working together to test a certain software or product. A moderator leads the testing session and provides the tasks that participants have to fulfil in using the product to be evaluated. This method works already very well at the stage of prototyping and helps validating the overall design of an application or software. It can be applied for the comparison of different design or implementation alternatives and it is particularly beneficial for applications that are meant to be used by people collaborating together. The method provides detail information about usage problems and needs, gathered through the observation of a rather natural interaction between end users. In addition, this approach is simple, fast to conduct and relatively low in its costs (Wilson & Blostein, 1998). For further information see Section 1.4.16. Table 7 displays the main characteristics of this method.

Table 7 Co-Discovery as a method for early designs and developments in VERITAS

Method	Main Objectives	Advantages	Disadvantages	Amount of end users	Costs
Co-Discovery Method ➢ Qualitative results	➢ Observe a pair of participants performing tasks	➢ Detailed information ➢ Fast and easy approach	➢ Many participants needed ➢ Can be of discomfort if	➢ Usually 2, max. 4 end users per	➢ Low

Method	Main Objectives	Advantages	Disadvantages	Amount of end users	Costs
	together	➢ Rather natural style of interaction ➢ In particular good for applications where people work together	the rules and goals of co-participation are not clear enough ➢ Analysis of qualitative data difficult ➢ Inter-individual differences: One participants might dominate and overpower the others and the session	session	

An important method to test a model of the desired product or system at any stage of the design and development process in VERITAS is *prototyping* (Crinnion, 1991). In general, two different forms of prototyping can be distinguished: low-fidelity prototypes (e.g. *paper prototypes* of a design without any implemented functionalities) and high-fidelity prototypes, which are already (at least in part) working types of the system or product that designers and developers are aiming for. At an early stage, non-functional prototypes should be developed and tested with end users. These can be first ideas and concepts of a user interface presented to end users on computer screens or sketches of how a final product or system might look like and work (e.g. on paper, as paper prototypes). Thereby, different aspects of a certain model (design, functions, feedback mechanisms, special features, etc.) can be tested (Bailey et al., 2008; Black et al., 2004; Hendry et al., 2005; Jun et al., 2004; Nichols, 2001; Signer & Norrie, 2007). An evaluation of early drafts allows the identification of usability problems and risks, but also the identification of user wishes and needs, and thus improves the outcome of the development and design process of the respective VERITAS tools. However, paper prototypes might be less suitable if it comes to the evaluation of large and complex systems. In general, the development of prototypes can be a very time consuming process and the costs for building them increases the level of realising the product or system in detail and functional implementation (Naghsh & Brace, 2004; Sefelin et al., 2003; Yeon et al., 2007). Further information on prototyping can be found in Section 1.4.18 and Section 1.4.19. Main characteristics of prototyping and paper prototyping as methods can be found in Table 8.

A similar method to paper prototyping is *storyboarding* which models the interaction with a system or product. In other words, it allows the validation of an early or later interaction design through paper sketches showing the episodes and sequences of the interaction with a system (Jantke & Knauf, 2005; Truong

et al., 2006). Like paper prototypes, storyboarding is a simple and cheap method that helps designers of VERITAS applications to evaluate if they head in the “right” direction with their interface design. Storyboarding is in particular useful for applications that offer a complex structure of information. More information about storyboarding as a method can be found in Section 1.4.11 and Table 8.

Card sorting is a method (originally from the field of information architectures) where end users are invited to help designers and developers of the applications under development to identify relevant categories concerning a particular area. A prominent example where card sorting is applied is in the identification of link structures on web pages (Wood & Wood, 2008; Hannah, 2010). Links on the top level page (e.g. home, contact, content) are categories and their names need to be related to the sub-categories they entail. Participants in the card sorting process are for instance given all possible pages of a webpage (each on one paper card) and they are requested to sort them intuitively into categories and to name these. Within this process participants generate the structure of a webpage and how different categories are related to each other. This increases acceptance of the webpage and how it is understood by the final end users. This method is very easy to conduct and can be used at an early stage in the VERITAS design process, and whenever the building of categories is needed. Further information of advantages, disadvantages, participants and costs can be found in Table 8.

Table 8 Prototyping in general, paper prototypes, storyboarding and card sorting as methods supporting the design and development of VERITAS applications.

Method	Main Objectives	Advantages	Disadvantages	Amount of end users	Costs
Prototyping ➢ Model of a system or product	➢ To test a model of the intended product or system in its early stage before it is finally developed.	➢ Allows to identify usability problems (and risks) and to analyze their cause with the users at an early stage of the design or development process (reduces costs and increases quality of the final product) ➢ Allows the test of different aspects of the model: the design, help gather feedback, and show ideas and features ➢ Helps users understand the idea and concept of the final product or system and thereby increases user involvement ➢ Allows fast test and quick feedback from users during development cycle	➢ Organizational needs of the producers might get out of focus ➢ Development of prototype takes time ➢ Implementation of prototype can be expensive ➢ Prototypes can be confusion to users (as they are incomplete) ➢ Prototypes allow only a partial analysis for the final product or system	Approx. 3-7	Low – High (depends on kind of prototype)
Paper Prototyping ➢ Model of a system or product	➢ To explore early problems in the design, allowing the user to express his ideas with minimal costs and high effectiveness	➢ Allows quick testing of individual components of a software design without the investment of actual coding ➢ Low fidelity encourages users to freely comment and suggest changes (unlike a polished product which may seem like it is already finished) ➢ Allows the detection of	➢ It is de-contextualized; individual components should be tested again in the real product ➢ Can be difficult to accommodate designs that offer users multiple paths ➢ Prototypes can be confusion to users (as they are incomplete	Approx. 5-7	Low

Method	Main Objectives	Advantages	Disadvantages	Amount of end users	Costs
		usability problems in early in the design process.			
Storyboarding ➢ Qualitative results	➢ Validation of a design through paper sketches showing episodes and sequences of the interaction with the system	➢ Simple and cheap ➢ Users can evaluate the direction that the interface is heading ➢ Useful for applications with a complex structure of information	➢ Novice designers do not like this technique because they still find challenges in its creation	Approx. 5-7	Low
Card Sorting ➢ Quantitative results	➢ Sorting of cards by users and naming of each resulting pile to express the common characteristics of these cards ➢ The aim is to discover the optimal organization of the information from the user's point of view	➢ Quick and cheap ➢ No technology required, so highly portable ➢ Feedback early in the design process ➢ Supports paper prototype ➢ Useful to categorize information. It enables designers and developers to understand how target users group the items ➢ Identifies terms that are likely to be misunderstood and/or difficult to categorize	➢ Challenging to capture results from a complex session ➢ Does not reveal interface problems ➢ Different people call the same thing by different names	25-30 to gain useful results	Low

Wizard of Oz is a method helping designers and developers of VERITAS applications to find out which input techniques or sensing mechanisms might present their interaction concept the best, if the feedback provided by their planned system would be adequate and understandable to its end users, or where user in general have problems with a product or system (Hudson et al., 2003). For this method, one member of the design or development team, of VERITAS application, is taking the place of the system and simulates the responses of it to an user, in real time. This member is traditionally not visible to the user and sits like a "wizard" in a back room watching the users' behaviour. In most cases, users participating are unaware that a person is responding instead of the computer system until the end of the experiment. Table 9 subsumes key characteristics of this method. Further information is provided in Section 1.4.22.

Table 9 Wizard of Oz as supporting method for the design and development of VERITAS applications.

Method	Main Objectives	Advantages	Disadvantages	Amount of end users	Costs
Wizard of Oz ➢ Qualitative results	➢ To observe the usage and effectiveness of a concept of a computer application or user interface by the end users, rather than to measure the quality of an entire system.	➢ Wizard of Oz method can provide valuable information as base for future designs ➢ Allows evaluate an application at an early stage in the design process. ➢ Observation of the user through interacting with her/him provides a unique insight into the user's actions. ➢ Good for the comparison and evaluation of different design concepts.	➢ Wizards need to be trained (additional costs) ➢ Not a very controllable test environment ➢ Difficult for the evaluation of large UIs. ➢ System performances or recognition rates cannot be assessed with this method.	Approx. 3-5	Medium

1.3.2.3 Overview of evaluation methods for designs and implementations in VERITAS

Methods for evaluation of designs and developments in VERITAS are listed below and supplemented by a short description. Each suggested method is described in detail within Section 0.

Evaluation through experts:

- **Expert Review** - This method consists of the evaluation of a system or application by experts who give useful comments and suggestions based on their expertise.
- **Heuristic Evaluation** - Is a method to evaluate a user interface design for usability using certain heuristics.

Usability Testing

Applied for the evaluation of an application with real target users performing a series of tasks with the system to identify usability problems, and to evaluate navigation paths, times to perform tasks and user's satisfaction of the application.

- **Cognitive Walkthrough** - Cognitive walkthrough is a review technique where expert evaluators construct task scenarios from a specification or early prototype and then role play the part of a user working with that interface -"walking through" the interface.
- **Pluralistic Walkthrough** - A team of users, usability engineers and product developers review the usability of the prototype of the application.
- **Guided Walkthrough** - The method is based on the guidance of a user through a prototype. During this session, the user is asked for different issues in order to gain a better understanding of the system through the user's eyes.
- **Thinking Aloud Protocol** - Think aloud protocols involve participants thinking aloud (about their thoughts, feelings and actions) as they are performing a set of specified tasks to gain data about the usability of a product or system.
- **Questionnaire** - Set of pre-defined questions for asking the user for their responses in order to generate statistical data.
- **Interviews** - Method to obtain relevant information from the user based on an interaction between an interviewer and a user at a time. The interviewer asks the user a set of questions that can be open. The results obtained from these questions are subjective and detailed information.

Analysis of captured (user) data:

- **Performance Measurement** – Method to establish if a product or system reaches the results desired by testing certain pre-defined parameters of performance.
- **Log-file analysis** - This method is based on an indirect observation of the user's behaviour related to the system by collecting the users' performance from server logs for later examination and analysis.

Inspection methods:

- **Standards Inspection** - Standards inspections ensure compliance with industry standards.

- **Feature Inspection** - Feature inspections analyze only the feature set of a product, usually given end user scenarios for the end result to be obtained from the use of the product.
- **Consistency inspection** – Consistency is checked by usability professional analyzing the consistency of all interfaces (of several VERITAS systems and tools) and noting the various ways that each product implements a particular user interaction or function.

1.3.2.4 Guidelines for testing the usability of designs and implementations in VERITAS at any stage of the implementation process

Depending on the general conditions particularly for VERITAS project, different UCD methods can be applied for the evaluation of designs and developments in VERITAS. Parameters for selecting appropriate methods comprise, amongst others, the amount of available potential users, budget and available time in the respective project.

To test the usability of a certain design or development in VERITAS, evaluations can be conducted either with usability experts (*expert review*, *heuristic evaluation*), through user tests with end users including methods such as *walkthroughs*, *thinking aloud protocols*, *questionnaires* and *interviews*, but also *performance measurements* and the analysis of *log-file data*. In addition designer and developer of VERITAS application can apply certain inspection methods (e.g. *standards inspection*, *feature* and *consistency inspection*) to further analyse if their systems or products are consistent to each other and compliant with the respective industry standards (Kartner, 1994; Presscott & Crichton, 1999; Rubin, 1994; Clemmensen & Qingxin, 2007).

A prominent method to test the usability of a certain design or developments is the evaluation by experts. Here, *experts review* a system or product based on their expertise and give useful comments and recommendations on its design or functionality to the development team. This helps solving usability issues before end users are involved in the testing. For further information see Section 1.4.10. One specific form of expert evaluations is *heuristic evaluations* (Nielson, 1992). It is most commonly used for the evaluation of user interfaces by a small sample of experts in human-computer interaction, who analyze the UI by applying certain heuristics (e.g. “Help users recognize, diagnose, and recover from errors”; see further Section 1.4.8 on heuristic evaluation) (Nielsen & Molch, 1990; Nielson 1992;1994; Dix et al., 2003). Even though this method helps to identify usability problems easy and rather quick, it is not sufficient to be applied on its own, as it is highly constrained by the knowledge of the evaluators, and what they know about the target group and target application. Neither expert reviews nor heuristic evaluations include end users. Therefore, their application as the “only” usability evaluation method is insufficient. Thus, methods which indeed involve end users need to be applied to complement the usability

evaluation of VERITAS systems or products (e.g. usability testing, cognitive walkthrough). Main characteristics of these methods can be found in Table 10.

Table 10 Expert evaluations as part of the usability evaluation of designs and developments in VERITAS.

Method	Main Objectives	Advantages	Disadvantages	Amount of end users	Costs
Expert Review ➢ Qualitative results	➢ Evaluation of a system or application by means of experts given useful comments and suggestions based on their expertise	➢ Resolves some issues that users should not have to worry about in later usability testing	➢ Constrained by the experts knowledge of the audience for which the system is intended ➢ Not sufficient on its own	No end users; Approx. 3-5 experts	Low

Usability testing (also *usability evaluation*) encompasses a set of methods to evaluate a system or product with real target users. These perform a series of tasks with the system to identify usability problems, and to evaluate navigation paths, times to perform tasks and user's satisfaction of the application. This approach in particular aims to understand the end users and why they might have difficulties using a certain proposed design (Dumas & Redish, 1993; Ghanam & Maurer, 2010; Hackman & Biers, 1992; Kantner, 1994). To achieve this aim, a set of methods have to be applied (e.g. *interviews* (Section 1.4.2), *questionnaires* (Section 1.4.1), *thinking aloud protocols* (Section 1.4.15), *performance measurements* (Section 1.4.17)), which turns it into a rather expensive UCD method. This method also requires the development of test scenarios including user instructions, pre- and post-interviews, logging of test-sessions, an appropriate test environment, trained observers of user's behaviour and a protocol for running each session equally. A small number of users are sufficient to indentify and analyse many problems and their causes of a design or development in relatively short time. The involvement of real users is the big advantage of this method compared to evaluations through experts. Found solutions can then be implemented in the following versions of prototypes and systems. Further information of usability testing in general can be found in Section 1.4.12. Main characteristics of this method are outlined in Table 11.

Table 11 Usability Testing as approach in evaluating designs and developments of VERITAS.

Method	Main Objectives	Advantages	Disadvantages	Amount of end users	Costs
Usability Testing ➢ Qualitative results	➢ Improve of the usability of a product by applying a set of	➢ Small number of users sufficient to identify	➢ Observation biases ➢ The meaningfulness of the data	Min. 10	High

Method	Main Objectives	Advantages	Disadvantages	Amount of end users	Costs
	methods	numerous problems in short time ➢ More real problems are found than with other methods such as heuristic evaluation.	collected rests on the authenticity of the users and tasks involved ➢ Time consuming to plan and analyse ➢ Does not cover all interface features ➢ Laboratory condition ➢ Not generalizable		

One of the methods that can be applied in the scope of usability testing is *walkthroughs*. *Cognitive walkthrough*, as well as *pluralistic* and *guided walkthroughs*, are also methods to test the usability of a system. Here, users have to use a designed/developed early prototype of a system and perform a specific task while using it. In using the system, users have to respond to a certain set of questions (e.g. “Will the user notice that the correct action is available“) that help designers/developers of VERITAS applications to identify usability issues. In addition, this method has proven to be helpful in revealing certain expectations or attitudes that users have towards a product or system which then can inform future developments (Wharton et al., 1994). In this approach, users are observed by the design/developing team, which can have an effect on their interaction performance. Designers and developers of VERITAS applications also need to be aware that the users they chose for the test session, present their points of view, which are of course highly subjective. It is therefore recommended to include at least 3-5 user participants in a study. In case of restricted time, designers or developers of VERITAS applications themselves can conduct a cognitive walkthrough by asking themselves standardized evaluation questions. However, caution must be taken in following this approach, as VERITAS designers might not behave like the average end user. More information about the three walkthrough methods is provided in Section 1.4.9. Table 12 subsumed key characteristics of this method.

Table 12 Walkthroughs of end users through designs and developments of VERITAS as usability test method.

Method	Main Objectives	Advantages	Disadvantages	Amount of end users	Costs
Cognitive Walkthrough ➢ Qualitative results	➢ Users have to use a designed/ developed early prototype to	➢ Quick resolving of usability problems ➢ Does not require a	➢ Subjective point of view will keep developers from	Approx. 3-5 end users; or designer themselves	Low

Method	Main Objectives	Advantages	Disadvantages	Amount of end users	Costs
	perform a specific task and thereby test the system's usability by answering usability questions ➢ Use system specifications, scenario-based role play ➢ Duration: approx. 1-2 hours per user	high-fidelity prototype ➢ Can reveal attitudes and expectations that the user might not otherwise express	recognizing some problems ➢ User performance may be biased by observation ➢ Does not address user satisfaction or efficiency ➢ The designer may not behave as the average user when using the application		

A very similar and useful method to evaluate the design or functionality of a system or product is the *Thinking aloud protocol*. Participants (the respective end users of VERITAS) have to perform a specific task and thereby articulate their thoughts, feelings and opinions about the object of evaluation. This session is observed by designers/developers of the VERITAS applications and tools. The feedback gathered through participants using the system or product is very valuable and helps designers and developers of VERITAS applications to understand users' relation between what they think, feel and do regarding their product. This method can also be applied at any stage of the design and development process, and within the pilot testing phase of VERITAS. See further Section 1.4.15 on Think aloud protocol. Table 13 shows the main characteristics of this method.

Table 13 Thinking aloud protocol to evaluate designs and developments of VERITAS with the respective end users.

Method	Main Objectives	Advantages	Disadvantages	Amount of end users	Costs
Think Aloud Protocol ➢ Qualitative results	➢ Vocalise thoughts, feelings and opinions whilst performing tasks ➢ Duration: max 2-3 hours per session	➢ Rapid and high-quality user feedback ➢ Access to relation between doing, thinking and feeling ➢ Direct observation of behaviour in relation to preferences ➢ The method might help some participants to	➢ Observation bias effects ➢ Slowed down usage process through thinking aloud ➢ Unnatural situation of using a product or system ➢ Increased mindfulness might prevent errors that	Approx. 5-7	Low-Medium

Method	Main Objectives	Advantages	Disadvantages	Amount of end users	Costs
		concentrate on the tasks while falling into a rhythm of working and talking throughout the evaluation ➢ Gaining an understanding of the user's mental model	might have normally occurred in the actual work setting. ➢ Verbalization of thoughts while performing a specific task is exhausting ➢ Elevator needs to be trained		

Interviews and questionnaires are highly recommended to be applied here as well to evaluate designs and developments within the VERITAS project. In *interviews,* the users (end users using VERITAS or VERITAS beneficiaries) can be asked about a system or product directly. An informal conversation about reactions towards the application reveals problems and opinions about it (see further Section 1.4.2). *Questionnaires* can help at this stage to analyze the satisfaction of users with a certain product or system. For this purpose, users have to fill out questionnaires about what they like and dislike about the design and the functionalities of the application (see further Section 1.4.1). Table 14 provides an overview about the main characteristics of both methods.

Table 14 Interviews and questionnaires as evaluation methods in the design and development stage of the VERITAS project.

Method	Main Objectives	Advantages	Disadvantages	Amount of end users	Costs
Questionnaires ➢ Quantitative and Qualitative results	➢ Information regarding some specific issues (e.g. knowledge about area, demographic data) with prefixed possible answers. ➢ Prompt the participants by asking direct questions.	➢ Appropriate technique for large samples (huge amount of target users can be reached) ➢ Answer's objectivity ➢ Systematic analysis possible ➢ Presents a good relation information-cost ➢ Much data can be acquired in short time ➢ User facilities are provided concerning	➢ Response rate is very low unless the questionnaire is distributed by mail ➢ Reliability of the answers is not very high ➢ No personal contact with users ➢ Truthfulness of the answers uncontrolled ➢ It may be user's inhibition answering some questions ➢ Less flexible than	min. 10 per area under investigation	Low

Method	Main Objectives	Advantages	Disadvantages	Amount of end users	Costs
		when and where to answer it	interview ➢ Method should measure the variable that is intended to be measured		

A method to test if certain pre-defined parameters (e.g. related to effectiveness and efficiency) of a product or system reach the results desired with regard to their performance is the "*performance measurements" method*. Another objective and rather quick and easy measurement of a user's performance is the *analysis of log-files.* This method is based on an indirect observation of the user's behaviour related to the system by collecting the users' performance from server logs for later examination and analysis. However, both methods cannot be used alone. They do not include users, evaluate aspects of user satisfaction, or reveal a better understanding of user behaviour. Table 15 subsumes key characteristic of both methods: performance measurement and log-file analysis.

Table 15 Performance measurement and log-file analysis as usability evaluation methods in the design and development stage of the VERITAS project.

Method	Main Objectives	Advantages	Disadvantages	Amount of end users	Costs
Performance measurement ➢ Quantitative results	➢ To test certain parameters of a system (e.g. performance time of a system the error rate)	➢ Effectiveness and Efficiency can be measured objectively	➢ User satisfaction can't be assessed with this method ➢ Is alone not enough: needs to be complemented by other and more qualitative methods.	Approx. 3-5 for qualitative results, min. 8 for reliable measurements	Low
Log-files ➢ Quantitative results	➢ To identify usage patterns as well as potential problems present in the usage of the system by collecting user data	➢ Provides a historical trace of usage traffic for a system ➢ Quick, easy way to gather data on user behaviour without having to actually recruit users. ➢ Completely transparent to the user	➢ Log files do not indicate why users made certain actions or avoided making others ➢ Log files do not indicate if and how users recovered from errors	Ideally a large scale of users	Low

Standards inspection is a method that can be applied already at any stage of the design and development process in VERITAS. It is a method to ensure that the design and/or functionality of the system or product is compliant with industry standards. Section 1.4.14.4 provides more details on the standards inspection method. In addition, designers and developers of VERITAS applications can conduct *feature* and *consistency inspections* of their developments. With feature inspections, a certain pre-defined task of a system or product is identified as well as the features that the application uses to perform this particular task (Nielson, 1994). Focusing on a product's or system's usability, this method seeks to evaluate each identified feature with regard to its usefulness and availability to actual end users and how well it is understood by them. The success of this method depends on the extracted features and if they are complete. Even though this analysis could be conducted also by designer and developers of VERITAS applications themselves (instead of end users), it is highly recommended to include end users in the evaluation process. Consistency inspection addresses the consistency of an interface design of several tools or applications that are similar. This analysis is done by experts of the VERITAS design and development team. In general, tests against certain standards are only useful for those applications that have features that can be compared to given standards but less useful when it comes to innovative designs and interaction concepts. For further information see Table 16 and Section 1.4.14.

Table 16 Inspection methods for evaluating designs and developments in VERITAS.

Method	Main Objectives	Advantages	Disadvantages	Amount of end users	Costs
Feature/ Consistency/ Standards inspection ➢ Qualitative and Quantitative results	➢ Analysis of certain product features for their availability, understandability, and general usefulness ➢ Use scenario-based end results to be obtained from the use of the product	➢ Necessary to guarantee the consistency of the features used in similar systems ➢ Standardized	➢ Expert knowledge needed ➢ Checklist of features to be checked needs to be as complete as possible ➢ Only few on what is important from a designers/ developers' point of view ➢ Only useful for common systems or applications where features can be compared to standards	No end users; approx. 1-3 designers	Low

1.3.3 General Planning of the Pilots in VERITAS

In the current chapter, a preliminary draft for the planning and implementation of the pilots in VERITAS is outlined. The pilot planning is described in detailed within the Internal Deliverable “ID3.6.1: Preliminary Pilot Planning and Evaluation Framework”, and will be concretised through “D3.7.1: Pilot plan for VERITAS framework users” and “D3.8.1: Pilot plans and framework”. The current outline for the VERITAS pilots encompasses accessibility, usability, technical validation and verification of the different components and applications of VERITAS.

The pilot planning will consist of two phases:

(1) An “Initial” pilot evaluation phase to be carried out when VERITAS components are at a suitable prototype stage where a test of a functional prototype may be performed.

The prototype should be free from technical errors and fulfil its technical specifications. This should be possible to do without the need to wait for the completion of the technical integration phase with applications used by designers and developers. The technical validation should show that the prototypes are error free, usable and robust. Equally important at this phase is to determine, as early as possible, if VERITAS meets the user requirements that have been stipulated. With reference to the identified use cases it should be demonstrated that the prototypes implement the required functionality.

(2) A “Complete” validation phase will subsequently be performed for the rest of the project and which may evolve as VERITAS evolves, based on a fully functional final prototype that will be used by designer, developers and beneficiaries for final testing. By complete validation we mean applying the evaluation techniques that have been chosen to the prototypes that have been developed. The results being reported and acted upon by the consortium members.

There are a number of expected results from the complete validation phase which will be important for demonstrating the success of VERITAS. The technical evaluation of VERITAS should clearly demonstrate that the components that are to be used within applications are of a high technical quality. That is to say, the components can be used with in a variety of applications and will not adversely affect their correct functioning. Proven metrics should show the worth of the project and give confidence to all who implement it with-in their applications and working practices.

An equally important result from the evaluations will be the benefits that may be obtained from changing working practices to include VERITAS. This will, of

course, justify the validity of the VERITAS project to the European commission and instill faith in VERITAS. This could prove useful should a subsequent project wish to use the results from VERITAS.

1.3.3.1 Plan for the initial evaluation phase

The usability and accessibility of the VERITAS developed tools needs to be quantified. That is to say, does the developed software meet software standards (see further Sections 1.4.14.3 and 1.4.14.4).

The software tool Morae is a potential candidate for recording evaluation sessions with VERITAS tools. Morae is an innovative software tool allowing for the complete and detailed management of usability testing, thus offering a higher quality of research and greater efficiency in carrying out the work. Morae has been developed by Techsmith, a U.S. company leader that specialises in the development of screen capture and recording software. This software has several purposes, including the analysis of usability tests. By recording all the evaluation sessions they may subsequently be assessed for a consistent application of the evaluation tests across all pilot sites. Whilst other tools are available and may be used by those familiar with them, we recommend Morae and provide a brief overview of it here.

Morae consists of three discrete modules: Morae Recorder (to record information); Morae Remote Viewer (to observe the recording); and Morae Manager (for managing the recorded information). These three components work together to record, monitor and share the user experience.

The Morae Recorder is installed on the computer when the user performs the test. It records the screen and system activity, as well as video and audio of the user. This information is automatically synchronised to create a complete digital file of the user experience. This will apply to the desktop application tests only.

The final component, Morae Manager, solves a common problem in usability testing. Much time can be wasted in locating the important parts of the recorded session in order to do an analysis of the recorded data. This component addresses this problem through the use of markers. As well as highlighting the key points of the session, these allow for the automatic creation of segments of the most important moments in the session, which can then be exported as audio and video clips.

It is thought that the Morae tool would be an invaluable aid in carrying out the pilot testing, principally because it allows the easy evaluation of all the scenarios under consideration not being intrusive. A brief description follows of the general evaluation methodology that is under consideration.

1.3.3.2 Plan of a General Evaluation Protocol

For each evaluation session the following protocol will be followed:

1. The participant will be made comfortable in the observation room.
2. The participant will be given a consent form to sign explaining the purposes of the test and the recordings that are made. All efforts should be made to provide an accessible version of the consent form for the participant.
3. A participant will be given a pre-evaluation questionnaire (see further Section 1.4.1). This will be designed to ascertain if the participant is adequately trained in order to carry out the tasks. .
4. The evaluation will be recorded for purposes of later analysis (Morae). Partners will use the software Morae for purposes of recording the trials. The files associated with the Morae software will then be transferred to the collaborative space for storage.
5. A participant will be asked to engage in a thinking-aloud protocol for purposes of recording their thoughts and reactions during the task (see further Section 1.4.15).
6. A participant will be asked to complete a particular task, which will be based on a pre-determined use case.
7. If a participant appears to have difficulty with a particular part of a task the participant will be requested to explain what aspect of the task is causing them difficulty. The evaluator should then record the reason. Later analysis should rate as to how severe he/she feels the fault is. A rating could be assigned according to the following criteria.

Cosmetic – the problem does not stop a user from completing the task.

Minor – the problem is significant enough to prevent a user from moving smoothly through the task; however a user is able to recover with relatively little difficulty.

Major – the problem is very significant and prevents the user from completing the task in such a way that it causes major interruption; however the user is able to recover, with some difficulty, to finish the task.

Catastrophic – the problem is so significant that the user cannot continue with the task or would give up on encountering the task in real life. When complete, the evaluator will ask the participant to similarly rank the problem.

1. The user will be de-briefed on the tasks just completed, explaining the purpose of the test and how the results will be used in the broader scope of the project.

2. The information gathered during the testing will be transferred onto an online storage medium that can be used for analysis by members of the evaluation team.

1.3.3.3 Feedback to Design and Implementation Teams

Feedback document will be filled in by the evaluation team and an end of cycle report will be produced to mark the end of the evaluation. The different types of usability and accessibility problems will be highlighted and the development teams made aware of the findings. Feedback will then be solicited from the development teams to justify the deviation from the expected and/ or plans to rectify the problem. Subsequent cycles of evaluation testing should start with a verification that the finding from the previous stage have been dealt with both as an assurance from those responsible and from tests specifically performed to verify the fact.

1.3.4 Methods for Pilot testing with designers/developers and VERITAS beneficiaries

The following UCD methods can be used within the Pilots involving the two VERITAS user groups: end users and beneficiaries to evaluate the developed VERITAS test-applications. In particular the following are highly recommended to be applied in this stage of the VERITAS process. The planning of the pilots will be done within WP3.6-WP3.8 and reported within internal deliverable “ID3.6.1: Preliminary Pilot Planning and Evaluation Framework”, and defined through “D3.7.1: Pilot plan for VERITAS framework users” and “D3.8.1: Pilot plans and framework”.

1.3.4.1 Overview

Methods for the pilot testing with end users of VERITAS are listed below and supplemented by a short description. Each suggested method is described in detail within Section 0.

Usability Testing

Applied for the evaluation of an application with real target users performing a series of tasks with the system to identify usability problems, and to evaluate navigation paths, times to perform tasks and user's satisfaction of the application.

- **Cognitive Walkthrough** - Cognitive walkthrough is a review technique where expert evaluators construct task scenarios from a specification or early prototype and then role play the part of a user working with that interface -"walking through" the interface.
- **Pluralistic Walkthrough** - A team of users, usability engineers and product developers review the usability of the prototype of the application.

- **Guided Walkthrough** - The method is based on the guidance of a user through a prototype. During this session, the user is asked for different issues in order to gain a better understanding of the system through the user's eyes.
- **Thinking Aloud Protocol** - Think aloud protocols involve participants thinking aloud (about their thoughts, feelings and actions) as they are performing a set of specified tasks to gain data about the usability of a product or system.
- **Co-Discovery** - Method to identify usability and usage problems in collaboration with others.
- **Interviews** - Method to obtain relevant information from the user based on an interaction between an interviewer and a user at a time. The interviewer asks the user a set of questions that can be more open-ended. The results obtained from them provide subjective and more detailed information.
- **Questionnaire** - Set of pre-defined questions for asking the user for their responses in order to generate statistical data.

Analysis of captured user data:

- **Performance Measurement** – Method to establish if a product or system reaches the results desired by testing certain pre-defined parameters of performance.
- **Log-file analysis** - This method is based on an indirect observation of the user's behaviour related to the system by collecting the users' performance from server logs for later examination and analysis.

1.3.4.2 Guidelines for Selecting UCD Methods

Depending on the general conditions for a particular test application to be developed within the VERITAS project, different UCD methods can be applied for the evaluation of their designs and developments. Parameters for selecting appropriate methods comprise amongst others the amount of available potential users, budget and available time in the respective project. The design, development and evaluation the pilot applications follows the same UCD approach as described for the development of the VERITAS tools themselves (cf. Section 1.1.2 on the enhanced waterfall model of the VERITAS UCD process). Methods for the gathering of application specific requirements (considering the respective application scenario: automotive, health care, smart living, workplace and infotainment) in the development of the pilot applications as well as guidelines to select appropriate methods can be found in Sections 1.3.1.1 and 1.3.1.2. Similarly, methods to be applied for the design and implementations stage of VERITAS are provided through Sections 1.3.2.1 and 1.3.2.2. Sections 1.3.2.3 and 1.3.2.4 offer methods for the evaluation of designs

and developments at early and later stages in the pilot development process through end users (WP3.7) as well as beneficiaries (WP3.8).

1.3.5 Concluding Overview over Methods for a UCD process in VERITAS

Table 23 provides a matrix of the user centred methods recommended to be applied in the respective stage of the VERITAS design and development process. In the following Section 0 is each of the methods described in detail.

Table 17 Matrix of methods for a user centred design development process in VERITAS for each phase of the project.

	Requirements Engineering	UCD methods for Design and Implementation stage	Evaluation methods for Design and Implementation stage	Pilot applications and testing with VERITAS users
Questionnaire	✓		✓	✓
Interviews	✓		✓	✓
Survey	✓			✓
Contextual Inquiry	✓			✓
Task Analysis	✓			✓
Participatory Design	✓	✓		✓
Co-Discovery Method		✓		✓
Prototyping		✓		✓
Paper Prototyping		✓		✓
Storyboarding		✓		✓
Card Sorting		✓		✓
Wizard of Oz		✓		✓
Expert Review			✓	✓
Heuristic Evaluation			✓	✓
Usability Test			✓	✓
Cognitive Walkthrough			✓	✓
Guided Walkthrough			✓	✓
Pluralistic Walkthrough			✓	✓
Thinking Aloud Protocol			✓	✓
Performance Measurements			✓	✓
Log-file Analysis			✓	✓
Standards Inspection			✓	✓

	Requirements Engineering	UCD methods for Design and Implementation stage	Evaluation methods for Design and Implementation stage	Pilot applications and testing with VERITAS users
Feature Inspection			✓	✓
Consistency Inspection			✓	✓

1.4 Specification of methods for a UCD process in VERITAS

This Section extents on each of the methods introduced within Section 1.3. All methods recommended for the different stages of the VERITAS design and development process are described in detail respecting in particular their main objective as well as the methodology on how each of this method can be applied by designing and developing partners of VERITAS. In combination with a presentation of the main advantages and disadvantages of each method and recommendations and tools to support the successful conduct and adherence to these methods, it is hoped that this section provides a helpful introduction to relevant UCD methods and guide for all designing and developing partners of VERITAS.

1.4.1 Questionnaires

A questionnaire is a set of pre-defined questions for gathering the user responses in order to generate statistical data. The objective of the questionnaire is to obtain statistical results to be later analyzed. It is less flexible than other methods such as the interviews but the information obtained can be analyzed rigorously. Furthermore, with this method it is easier to get more information and to reach a higher percentage of the target users.

There are different ways to administrate them, i.e. through post or through an electronic platform. This method is less flexible than others, but it can reach more people and be analyzed in a more strict way.

1.4.1.1 Objectives

The main objective of this method is to obtain quantitative information regarding some specific issues with prefixed possible answers. The topics analyzed by means of this method imply definable events, quantities and aspects.

This method could be useful in case the problem or situation under study has been completely defined and will not be changed during the project.

The questionnaires should be reliable and valid. Its application to the same individual should present the same results. Besides, this method should

measure the variable that is intended to be measured. In this point it can be distinguished two types of validation:

- Internal Validation. Certain of the measurement obtained refers exactly to the variable wanted to be measure.
- External Validation. Possibility to generalize the results obtained from a specific context.

1.4.1.2 Methodology

The questionnaires present general phases that should be followed, namely:

1. Definition of the questionnaire's objective.
2. Definition of the potential user groups. It is essential to identify the target users, also taking into account indirect ones. Once the groups are identified and categorized (primary users, secondary users and third users), the prioritization of them should be done according to their relevance.
3. Write the questionnaire. Based on the objective defined in the first step, selecting the specific information needed by defining groups of questions according to its thematic (personal data, medical data, capabilities…)
4. Distribution and recompilation of the questionnaires.
5. Analysis of the results.

The information provided by a questionnaire can be classified in different groups according to the type of information to be extracted. The questions are classified according to this groups and the further analysis of the outcomes is also based in this classification.

Possible groups of questions that can be present in any questionnaire are:

- **Demographic** - Information related to personal information focused on the
- **Technical data** - Information related to the usage of the Information and Communication Technologies by the user.
- **Medical data** - Information related to specific medical information (very useful for medical projects).
- **Capabilities** - Information about the user's capabilities (very useful for e-inclusion projects)
- **Knowledge of the area** -Specific question about the knowledge of the area under study.

Questions more specific to the area under study should be also classified by thematic group.

Example:

Questionnaire about a platform that offers several tools for developers in the Open Source Software field:

- General overview about the platform
- Specific questions about each tool provided
  - General opinion
  - Usability
  - Functionalities

1.4.1.3 Advantages and Disadvantages

The questionnaires, as a method to extract requirements from the users, present the following advantages:

- It presents a good relation information-cost
- Appropriate technique for large samples
- Answer's objectivity
- Much data can be acquired in short time
- User facilities are provided concerning when and where to answer it
- The outcomes are objective so a quantitative analysis can be carried out

This method also present disadvantages:

- The response rate is very low unless the questionnaire is distributed by mail.
- The reliability of the answers is not very high
- It is not the best way to collect information for every user groups
- There is no personal contact with the users
- There is no way to check the truthfulness of the answers
- It may be user's inhibition answering some questions

1.4.1.4 Questionnaires types and Questions

Pre-test - This questionnaire gives information about the general profile of the user and knowledge of the user.

Pre-task - This questionnaire aims at compiling information about particular tasks carried out by the user.

Post-test - This questionnaire collects information about the opinions and assessment of the activity or applications after its execution.

Question types to apply within the questionnaire:

General questions
Questions to establish the user profile. Questions about the age, sex, residence and other are included here.

Example:

Gender: ☐Female ☐Male

Open questions
Questions aim at obtaining subjective information. The user can give interesting suggestions and find unexpected mistakes.

Example:
If in the testing phase (f), how do (would) they get involved? (e.g. by a VR simulation tool to allow them test the application, there is a human factors team assigned to it, etc.)_____

Scalar questions
These questions allow the user to establish a specific point in a numeric scale.

Example:

Evaluate your autonomy at work on the following 5-point scale

1 – I can't do my job without the contribution of my colleagues	2	3	4	5 I am totally autonomous

Multiple choice questions
Questions where the possible answers are shown and the user is asked for marking one or more of the options presented.

Example:

Are you familiar with any of the following accessibility guidelines/standards? (Multiple answers are possible)

☐ WAI-ARIA Rich Applications
☐ Web Content Accessibility Guidelines 1.0 (WCAG 1.0)
☐ Web Content Accessibility Guidelines 2.0 (WCAG 2.0)
☐ Section 508
☐ Authoring Tool Accessibility Guidelines (ATAG)
☐ None

Ordered questions
The user should put in order a number of options presented.

Example:

Order the following configuration options from the most useful to the less one for you

- ☐ Colour contrast
- ☐ Bigger fonts
- ☐ Bigger control keys
- ☐ Bigger screen
- ☐ Touchable screen

1.4.1.5 Tools

There are two main ways to carry out the questionnaires:

- Electronic platform. The user access a web platform where the questionnaire can be filled in. He completes is and finally sends it by clicking the SEND button. The answers are automatically stored.

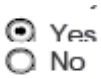

Figure 6 Electronic questionnaire

- Paper. The questionnaire is given to the user in hand. The user fills in the questionnaires and gives it back pollster. The answers from all the users should be later collected.

Figure 7 Paper questionnaire

1.4.1.6 Recommendations

There are several recommendations that should be taken into account when developing a questionnaire:

- The questions should be clear enough. The user should not need further information to understand the question.
- The possible answers should be known in advance. The information provided by the questionnaires is limited to the quantification of how many users had selected each possible answer.
- The questionnaires should be anonymous. There could be some questions that the user would prefer to answer anonymously.
- Take care of the length of the questionnaires. Too long questionnaires could be useful but the user would not be comfortable with them. It is

needed a balance between the information to get and the users' patience.

- This method is followed by a static analysis so it is essential to have numeric questions to evaluate (usage of scalar questions).
- Take care with the open questions. The usage of this kind of questions should be limited.
- If the questionnaire is given by the interviewer to the user, he should not be present or looking to the answers of the user until he/she has left.
- In the scalar questions try to include both positive and negative statements.
- In the open questions, try to be as much relatively specific as possible in order to simplify the analysis phase.
- Take care of the vocabulary you use in the questions. Depending on those polled technical terms should be avoided.

1.4.2 Interviews

The interview is a method to extract information form the user involving him with one interviewer in order to obtain a unique point of view about the issue under study. The information provided by the interviews is non-statistical and should be carefully analysed by professionals in the field. Through the interviews, users' preferences and attitudes can be obtained.

This method should be used for the extraction of requirements in order to understand the field, and in the design process to see in how far requirements are met.

1.4.2.1 Objectives

The main objective of the interview is to obtain as much information as possible from a face to face session with the user. It is a very useful method for those users that find any kind of difficulty to express their ideas in writing. It is based on a collection of questions done by the interviewer to a user at a time. This contact one to one allows the acquisition of more detailed information from the user.

By means of the interviews the under study field could be better understood. The questions are used as a tool to get tacit information and the users' personal points of view.

1.4.2.2 Methodology

The interviews are a very useful method for gathering information in a direct and organized way. By means of the questions previously prepared, the user shares his experience about the field under study. Unlike the questionnaires, the questions prepared can be modified during the interview and be adapted to the context.

The location to carry out the interviews can vary. They can be done over the phone or by person. If the interview is done by person, the specific location could be a neutral one or in the particular environment where the system is going to be used.

The questions should be written down in advance so a stricter plan could be followed. It is necessary to take into consideration the specific information that is waited to be obtained from this process. The questions that will be asked to the user should follow a coherent plan so the user will not get lost.

This method is very effective for high level evaluations, especially for getting information regarding the users' preferences, impressions and attitudes.

1.4.2.3 Advantages and Disadvantages

The advantages that this method presents are:

- High response rate
- Great reliability of the data collected
- The user's real needs of information can be known
- It is possible to solve user's doubts during the interview due to the direct relation between the interviewer and the user.
- Very useful method for users with low cultural level and with difficulties to express their ideas in writing
- Useful method to find not foreseen problems in the design phase.

The disadvantages that this method presents are:

- Many economic and personal resources are needed to carry out the interviews
- Possible lack of objectivity and bias
- Difficult to apply to disperse populations

1.4.2.4 Tools

Interviews are carried out in person, so the only tools needed are the questions that should be noted down and any other additional elements to record or accomplish the process.

It is essential that the questions to do the interview are written so an outline can be followed during the process. In order to obtain as much information as possible, the option of using any record system (tape recorder, video recorder) could be very useful, so later reviews of the tapes could let the extraction of further information.

1.4.2.5 Recommendations

- The quality of the information you get from the interviews is based on the questions' quality. Take care of the question's writing to be as clear and useful as possible.
- The interview should be prepared in advance.
- During the interview the questions could be adapted to obtain as much information as possible.
- Some additional questions can be added during the interview according to the users' answers.
- Follow a top to bottom approach during the interview.
- The possible answers should not be defined in advance.
- The location of the interview wherever possible may be in the environment where the user is going to use the system.
- Do not use in the interviews questions regarding the interaction with the system. For this kind of questions other methods are more appropriated such as the observation of the user during a testing session.
- If the interviews are going to be conducted by more than one person an introduction could be useful to maintain the consistency across the interviews.
- The length of the interview may be around 45 and 60 minutes. Less time could make difficult the acquisition of information. More time could tire the user.
- Focus on participants' personal experiences not on what they will do.
- Don't use questions where you lead the user in a positive or negative direction. If you ask the user what does he like about something you should also ask what he dislikes about it, too.
- Do not use questions where the answer is just yes or not. The information provided from this kind of question will be useless.
- Ask the questions one by one, do not ask two things in the same statement.
- Do not use multiple-choice questions. The user could get lost if you ask this kind of questions verbally and in an interview this questions do not give much information. This kind of questions is better for the writing questionnaires.
- Try to make a test of the interview with someone within the organization that is preparing the interview. It could help to find misunderstandings in the questions as well as refine the timing.
- If the user allows it, record the interview so later you could obtain more information from it than in the moment of the interview.

1.4.3 Surveys

A series of questions consisting of mainly closed-end answers (multiple-choice) used to identify patterns among a large number of people. The set of questions

are distributed to a large amount of people and online mechanisms can be used to carry out the surveys.

1.4.3.1 Objectives

The main objective of this method is to gather information related to the user's preferences. This method is not focused in the users' opinions about the actual performance of a system. It is centred in the data the user can provide about which their preferences are from a quantitative point of view.

It is a complementary method to the questionnaires that provides more quantitative information that the open-questions of the interviews. Despite the fact that from the interviews quantitative information can be gathered as well, the planning of the surveys facilitates the obtaining and collection of this kind of data. However qualitative information can be also be extracted from this method about the user habits or attitudes.

The surveys are mostly used to measure user satisfaction or to build or validate user models.

1.4.3.2 Methodology

The development of the survey is similar to the one expressed in the questionnaire section. It only differs in objective of the questions. Meanwhile the questionnaires can be more generic, the surveys are more related to the user's preferences and can be used as a complementary method to the interviews.

The planning of the survey should take into account the consideration steps shown below:

1. Define who the target users are before you compose the questions.
2. Identify the method that will be used to distribute the surveys taken into account which of the considered ones will give you the best results. If the target users are concentrated in a specific location the best choice could be to go there directly and ask them to fill in the survey. However if the target users are spread and are also used to work with the computer, the online survey-tools would be the better choice. Study carefully the characteristics and capabilities of the target users before selecting the method to carry out the surveys.
3. Define the time the survey is going to take. If the user feels he is going to receive some kind of compensation if he carries out the survey, the number of questions could me higher.
4. Decide if the end of the survey process is going to be determined by a deadline of by a minimum number of surveys completed.
5. Decide the tool you are going to use in the collection and analysis phase.

1.4.3.3 Advantages and Disadvantages

The advantages that this method presents are:

- Low costs.
- Useful in describing the characteristics of a large population (larger samples feasible; statistically significant results).
- Can be administered from remote locations using mail, email or telephone.
- Many questions can be asked about a given topic giving considerable flexibility to the analysis.
- Flexibility in how questions are administered (face-to-face, phone, email, etc.).
- Standardized questions make measurement more precise (uniform definitions upon the participants are enforced).
- Usually high reliability.

The disadvantages that this method presents are:

- As it relies on standardization, it forces the researcher to develop questions general enough to be minimally appropriate for all respondents, possibly missing what is most appropriate to many respondents.
- Large sample needs to be available and has to reply.
- Survey research as opposed to interviews can seldom deal with "context".

1.4.3.4 Tools

Several tools are provided in the network to carry out the surveys online way, so it is easier to reach the user and more effective to reach a larger amount of people. They also avoid efforts associated to the cost and effort of printing. These tools provide mechanisms for authoring surveys online, administering them and analyzing the results. Some of the possible online tools are provided in the table below.

Table 18 Online survey tools

Name	Web	Characteristics
Snap Surveys	SnapSurveys.com	Online, paper, PDA and kiosk surveys in any language. It provides a free trial version (online request needed).
Survey Gizmo	SurveyGizmo.com	Online software to create surveys easily. It provides a free trial version (14 days).

Name	Web	Characteristics
Snap Surveys	SnapSurveys.com	Online, paper, PDA and kiosk surveys in any language. It provides a free trial version (online request needed).
Survey Gizmo	SurveyGizmo.com	Online software to create surveys easily. It provides a free trial version (14 days).
Survey Monkey	SurveyMonkey.com	Web-based survey tool. It provides a free trial version but a previous registration is needed.
Survey Share	SurveyShare.com	Creates and deploys Web surveys Trial version available but a previous registration is needed.
Zoomerang	Zoomerang.com	Creates surveys and analyze and report survey results. Deploy via email, the web or our survey panel Free trial version available

These tools generally present a trial version, so, for further usage and functionalities a commercial version is needed. Most of them allow the online analysis and also provides an Excel file with the data to be downloaded.

Figure 8 Surveygizmo example

There are some studies that demonstrate that the feedback from the users is more positive if they are asked through an anonymous web survey than directly in person or by phone. The users are more sincere if they are not asked directly. They tend to answer what they think the interviewer is waiting to hear in order to not disappoint him and make them look better.

1.4.3.5 Recommendations

- Making sure questions are well-written so that you get accurate answers without leading respondents to a particular answer.
- Do not use questions that make the user to speculate. They questions mustn't begin with the sentences like "If…".
- Multiple-choice questions or with just one answer between two options are better to be evaluated later and they are easier to answer by the participants.
- This method is very useful to evaluate the opinions of the users. It is not easy to state a negative opinion about something but is much easier to express it when a ranking is proposed. Therefore use questions where the users must select an option within a set range of choices (strongly agree, agree, neither agree nor disagree, disagree, strongly disagree).
- Make a carefully study of the target users in order to select the better method to carry out the surveys (in person, by phone, using online tools…).
- The time for the survey should not be longer than 5 to 10 minutes. In those cases where the user will receive any kind of compensation for doing the survey, the time employed could be a little bit longer.
- Give the participants an estimate about the time is going to take them to complete the survey and give them information about how much is left by putting numbers in the pages or using a progress bar in online applications.

- The surveys should be carried out until you reach a deadline or a minimum number of surveys completed.
- The evaluator should not see the responses until after the participant has left.
- The survey should be previously reviewed and tested before its distribution.

1.4.4 Contextual Inquiry

The observation inside real work context takes information from the real work context of the representative users in order to understand which are their needed or how they work to achieve their tasks. This method can combine an observation phase with other interviewing processes.

It is used in the first phases of the design process as well as in the evaluation process of a system.

1.4.4.1 Objectives

The main objective of this process is to gather additional information regarding the context where the participant works. Specifically the data extracted considers the following topics:

- Real-life problems the user is facing.
- The equipment the user has to carry out his work.
- The conditions the user has to work (space, how often he is interrupted…).
- Their preferences regarding the tools used in their work. This information is very useful for the design phase.

1.4.4.2 Methodology

The first step is to inform the user about the process. A little introduction about the purpose of this method and a description of what is going to be done should be done. Consent forms should be distributed to notify the user the confidentiality of the data.

There are two types of observation:

- Active observing. The participant explains you what exactly he does as if he were teaching you how to perform some tasks. This kind of observation could influence in how the participants really behaves.
- Passive observing. The participant should act as if you were not there and your role is just to watch and examine his behaviour.

1.4.4.3 Advantages and Disadvantages

The advantages that this method presents are:

- Direct measurement of behaviour, no biased report or narrative of intentions and procedures.

- More valid (user behaviour less prone to lies).

The disadvantages that this method presents are:

- Requires long times of observation.
- Less reliable.
- Blind to cognitive or affective variables.
- Data is not generalizable.

1.4.4.4 Tools

Once the information has been gathered, it is important to identify trends in the participants' results. A very useful technique is the Affinity Diagrams.

An Affinity Diagram is a graphic tool to organize different and separate items into groups to identify and define a trend.

This tool has several steps that should be followed:

1. Generate ideas. The ideas have been generated during the observation phase so the notes taken during this process should be gathered.
2. Display ideas. Post-it notes are distributed so the team that has collected the notes writes down a statement in each one.
3. Sort ideas into groups. Put the post-it notes in a wall and without talking begin to group them finding relation among them. Place the related ones in the same column and try to add in the columns defined the notes that are not classified. This process will end when all the ideas are placed in the groups.
4. Create header cards. Once the groups have been defined the next step is to name each group. The title selected should be clearly enough that people outside the time can read it and understand its content. Relationship within groups can be identified in this phase and superheaders can be defined.
5. Draw finished diagram. Write the problem in the top of the diagram and then the schema defined with the superheader cards above the headers. Then below each header the ideas related should appear in the same column.

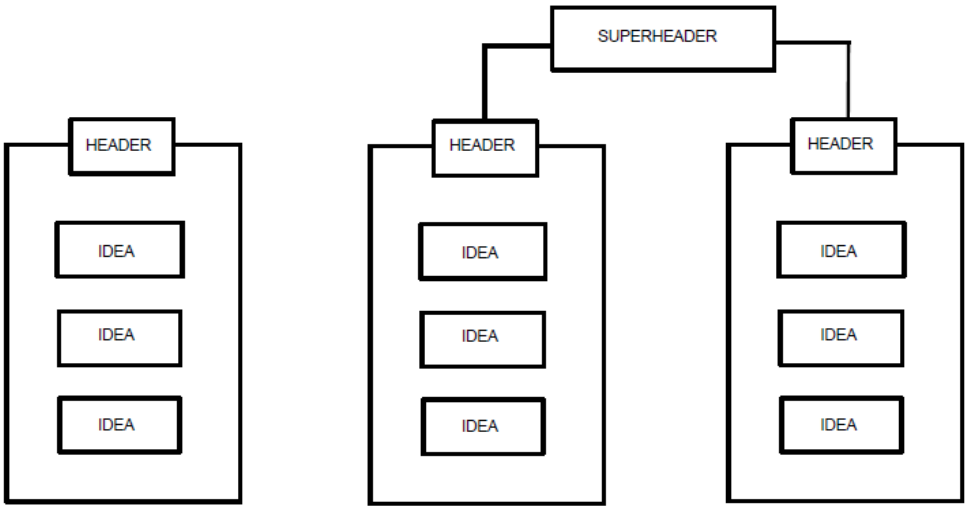

Figure 9 Affinity Diagram Example

1.4.4.5 Recommendations

- In case you do not have enough time with the participants, the active observation would provide more information.
- The signatures on consent forms are important in order to use the information extracted.
- This method can last from a few hours to several days, but if the participant cannot dedicate more than two hours it could be better to carry out an interview.
- The participant won't adjust to your presence until 15 minutes has passed so do not begin with the observation process until this time has passed.
- Some previous questions can be done, especially regarding participant's typical processes.
- The observer should turn off his cell phone or any other thing that can disturb the participant during the process.
- Do not distract the participant with sound or body language, the main idea is to be unnoticed.
- The interview process should be careful and it should be avoided the interpretation of the information gathered. In case of doubt, verify the assumptions with the user.
- Try to make the interview part as short as possible. Just one hour of interview could be enough.

1.4.5 Focus groups

A focus group is a group discussion where a moderator leads participants through questions on a specific topic. By means of a focus group, users are asked to share their opinions, thoughts and ideas about a specific subject.

Focus groups are often used as an input in the design process and provide non-statistical data.

1.4.5.1 Objectives

The main objective of this method is to get additional information from the user by means of an open discussion among a few users. This new data is caught through the spontaneous reactions and ideas that evolved during the debate.

1.4.5.2 Methodology

The moderator is responsible for the preparation of the topics to discuss, as well as to collect all the information generated by this process.

The moderator introduces the topic that is going to be discussed and explains the participants what is expecting to get out from this process. Then, he should explain why the participants have been selected to carry out the focus group and how this information is going to be used.

After the introduction the moderator should begin with the questions that are wanted to be discussed. In the first question the moderator should get everyone to talk so later the participation would be easier. Then, the moderator will begin to raise the questions and the participant will begin to share their opinions and ideas meanwhile the moderate should stay out of the conversation. The moderator is there only to listen to the participants.

1.4.5.3 Advantages and Disadvantages

The advantages that this method presents are:

- Moderator in face-to-face session can motivate the discussion and engage participants to reveal their opinion
- New thinking about a topic can be stimulated through group discussion (more in-depth and intense form of discussion)
- trustworthy naturalistic data that also lead to important insights about human behaviours by allowing all participants to say anything they would like in front of the whole group
- rather natural discussion evolves
- a well-designed guide encourages group members to relax, open up, think deeply, and consider alternatives

The disadvantages that this method presents are:

- Evaluation of the gathered “discussion data” is rather complicated
- It is possible to gauge a groups’ overall reaction to educational materials, but not on an individual basis.
- Focus groups do not produce reliable data on topics that produce extremely strong feelings
- No generalizations possible
- Not objective

1.4.5.4 Tools

The tools needed for this method are just the questions to state to the participants that should be previously written down. A good option could also be to use record to extract more information later.

The identification of the participants is also important so the nametag is an additional tool that can make this process easier.

If the focus group is held around an object, the object of investigation should be brought to the discussion, so that participants can point out certain weaknesses or strength and discuss them directly with the others.

1.4.5.5 Recommendations

- It is needed an experienced moderator to get effective information from this method.
- The list of topics to discuss must be previously prepared.
- The questions used on a focus group are similar to the ones written down when preparing an interview process. The tips you use in the interviews can be applied to the focus groups too.
- Begin the focus group with questions easy to answer.
- In the middle of the focus group use questions that intend to generate ideas about a specific topic within the users, when they are more comfortable.
- Assign time blocks to each topic and adjust the schedule to them.
- If the focus group is going to last much time, put the most important questions in the middle of the topic list to discuss.
- The number of people of each session should be between 6 and 8.
- The session should last between 1 to 2 hours.
- Give to each person a nametag so each one can be addressed by his name.
- The discussion should begin with a little introduction.
- Clarify the participants the aim of the focus group and how the information extracted from it is going to be processed. It is important to point out the confidentiality issue.
- The moderator should not participate in the discussion. He should only raise the questions.
- If the moderator asks directly to a participant who has not talked during all the phase, he should repeat the question.
- The moderator should not share his opinion during the process.
- When there is a change of topic the moderator should clear this break given verbal information about the change.

- In order to indicate the participants that the activity is nearing its end, the moderate could make an evident gesture that implies it (e.g. look at the watch).
- The moderator should arrive before the session starts.
- Ask the participants if they have any question about the process before the beginning.
- Offer refreshment to the participants in order to relax the session could be a good idea.

1.4.6 Card Sorting

This method was originally developed by psychologists in order to study how the human mind organizes and categorized information. One of the main problems designers and developers find is related to the organization and presentation of the information. Through card sorting, intuitive categories are suggested. This method consists on a series of writing labels (cards) that represent several concepts. Users are asked for categorizing the cards, sorting them, according to the relation they find among them. Once the piles of cards are sorted, users should give a name to each pile to express the common characteristics cards have. This method is often used in order to assess the conceptual differences on system understanding between designers and users.

1.4.6.1 Objectives

Software designers and developers find difficult to organize information and functions in an easy way for the users. The main objective of card sorting is to understand how users imagine the organization of this information and how their mental model works. In this sense, this method tries to discover the optimal organization of the information from the user's point of view.

1.4.6.2 Methodology

This method is very useful when you have items identified and you want to categorize them from a final user point of view. There can be distinguished two kind of card sorting:

Close sorting. Researchers already define the groups and the users must classify the cards according to the given named-groups. This methodology is used when a design is already done or the researcher wants to test categories defined in a previous open sorting session.

Open sorting. Users sort the cards and they also label the resulting piles considering their own criteria.

A card sorting session can present the following steps:

1. The cards are prepared. The supervisor of the session prepares a card for each concept that wants to be classified. These concepts are gotten hold of other extraction requirement methods such as interviews.
2. The cards are given to the users in a random order. He should sort them based on a similarity among them. This similarity must be decided by them and can be changed during the session. He should decide why he thinks cards are similar.
3. After creating several groups, this ones can be pile in larger ones. This process can be stopped whenever the user thinks the classification is done.
4. Finally, the user names each of the groups done.
5. Enter the data in a spreadsheet, and examine the groupings. You can use electronic tools such as IBM's EZSort program.

1.4.6.3 Advantages and disadvantages

The advantages that this method presents are:

- Quick and cheap
- No technology required, so highly portable
- Feedback early in the design process
- This method can support paper prototype
- Useful to categorize information. It enables designers and developers to understand how target users group the items
- Identifies terms that are likely to be misunderstood and/or difficult to categorize

The disadvantages that this method presents are:

- Challenging to capture results from a complex session
- Does not reveal interface problems
- Different people call the same thing by different names

1.4.6.4 Tools

Tools employed in card sorting sessions are based on the usage of common and familiar elements. Cards can be done using post-its, pieces of paper or cards. Users are also provided with blank cards as well as pencils to write new items not considered. As the process may involved a large number of cards it is necessary to have space enough to work and put the cards. It can be use a blackboard where the cards are pasted or a big table to put them on. It is also possible to have a record system to analyse the mental process users have to reach the final classification.

Figure 10 Card sorting session

For later analysis of the information it could be useful to use a specific tool such as the IBM's EZ Sort tool. This tool presents two different packages, U sort and Ez Calc.

U sort. It is used by the participants of the sessions to sort virtual cards. This virtual process can be done afterwards by the designers using the results from the typical session.

EZ Calc. This part helps to obtain the results from the card sessions by performing a cluster analysis and generating tree diagrams.

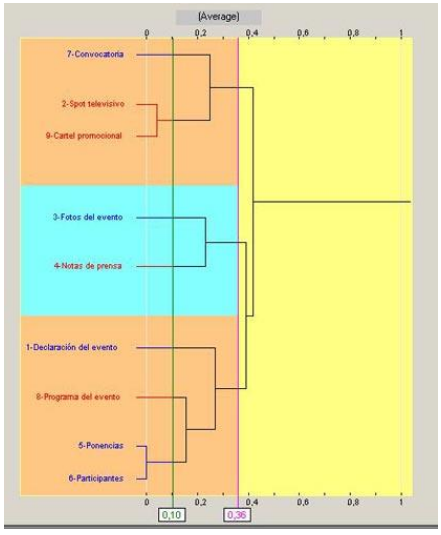

Figure 11 Tree diagram provided by EZ Calc

1.4.6.5 Affinity diagram

An affinity diagram is method for organizing the structure of a system. The possible screens a system will present are written down. This can be done by the designers or by the target users of the application. After drawing the functions or screens it is needed to organize them by grouping them according to some similarity between the functions and screens. This method could be very useful for obtaining further information about a domain that is not well known. Unless this technique is similar to the card sorting, this method obtains

a consensus result meanwhile card sorting just shows the possible “affinity diagrams” each user defines.

Objectives - This method has as its main objective the identification of the scope issues to be taken into account in a system design. It tries to organize brainstorming ideas in order to be used in the design process.

Methodology - The methodology use is very similar to the one already explained in the card sorting method (see Section 1.4.6). It is important to have a previous planning of the session with the users. Concepts should be written down in advance and the room used must have a blackboard or a table where the notes can be pasted.

During the session the steps to be followed must be:

1. Explain the participants what the session consists of. As in card sorting there should be additional cards where they can include new concepts not considered a priori.
2. Users classify the cards according to their similarity. There should be a consensus among all the participants.
3. Named each group considering a concept that defines all the elements of the group.

This method has similar advantages and disadvantages to the card sorting method. The main difference between them is the final consensus achieved at the end of this session.

1.4.6.6 Recommendations

- This method can be used in conjunction with paper prototype in the design process.
- The concepts to classify must have a close relation to the application to be developed.
- No additional information should be given to the users sorting the cards. The only data must be that they should group the cards according to the similarity they can find among them.
- Make users feel as comfortable as possible so they can express themselves easily.
- Be sure that each term you use is completely clear and cannot be confused with any other. Do not be ambiguous and be as precise as possible.
- Use between 25 and 30 participants to get useful results.
- Be clear and explicit explaining the users the purpose of the card sorting session.
- In some occasions it would be useful to give detail descriptions of the terms to classify in order not to promote a common understanding of

them. Try to give in the other side of the card a brief description of the meaning of each term.

- Users should explain why they have included each item in each category.
- Be sure that all the items have been included in a group
- Provide additional cards for additional elements no considered a priori so users can include and categorize new ones.
- Leave participants alone during the sort session to let them feel more comfortable.
- Unless you leave participants alone be available so they can ask you questions or let you know that they have finished.
- At the beginning give general instructions to the users in order to avoid misunderstandings about the card sorting itself.
- Pay special attention to the selection of the participants, they should be representative of the target users of the application.
- Leave time enough to perform the session.
- Shuffle the cards before any card sorting session
- Take care with the size of the font you use for the cards. It should be big enough according to the participants' characteristics.
- Do a previous example with easier concepts such as sports or animals so participants can understand better what is expected from them.

1.4.7 Participatory Design

Participatory design is a method that consists of a direct involvement of people in the design process of a specific application. This method involves the users during the design process as well as during the development of the application itself. It is applied when a prototype of an application or system is needed. The users themselves are the ones who design the prototype using different approaches. Afterwards the initial prototype can be refined by the designers using more traditional processes.

1.4.7.1 Objectives

The main objective of this method is the involvement of the users in the design process of an application. Leaving them to design the systems using familiar elements such as pieces of papers and pencils, their suggestions are considered equally than the ones given by the technical designers. Users taking part in participatory design sessions are a representative sample of the final users and might increase later acceptance of the application.

1.4.7.2 Methodology

There can be distinguished three different approaches related to the participatory design. They are User Sensitive Inclusive Design (USID), Task Analysis Framework (TAF), Plastic Interface for Collaborative Technology

Initiatives through Video Exploration (PICTIVE) and CARD (Collaborative Analysis of Requirements and Design).

- **USID.** This method is focused on the work with elderly and disabled people as their key final users. In this approach users are not considered as tester for usability experiments but designers should empathize with the user and optimize communication channels with them. This methodology can present the following phases: (1) producing the script, in collaboration with the researchers, (2) briefing and rehearsing the actors, (3) the performance and (4) the facilitation of the interaction with the audience.
- **TAF.** This method is interesting for those designs where several scenarios are shared. By means of this methodology the user understands the scenario where the application will be used. Comprehending the context facilitates the communication between the final user and the developers in order to define the specifications of the system.
- **PICTIVE.** This method is based on a paper mock-up involving users in the development process. This method aims at represent a graphical user interface (GUI) by providing the participants with papers, scissors and pencils. Avoiding the use of software designs allows an easier understanding for participants who may not be computer literate (Muller, 1991; 1992; 1993).
- **CARD.** This participatory design method is focused on the analysis and definition of flows. It uses cards where the different screens for the flow are represented. These cards are used as the way to meet a common point between users, designers and developers (Muller, 2001; Tudor et al., 1997).

1.4.7.3 Advantages and disadvantages

The advantages that this method presents are:

- More user involvement brings more accurate information about tasks and an opportunity for users to influence design decisions
- This method can recommend important contributions that could have been missed.
- The inclusion of users' designs might increase users' acceptance of the final system.
- Provides a forum where comments and suggestions can be shared.
- Users are involved in the design to the same extent than designers. Technical and non-technical participants are involved equally in the design process.
- Designers and developers have the opportunity to understand in a better way the needs of the final users of the applications.

- Techniques used for this method are very easy to understand and learn.

The disadvantages that this method presents are:

- Extensive user involvement may be costly and may lengthen the implementation period
- Possible rejection from people that are not involved in the process or whose suggestions are not considered.
- Designers can be forced to compromise their designs to satisfy incompetent participants
- Having participants for the sessions could be difficult for some kind of users due to their disabilities, such as cognitive, or due to their short available time (professions such as doctors).
- Extra effort for the developers due to the inclusion of the users into the design process.

1.4.7.4 Tools

In order to perform a participatory design session, it is needed to prepare a workshop related to the application to be developed. In this sense, the localization and conditions of the environment are essential issues to facilitate the success of the session. Several elements, depending on the participatory design approach, might be considered. Due to its participatory feature, interactive elements for users are necessary tools. Pieces such as post-its, pencils and papers are used to create the systems in a familiar way to the participants. Besides, record the session could be very useful for later analysis, so a record system could be a key point.

Figure 12 Participatory design session

1.4.7.5 Recommendations

- It could be difficult for the users to understand the designers, so easy approaches should be considered to perform this method. Prototypes should be used such as mock-ups and additional elements, for example

office products, to design the applications such as slips of paper, post-its…

- Record the sessions to extract later information.
- Create and foster an environment where the user can feel comfortable to express his opinions.
- Be careful with the selection of the users that are going to participate in order to get a successful participatory design experience.
- Participants should be informed about what developers expected from them and how their opinions and suggestions can influence the final design of the system.
- It could be very useful to have psychologists involved in the process as consultants for the participatory design team.
- It is needed a knowledgeable moderator during the sessions.

1.4.8 Heuristic Evaluation

This is an evaluation method aim at finding usability problems that can be present in a user interface design. It is based on the evaluation of the interface by means of a small group of evaluators, with reputable experience in the Human Computer Interaction (HCI) field. This evaluation is based on some usability principles called heuristics.

1.4.8.1 Objectives

The main objective of this method is the analysis of the usability of an interface by means of expert evaluators. The evaluations are based on the usage of predetermined parameters named heuristics. They are general rules that are able to describe common characteristics and properties of an interface that must be usable.

1.4.8.2 Methodology

There is not an established evaluation methodology due to each evaluator can decide on his own how to proceed with the session. Each evaluator analyses the interface on his own. The analysis is based on a list of predetermined heuristics, but the evaluator, based on his expertise, can include additional ones.

The first step should be intended to get the flow of the interaction and a general idea of the system's scope. After that evaluators can focus their analysis on specific interaction elements. During the evaluation, the evaluator should go through the interface several times comparing the dialogue elements with the heuristics defined. The issues identified during the evaluation cannot be just the identification of a problem but also the specification of the heuristics related that have not been accomplished. The evaluator should give detailed and justified information about each problem detected.

Only after the evaluation is completed all the evaluators are together to discuss the results of their analysis. The outcomes of this method are a list of usability problems in the interface related to specific usability principles that have not been fulfil.

Figure 13 Heuristic evaluation session

The most commonly applied usability heuristics are those ten defined by Jakob Nielsen (1994):

Visibility of system status – The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.

Match between system and the real world - The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.

User control and freedom - Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue. Support undo and redo.

Consistency and standards - Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.

Error prevention - Even better than good error messages is a careful design which prevents a problem from occurring in the first place. Either eliminate error-prone conditions or check for them and present users with a confirmation option before they commit to the action.

Recognition rather than recall - Minimize the user's memory load by making objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.

Flexibility and efficiency of use - Accelerators -- unseen by the novice user -- may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.

Aesthetic and minimalist design - Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.

Help users recognize, diagnose, and recover from errors - Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.

Help and documentation - Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large.

1.4.8.3 Advantages and disadvantages

The advantages that this method presents are:

- Inexpensive, quick, and easy way to identify usability problems
- Different people find different usability problems. Experience from different evaluators gives different points of view and several usability problems can be identified.
- Having the possibility of using of an observer helping the evaluator in operating the interface in case of problems.
- It is possible to perform heuristic evaluations of interfaces that are just in paper and have not been implemented.

The disadvantages that this method presents are:

- Constrained by the evaluator’s knowledge of HCI and knowledge of the audience for which the system is designed
- Possible to identify usability problems that actually may not be a problem of the user
- Not sufficient on its own (developers will not catch the same problems as users will)
- If the system to evaluate is domain-dependent it might be necessary to have an observer that could help the evaluator to understand the purpose of the interface.

1.4.8.4 Tools

In order to perform the heuristic evaluation sessions some tools will be necessary. First of all, some a record system will be needed for later analysis of

the sessions. Besides, the specific interface to be analyse, whether paper or implemented, will be needed, as well as additional material for the evaluators to take notes.

Moreover, logistic issues are vital for the fruitful progress of the session. The place to carry out the evaluation should satisfy certain characteristics to dispose the evaluators in a comfortable environment.

1.4.8.5 Recommendations

- It is necessary to involve multiple evaluators in a heuristic evaluation in order to find as much usability problems as possible. In an analysis of six studies, Nielsen found that three to five evaluators detected most of the usability problems.
- Record the results of the evaluations. The evaluator can write down his results but in order not to improve the efforts of the evaluator a better option is the record of the verbalization of the comments to an observer.
- The session for each evaluator should last between one and two hours. If the interface is much complex more time could be needed but in that case splitting the whole session in small ones could be for fruitful.
- If the interface to evaluate will be used by general population, it is not needed to have an observer involved.
- Evaluators should be as specific as possible given details about each problem. If there is an interaction element with more than one trouble associated, each one must be explained and justified separately.
- Identify the target users that are going to use the application and therefore can be the evaluators
- Select an appropriate space to carry out with the sessions. It is important that the place has silence enough for performing the evaluation.
- Prepare additional material to record the session and later get useful information from them.
- It could be very interesting to ask some background questions to the evaluators before the sessions starts in order to gain in confidence. Tools
- As much evaluators participating in the session as many results will be gotten. It must be done a study of the relation between costs and results. More evaluators mean more time and resources to perform the evaluations. It is needed to find a balance between number of evaluators and costs associated.
- Some caveats should be made about selecting your experts. You'll want experts who know what they're doing. These folks should have a broad background in usability evaluation and human-computer interface design. It might be hard to find an expert that knows the subject matter of the product ("domain knowledge") in addition to HCI expertise, but if you can, you'll get a lot out of that person.

1.4.9 Cognitive Walkthrough

Cognitive walkthrough is a review technique where expert evaluators construct task scenarios from a specification or early prototype and then role play the part of a user working with that interface by "walking through" the interface. They act as if the interface was actually built and they (in the role of a typical user) work through the tasks. Each step the user would take is scrutinized: impasses where the interface blocks the "user" from completing the task indicate that the interface is missing something. Convoluted, circuitous paths through function sequences indicate that the interface needs a new function that simplifies the task and collapses the function sequence.

1.4.9.1 Objectives

Begin by evaluating a system specification in terms of the tasks users will perform with that system. It helps to identify the user's goals and purpose for each task. For example, the interface for operating a car begins with the goals of opening the door, sitting down in the driver's seat with the controls easily accessible, and starting the car. And we're not even driving yet! This example shows the granularity that some walkthroughs attain. The goal of "opening the door" could be broken down into sub-goals: find the key, orient the key, unlock the door, open the door. Each of these goals requires cognitive (thinking) and physical actions. To open the door, do I orient my hand with the palm up or with the palm down? What affordances are provided for opening the door?

During the walkthrough, identify problems in attaining the goals. For example, some car doors accept keys only if they're oriented one way. Does this cause an unacceptable delay for the user? Since the sub-goal of opening the door is a prerequisite to operating the car, this might be a large issue.

1.4.9.2 Methodology

The participant gets a certain task and has to perform “the walkthrough” by asking her/himself a set of questions for each subtask. By answering the questions for each subtask, usability problems can be identified. Typically questions that can be asked are for instance:

Will the user try to achieve the effect that the subtask has? - Does the user understand that this subtask is needed to reach the user's goal?

Will the user notice that the correct action is available? - E.g. is the button visible?

Does the user get feedback? - Will the user know that they have done the right thing after performing the action?

Will the user understand that the wanted subtask can be achieved by the action? - E.g. the right button is visible but the user does not understand the text and will therefore not click on it.

1.4.9.3 Pluralistic walkthroughs

Pluralistic walkthroughs are meetings where users, developers, and usability professionals step through a task scenario, discussing and evaluating each element of interaction. Group walkthroughs have the advantage of providing a diverse range of skills and perspectives to bear on usability problems. As with any inspection, the more people looking for problems, the higher the probability of finding problems is. Also, the interaction between the team during the walkthrough helps to resolve usability issues faster.

Most pluralistic evaluations involve a large group, with a usability professional as the session leader and facilitator. The group can consist of end users, product designers, documentation staff, and health/safety professionals in addition to usability staff.

Everybody as a group discusses several scenarios derived from end user input. Based on their expertise as usability professionals, or experience as end users, usability problems are identified and classified for future action

1.4.9.4 Guided Walkthrough

This method is based on the guidance of a user through a prototype. Meanwhile this session is performed, the user is asked for different issues in order to know the understanding of the system by him.

The main objective of this method is the inclusion of real users in the evaluation process of a prototype. Unlike other methods it is desired a control and conducted session where the developer or designers defines the critical points to ask the user.

The methodology of this method is base on the guidance of the user through an imaginary system. The user goes through the different stages and actions of the prototype having the guide of the interviewer. The interviewer himself stops and asks the user in specific moments of the session. The designer has the session under his control not leaving the user to perform free actions. They are already marked, so the user only has to answer the question asked whenever is considered by the interviewer.

Figure 14 Guided Walkthrough session

1.4.9.5 Advantages and Disadvantages

Advantages of the Cognitive, Pluralistic and Guided Walkthroughs are:

- Does not require a high-fidelity prototype
- Can reveal attitudes and expectations that the user might not otherwise express
- Usability issues are resolved faster
- Greater number of usability problems can be found at one time

This method also present disadvantages:

- Does not address user satisfaction or efficiency
- The designer may not behave as the average user when using the application
- Subjective point of view will keep developers from recognizing some problems
- User performance may be effected by observation, nervousness, or other assessment factors

Disadvantage of the guided walkthrough is additionally:

- Must be conducted carefully to avoid accidentally leading users to conclusions or misinterpreting their actions

1.4.9.6 Recommendations

- Previous plan of the session is needed in order to perform a coherent session.
- Interviewer should be as objective as possible in order not to have an influence on the user's answers
- A record system could be useful to extract additional information later.

1.4.10 Expert Review

This method consists of the evaluation of a system or application by means of experts given useful comments and suggestions based on their expertise. This method increase the probability of identifying the main problems the

applications can present. The proposals provided are more focused on best practices and design principles.

1.4.10.1 Objectives

The objective of this method is to gather as much information as possible coming from the evaluation of a specific system from an expert point of view. Expert evaluators test the application, instead of considering the final users of the application as the evaluators.

1.4.10.2 Methodology

The expert is asked to use the system to be evaluated. He has to perform a series of tasks to analyze the usability of the application. No question should be asked to him, just given him free to perform what is asked. The evaluator will detect the elements and flows with problems. Not only has to be mentioned the usability problems but additional information about how to solve it might be provided.

1.4.10.3 Advantages and disadvantages

The advantages that this method presents are:

- Resolves some issues that users should not have to worry about in later usability testing

The disadvantages that this method presents are:

- Constrained by the experts knowledge of the audience for which the system is intended
- Not sufficient on its own (developers will not catch the same problems as users will)

1.4.10.4 Tools

No specific tool is needed for this session. A record system could be useful in order to analyse the information in am ire detailed way. Besides, additional elements for the reviewer could be needed, such as paper and pencil to note down the comments and suggestions in case no observer or record system is available.

1.4.10.5 Recommendations

- Use more than one expert to have different points of view, between three and five.
- Do a previous and complete explanation of the application to evaluate. If the expert knows exactly the purpose of the system it will be easier to perform a useful test.
- Clarify the target user of the application to evaluate.
- Record system for the session could be useful.

1.4.11 Storyboarding

Storyboarding is a UCD method that shows the relation between individual displays and actions within a system. It is based on the use of images demonstrating an interactive sequence that represent the behaviour of an application.

This method provides real information about the structure and the scope of the application to be tested. Not only is it used for validating an already ended design but it can also be used to explore design possibilities in early phases.

1.4.11.1 Objectives

The main objective of this method is to show the relation between the inputs of a system and its outputs. The inputs are considered as the user's actions, as his interactions with the application. It is used to demonstrate the interfaces of the system as well as the context of use of the application.

1.4.11.2 Methodology

A storyboarding of an application may include a series of images representing menus, dialogue boxes, buttons and windows. Using a sequence of the screens it is given enough information about the different functionalities provided, the navigation process and the information given of the system.

The storyboarding is based on a series of graphs with annotations. There can be distinguished two different elements:

Nodes - These are the scenes or episodes of the “story”. It is important to define the difference between scenes and episodes. Meanwhile episodes are more basic and can be implemented in several ways, scenes are more complex and are made up of sub-graphs.

Edges - These are the possible transitions between the scenes.

Figure 15 Storyboarding session

1.4.11.3 Advantages and Disadvantages

The advantages that this method presents are:

- Simple and cheap
- Users can evaluate the direction that the interface is heading
- Low fidelity prototyping technique
- Useful for applications with a complex structure of information

The disadvantages that this method presents are:

- Novice designers do not like this technique because they still find challenges in its creation

1.4.11.4 Tools

Storyboarding session can be performed in two different ways:

Classical - This is the most extended way to carry out these sessions. By using common elements such as papers and pencils, the session can be done. Each screen is represented in a piece of paper, each step of the story.

Technological - By means of computer drawing tools the scenes and episodes of the storyboarding can be done.

1.4.11.5 Recommendations

- Represent scenarios with high-level sequences to avoid the distraction of the users.
- It is very useful for considering the context of the application to be developed

- Show the storyboarding to a designer colleague before using it with real users.
- Use simple approaches with no much information
- Be careful when selecting the users taken into account their knowledge level of the domain.

1.4.12 Usability Test

This method is focused on user needs, uses empirical measurement, and iterative designs. Usability test are session aim at evaluating an application by collecting data from the tests performed by real target users. These users are asked to perform a series of tasks with the system to be tested. From these session several data is obtained such as usability problems, quantitative data, navigation paths, time to perform each task and user's satisfaction with the application.

There are six elements of usability testing:

- Development of problem statements or test objectives.
- Use of a representative sample of end users which may or may not be randomly chosen.
- Representation of the actual work environment.
- Observation of end users who either use or review a representation of the product. Controlled and sometimes extensive interrogation and probing of the participants by the test monitor.
- Collection of quantitative and qualitative performance and preferences measures.
- Recommendation of improvements to the design of the product.

1.4.12.1 Objectives

According to Dumas & Redish (1993), this method presents five main objectives [66]:

- Improve the product’s usability.
- Involve real users in the testing.
- Give the users real tasks to accomplish.
- Enable testers to observe and record the actions of the participants.
- Enable testers analyse the data obtained and make changes accordingly.

1.4.12.2 Methodology

There are different techniques that can be used to perform a usability test. Among the most common we have:

Interviews. The user is asked directly though an informal conversation about his reactions and opinions about the system (see further Section 1.4.2).

User satisfaction questionnaires. Users must fill a questionnaire where it is asked about his likes and dislikes about the design and the functionalities of the application (see further Section 1.4.1).

Videotaping. It is used to review the participant's interaction with the system in order to show the designers the problems users found (see further Section 1.4.4).

Think aloud techniques. The user is asked to perform a series of tasks. During these tasks he expresses all he is doing during the performance as well as his opinions (see further Section 1.4.15).

The data that wants to be obtained though this method can be also classify in the following groups:

- Time for users to learn a specific function
- Speed of task performance
- Type and rate of errors by users
- User retention of commands over time
- Subjective user satisfaction

Not all usability test are the same, there can be distinguished three types of Usability Tests:

Participative user based evaluation. It is used in early phases of the design process. It is based on a low-interaction prototype. Users are asked to explain their expectations and to perform some simple tasks.

Diagnostic evaluation. It is used to identify usability problems. The user is observed meanwhile he is performing some tasks on his own and afterwards he is interviewed.

Performance testing. A usability evaluation under real conditions is carried out. The main goal is to identify usability problems and to compare quantitative measures such as success rate, task time and user satisfaction with requirements (see further Section 1.4.17).

1.4.12.3 Advantages and Disadvantages

The advantages that this method presents are:

- A small number of users can identify numerous problems in a relatively short amount of time finds more authentic problems than inspection methods

- Short duration of the session.
- More real problems are found than with other methods such as heuristic evaluation.

The disadvantages that this method presents are:

- User's performance may be affected depending on the perceived unreality of the session, their nervousness, and the effect of being observed
- The meaningfulness of the data collected rests on the authenticity of the users and tasks involved
- Time consuming to plan and analyse
- It does not cover all the interface features
- Test are performed within a laboratory under unreal conditions
- A small number of participants do not represent the whole target user population.
- Expensive method

1.4.12.4 Tools

Depending on the type of application to be evaluated the material needed to perform this session can vary. First of all the environment to carry out with the session is an essential factor. Sometimes it is very useful to do them in a usability lab meanwhile in order occasions the common place the user is could be the better option.

It is very interesting to record the session in order to analyze results later. For questionnaires and interviews there are some electronic tools that can be use (for further information see Sections 1.4.1 and 1.4.2).

Figure 16 Usability test session

A mock-up or prototype of the application is needed so the user can interact with them and provide reliable information.

1.4.12.5 Recommendations

- Large number of users is needed to represent the whole target user population. At least 10 users are needed. The number can vary depending on the complexity of the application.
- Speaking out loud could help evaluators understand user's actions (see Think Aloud Protocol, Section 1.4.15)
- Usability test must be done with just one user at a time
- Because of the cost associated to each session it is necessary to find equilibrium between the number of sessions and the costs.
- Try to have to people during the session: one to note problems found by the user and another one to answer user's questions.
- It is needed to have some form of design, either a mock-up or prototype (see further Sections 1.4.18 and 1.4.19).
- Use this method preferable for gathering non-statistical data
- Use this method before ending the implementation process.
- It is a very useful method for iterative design processes.
- The conduction of the test should be done by experts in user-interface design and testing
- Test might be done in usability laboratories equipped with an area that allows the designers to observe the testers unnoticed
- In order to reduce cost it can be used mobile usability testing kits.

1.4.13 Task Analysis

Task analysis is a method aiming at studying what the user has to do in relation to cognitive actions and processes that are required to perform a specific task. This method is essential when the actions are needed to be analysed in detail. Some system development requires an exhaustive understanding of the actions associated to a task as a basis for the design.

1.4.13.1 Objectives

The main objective of this method is to understand what people are doing and why do they do specific actions to perform a particular task. This method is used in order to get:

Triggers - What drive a person to perform a certain action?

Use cases - How the user carries out a task?

Goals - Which is the intention of the user?

1.4.13.2 Methodology

There are different methodologies that can be applied to the task analysis method. On the one hand there is the hierarchical task analysis. In this analysis high level tasks are decomposed in simpler ones, detailing the components and

the sequences among them. On the other hand it is possible to create a flow chart. It will show a sequence of actions from the user's point of view associating inputs and outputs.

Nevertheless, a description of the task is needed and there are two different way of describing tasks:

Scenarios - These are a description as a story to describe the tasks to be performed. It does not include technical information about the system. By means of these narrative descriptions some requirements can be extracted. It describes a flow of events.

Use cases - It is a description of a specific function a system can provide. It includes a sequence of actions to carry out the outcome in order to achieve a particular goal. It describes user's functional requirements.

There is also a special kind of use case named essential use case where it combines typical use cases with scenarios. This use cases represent a more general case including some scenarios.

1.4.13.3 Advantages and disadvantages

The advantages that this method presents are:

- Can reveal new information that is exploitable in the software design (e.g. short cuts that expert users take)

The disadvantages that this method presents are:

- Can be time consuming to carry out
- If not observing an expert user, you can inadvertently reproduce an inefficient way to complete a task
- If you do observe an expert user, you may not find out the problems specific to beginners

1.4.13.4 Tools

Considering both ways of describing tasks several tools can be used to perform the descriptions. It is possible to use only natural language as an explanation of the scenarios or use cases. However, there are technical tools that can be applied to simplify later development phases. It is the case of the UML diagrams, where the use cases and scenarios can be expressed.

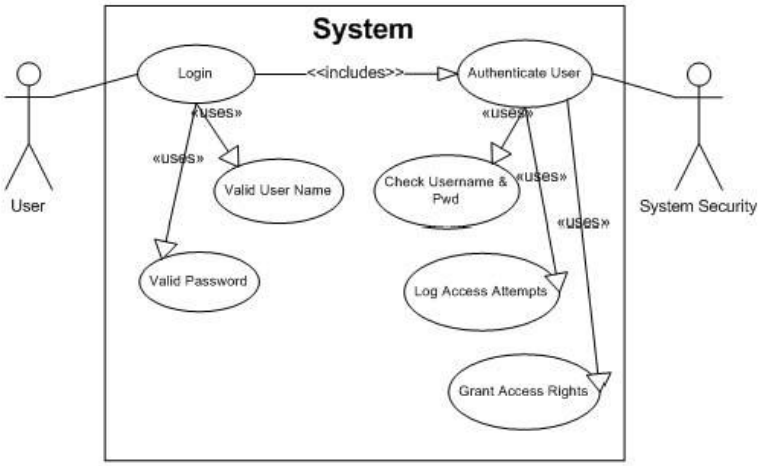

Figure 17 Use case diagram

Some of these use cases representation tools are:
UML Tool - It is a software application aiming at supporting UML notation and semantics. It can be used to develop UML diagrams of use cases and scenarios.

SysML Tool - It is a software application that supports Systems Modelling Language for designing graphical use cases for systems engineering applications.

Visual Studio - It is an integrated development environment that allows the creation of UML use case diagram within all its functionalities.

There are many other tools such as Nevron Diagram Designer, QuickUML or MaintainJ, that can be used for this purpose.

1.4.13.5 Recommendations

- Use this method when your target users as well as the tasks to be performed are well defined.
- Focused on the main functionalities you want to define in the system.
- Use at least 5 participants per session.
- Try to define different workflows.
- Do not develop complex use cases, it is better to define more use cases but simpler.
- Graphical outcomes of task analysis are more useful for the development process and easier to understand.
- Be as simple as possible if you decide to use natural language to describe use cases and scenarios.

1.4.14 Feature inspection

Feature inspections analyze only the feature set of a product, usually given end user scenarios for the end result to be obtained from the use of the product. For example, a common user scenario for the use of a word processor is to produce a letter. The features that would be used include entering text, formatting text, spell-checking, saving the text to a file, and printing the letter. Each set of features used to produce the required output (a letter) is analyzed for its availability, understandability, and general usefulness.

1.4.14.1 Objectives

Feature inspection allows the description of the technical features of a software system as detailed as possible, so that it allows the comparison between systems of the same type. The results of feature inspection are meant to help designer to decide which of the systems supports a certain task more appropriate.

1.4.14.2 Methodology

List the features in the product or system in the sequences they would be used to perform various tasks. Look at the accessibility of each feature in the context of the tasks. Can the user get to each feature without much trouble? Are the features well named and easily recognized?

One time-tested way to perform feature inspection is to have the documentation staff attempt to document each user scenario as procedures. Features that are hard to describe in the documentation are probably hard to find for the user in the first place.

1.4.14.3 Consistency inspection

Consistency inspections ensure consistency across multiple products from the same development effort. For example, in a suite of office productivity applications, common functions should look and work the same whether the user is using the word processor, spreadsheet, presentation, or database program.

Consistency inspections begin with a usability professional analyzing the interfaces to all of the products and noting the various ways that each product implements a particular user interaction or function. An evaluation team then meets, and using the usability analysis as a basis, negotiates and decides on the one golden implementation for the usability attributes of each product.

This technique is best used in the early stages of development, when initial development work has not progressed to the point where products that require extensive changes to ensure consistency will not require total overhauls. The ideal time for consistency inspections is when design documents for each of the

individual products are almost done, and before any actual work on building the products has commenced.

Objectives - Consistency inspection allows designers developing for instance multiple projects to see whether they do things in the same way as other similar designs. Are provided user interface functionalities consistent to other commonly used design solutions (e.g. print icon for printing, window interface design)?

Methodology - Form an inspection team, drawing members from each development team for all products covered in the inspection. These members should have the authority to negotiate for or against different design elements, and the power to change their product's design at the review meeting. Have a usability professional analyze each product as to its user interface, taking care to highlight areas that are vastly different from other products. This initial document will serve as the basis for the team's discussion during the meeting.

During the meeting, the team discusses the user interfaces to their products in terms of the usability professional's document, and for each element, comes to an agreement on what that element should look and work like in all of the products. This agreement must be unanimous by every member of the team, and buy-in from each product's development team (buy-in for their representative's decisions) should be procured prior to the convening of the meeting.

Keep a running tally of the changes to be made and decisions agreed upon. Any issues that cannot be resolved quickly should be "parked" and discussed at a later, more focused meeting.

1.4.14.4 Standards inspection

Standards inspections ensure compliance with industry standards. In such inspections, a usability professional with extensive knowledge of the standard analyzes the elements of the product for their use of the industry standard.

For example, software products designed for the Windows environment should have common elements, such as the same functions on the File menu, a Help menu, etc. Or, products designed to be marketed in a particular country may have to conform to that country's ergonomic standards. Many monitors or keyboards are restricted from some uses in certain European countries due to occupational safety and health standards in those countries.

This technique is best used in the middle stages of development, as the actual design is being developed with the given standard in mind. For some products, the standards inspection will be the major milestone allowing the initial design to proceed into manufacturability analysis and further engineering work.

Standards inspections assure a system's compliance with industry standards (e.g. health and safety standards).

In most cases, the inspection must be performed by an expert in the standard. For conformance to an operating system environment, perhaps the inspection could be performed by a representative of the operating system company. For conformance to a national safety and health standard, the inspector would probably be a member of that country's standards organization.

1.4.14.5 Advantages and disadvantages

The advantages that this method presents are:

- Necessary to guarantee the consistency of the features used in similar systems
- Standardized

The disadvantages that this method presents are:

- Only useful for common systems or applications where features can be compared to standards
- Expert knowledge needed
- Checklist of features to be checked needs to be as complete as possible
- Only few on what is important from a designers/ developers' point of view

1.4.14.6 Recommendation

- The preparation phase is very time-consuming and complex, the evaluation however is less problematic
- Successful feature inspection depends mainly on the quality of the feature checklist along which the evaluator examines the software. The most appropriate approach to developing feature checklists is top-down, i.e. starting with principal functions before discussing their details.
- Feature checklists should incorporate the knowledge of what is important from the user's point of view with what is possible from the technical point of view
- Feature checklist in the context of evaluation should be standardised (independent of situational variables, and able to cover different approaches to a problem)
- Feature checklists are based describe only features that are common technology, therefore might not be applicable to new technical solutions.

1.4.15 Thinking Aloud Protocol

Thinking Aloud protocol is a technique used during usability testing. During the course of a test, where the participant is performing a task as part of a user scenario, you ask the participant to vocalize his or her thoughts, feelings, and opinions while interacting with the product.

Use this technique in any stage of development. Thinking aloud is a cheap way of getting a lot of good qualitative feedback during testing.

1.4.15.1 Objectives

Think aloud protocols involve participants thinking aloud (about their thoughts, feelings and actions) as they are performing a set of specified tasks to gain data about the usability of a product or system.

1.4.15.2 Methodology

You begin by providing your participant with the product to be tested (or a prototype of its interface) and a scenario of tasks to perform. Ask participants to perform the tasks using the product, and explain what they're thinking about while working with the product's interface.

Thinking aloud allows you to understand how the user approaches the interface and what considerations the user keeps in mind when using the interface. If the user expresses that the sequence of steps dictated by the product to accomplish their task goal is different from what they expected, perhaps the interface is convoluted.

Although the main benefit of the thinking aloud protocol is a better understanding of the user's mental model and interaction with the product, you can gain other benefits as well. For example, the terminology the user uses to express an idea or function should be incorporated into the product design or at least its documentation.

1.4.15.3 Question-asking Protocol

The question-asking protocol simply takes thinking aloud one step further in that instead of waiting for users to vocalize their thoughts, you prompt them by asking direct questions about the product. Their ability (or lack of) to answer your questions can help you see what parts of the product interface were obvious, and which were obtuse.

As with the thinking aloud method, you begin by providing your participants with the product to be tested (or a prototype of its interface) and a scenario of tasks to perform. Ask the participants to perform the tasks using the product, and explain what they're thinking about while working with the product's interface. Also ask them pointed, direct questions about the product; for example, "How would you send the email message?" Their response, either in terms of the product being tested or in other products from their past experience, will provide insights into their mental model of the product.

1.4.15.4 Advantages and Disadvantages

The advantages that this method presents are:

- Direct observation of behaviour in relation to preferences (without necessary asking for it)
- The method might help some participants to concentrate on the tasks while falling into a rhythm of working and talking throughout the evaluation.
- Gaining an understanding of the user's mental model (are the concepts understood by users, where are problems, at which points is the user confused and why?).

The disadvantages that this method presents are:

- Slowed down usage process through thinking aloud.
- Unnatural situation of using a product or system (might distract participants if very different from their normal learning style).
- Increased mindfulness might prevent errors that might have normally occurred in the actual work setting.
- Verbalization of thoughts while performing a specific task is exhausting (shouldn't go beyond 2-3 hours).
- Trained elevator ideally needed.

1.4.15.5 Recommendations

- Encourage the user to comment liberally on his/her actions, intentions and thoughts.
- Explain that you may give only a bare minimum of help to the user, and apologising in advance for this. The user should try to find their own way as much as possible.
- Write down notes of what was said (and additionally record the session). Notes can be made using a structured data sheet with given categories that you want to focus your observation on.

1.4.16 Co-Discovery Method

Co-discovery is a type of usability testing where two participants attempt to perform tasks together while being observed. The advantage of this method over the thinking aloud protocol is two-fold:

- in the workplace, most people have someone else available for help
- the interaction between the two participants can bring out more insights than a single participant vocalizing his or her thoughts

This technique can be used during any phase of development. It is ideal for Computer-Supported Cooperative Work (CSCW) products, groupware, and other products designed to be used by workers in team environments.

1.4.16.1 Objective

To identify usability and usage problems in collaboration with others, and to discover user needs.

1.4.16.2 Methodology

You begin by providing your participants with the product to be tested (or a prototype of its interface) and a scenario of tasks to perform. Ask the participants to perform the tasks using the product, and explain what they're thinking about while working with the product's interface. Have them help each other in the same manner they would if they were working together to accomplish a common goal using the product.

1.4.16.3 Advantages and Disadvantages

The advantages that this method presents are:

- Rather natural style of interaction
- More detailed information than think aloud method alone (see Section 1.4.15)
- Fast and easy approach
- In particular good for applications where people work together

The disadvantages that this method presents are:

- Many participants needed
- Can be of discomfort if the rules and goals of co-participation are not clear enough
- Analysis of qualitative data difficult
- Inter-individual differences: One participants might dominate and overpower the others and the session

1.4.16.4 Recommendations

- An appropriate usability test method for the task under investigation with the different participants needs to be found
- Amount of participants needed depends on the usability method to be applied. Two to four participants per Co-discovery session.
- A clear evaluation goal is needed for this method.
- Rules for the conversation between participants should be defined at the beginning.
- Be aware that participants may or may not feel more anxious about “looking bad” in front of another person than they would in a single user test.

1.4.17 Performance Measurement

Some usability tests are targeted at determining hard, quantitative data. Most of the time this data is in the form of performance metrics; how long does it take to

select a block of text with a mouse, touchpad, or trackball? How does the placement of the backspace key influence the error rate?

Often these metrics are used as goals during the design of a product. Goals can be stated as stipulations, for example, "Users shall be able to connect to the Internet without errors or having to call the toll-free number," or "75% of users shall be able to complete the basic task in less than one hour." These benchmarks are devised during initial usability testing, either of a previous release, or of a competitor product. .

1.4.17.1 Objective

To establish if a product or system reaches the results desired by testing certain pre-defined parameters of performance.

1.4.17.2 Methodology

You begin by following the basic usability test concepts of determining a purpose, identifying test objectives, designing the tests, and running the experiment. For performance metrics, though, consider the following additional issues:

Objectives must be quantifiable - As before, the test objectives have to be expressed in testable terms, but when measuring performance, they have to be quantifiable. For example, you could ask the question, "What's more efficient, keyboard shortcuts or toolbar buttons?" A question worded this way could be tested with two interfaces, one using keyboard shortcuts, and the other using buttons. You'd record the performance of each user by timing how long it took them to execute a number of commands, and log their error rates.

Examples of quantified usability issues are the following:

- Time to complete a given task
- Amount of tasks that can be performed/done in a given time frame
- Ration between errors and successful interaction
- Time needed to recover from made errors
- Amount of errors
- Amount of features never used by users
- Amount of system features the user remembers afterwards
- Amount of times the user accessed the help system or help manual
- Time users spent with the help system
- Proportion of users who would “prefer” using the system compared to a similar one

Experimental design is really important - Since the goal of a performance measurement test is to gather valid quantifiable data, your experimental design must be valid as well. Quantitative tests assume that your change in the independent variable (for example, the presence of keyboard shortcuts or

toolbar buttons) influences the dependent variable (time it takes to execute commands using one of the two options). This influence is called the experimental effect. However, if other factors are introduced into the design, the effect may be confounded, that is, not statistically valid due to tainting by the other factors. Your design must take into account possible confounding factors and eliminate possible sources of tainting.

Data doesn't tell the whole story - Testing solely for the purpose of procuring performance data doesn't seem to be as common as it used to be, for several reasons. Performance testing requires very rigorous test designs and extensive resources. Most companies don't have the time or money to do research of this kind. Also, the types of things tested are often at a very granular level. Does it really matter if it's half a second faster to use a keyboard shortcut than a toolbar button? Maybe if you're designing call centre software, and amortized over thousands of operators across the country, saving each one half a second per call could save millions of dollars per year. But for most office productivity applications half a second isn't really important.

1.4.17.3 Advantages and Disadvantages

The advantages that this method presents are:

- Effectiveness and Efficiency can be measured objectively

The disadvantages that this method presents are:

- User satisfaction can’t be assessed with this method
- Is alone not enough: needs to be complemented by other and more qualitative methods.

1.4.17.4 Recommendations

- Goals for the usability test need to be defined in terms of usability attributes (e.g. easy to learn, efficient to use, easy to remember, few errors, subjectively pleasing).
- An undisturbed test environment is needed, in particular for time measurements.
- The test should be done under conditions close to those under which the product or system is intended to be used.
- To compare the data from different user interfaces, some kind of inferential statistics test might need to be performed.
- Whereas 3-5 users are enough to identify problems, minimum 8 users are needed if reliable measures are needed.

1.4.18 Prototyping

Prototyping models your final product and allows you to test attributes of the final product even if it's not ready yet. You simply test using your model.

This technique can be used at any stage of development. As development progresses and the product is more complete, your prototype will encompass more and more of the product's final features. At some point, building additional prototypes will be less efficient than simply using early builds of the product.

1.4.18.1 Objectives

To test a model of the intended product or system in its early stage before it is finally developed.

1.4.18.2 Methodology

You begin by constructing a model of the final product--what it will look like, how it will work, and so on. With many user interfaces, this model can be as simple as paper-and-pencil drawings or as complex as actual working code. With hardware interfaces or workstations, this model can be cardboard or foamcore mock-ups. The closer your prototype is to the actual thing, the better your evaluation will be--however, you can get great results from very simple, "low-fidelity" prototypes.

There are a number of different terms you'll hear in conjunction with prototyping methods. The following is a sampling of some of these distinctions:

Rapid Prototyping: design methodology that quickly develops new designs, evaluates those designs, then "throws-away" the prototype when the next new design is developed along with a new prototype.

Reusable Prototyping: also known as Evolutionary Prototyping; effort used in constructing the prototype isn't wasted because parts (or all) of the prototype can be used to make the actual product. Mostly used in software development, although some hardware products can use the prototype as the basis for mold design in plastic manufacturing or auto body design.

Modular Prototyping: also known as Incremental Prototyping; new parts are added on as the design cycle progresses.

Horizontal Prototyping: prototype covers a large breadth of features and functions, but most aren't working. Great for testing breadth of scope but not actual use.

Vertical Prototyping: prototype covers only a narrow slice of features and functions that do work. Great for testing usage in a small portion of the product.

Low-fidelity Prototyping: prototype is implemented using paper and pencil, and thus mimics the function of the actual product, but doesn't look at all like the actual product. Great for testing on the cheap (see further Section 1.4.19).

High-fidelity Prototyping: prototype is implemented to be as close to the actual design as possible in terms of look and feel, interaction, and timing.

1.4.18.3 Advantages and Disadvantages

The advantages that this method presents are:

- allows to identify usability problems (and risks) and to analyze their cause with the users at an early stage of the design or development process (reduces costs and increases quality of the final product)
- allows the test of different aspects of the model: the design, help gather feedback, and show ideas and features
- helps users understand the idea and concept of the final product or system and thereby increases user involvement
- fast test and quick feedback from users during development cycle

The disadvantages that this method presents are:

- not suitable for large applications (too complex to for easy prototyping)
- attachment of producer to early drafts of products or systems can be problematic
- organizational needs of the producers might get out of focus
- development of prototype takes time
- implementation of prototype can be expensive
- prototypes can be confusion to users (as they are incomplete)
- prototypes allow only a partial analysis for the final product or system

1.4.18.4 Recommendations

- Prototyping is most beneficial in systems that will have many interactions with the users.
- Do not modify the prototype during the test.
- Keep track of the improvements.
- Prototyping is very effective in the analysis and design of web applications, in particular for user-computer dialogs with loads of interaction between the computer and the user. Here, the benefit that can be obtained from building a quick system and letting the user play with it are the highest.
- It is highly recommended to use this method in an iterative design process.

1.4.19 Paper Prototype Test

This method provides a mock-up or low fidelity version of the system that is evaluated by real users. It is widely method used for exploring, communicating, and evaluating early interface designs. During these sessions they will express their needs and usability problems based on the tasks carried out.

1.4.19.1 Objectives

The main objective of this method is the exploration of early problems in the design, allowing the user to express his ideas with minimal costs and high effectiveness. Using simple elements such as pieces of paper, the user can navigate through the application in an easily way, expressing freely his opinions and problems found.

1.4.19.2 Methodology

The prototypes to perform the session are typically constructed making use of a combination of papers representing the different screens the system provides. Using elements such as pieces of paper, colours and sticky notes to represent the results make it more comfortable to the user instead of technological solutions.

A methodology to carry out a paper prototyping test could present the following steps:

1. Welcome to the users that are going to participate in the session
2. Introduce the project and the application. It should be also explained the purpose of the session and what is wanted to be gotten.
3. Short explanation about how to proceed with the session and the paper prototype procedure.
4. Hand out the paper prototype and let them start
5. Observe the subjects and record their behaviour

The user performs a series of tasks meanwhile there is an observer that takes notes in order to get conclusion about usability features.

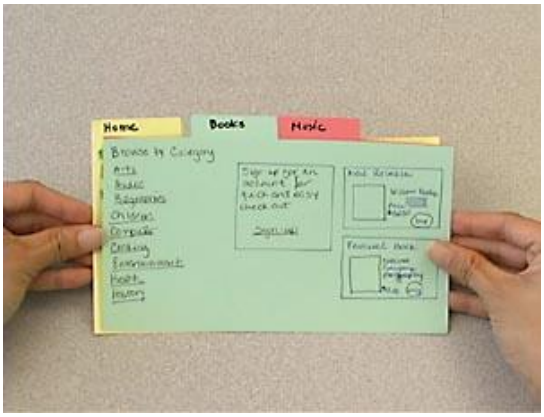

Figure 18 Paper prototyping session

1.4.19.3 Advantages and Disadvantages

The advantages that this method presents are:

- Cheap and fast to conduct

- Allows quick testing of individual components of a software design without the investment of actual coding
- Low fidelity encourages users to freely comment and suggest changes (unlike a polished product which may seem like it is already finished)
- Allows the detection of usability problems in early in the design process.

The disadvantages that this method presents are:

- It is de-contextualized; individual components should be tested again in the real product
- Can be difficult to accommodate designs that offer users multiple paths
- prototypes can be confusion to users (as they are incomplete)

1.4.19.4 Tools

There are different ways to perform the prototypes. As its name indicates, ideally the prototype is developed using pieces of paper. It is possible to use other types of mock-ups based on technology. This is the case of other tools such as Director, Flash, and Visual Basic. Through these tools it is possible to build high-fidelity representations. The main advantage they present is the direct interaction with the prototype. However, the time and cost associated to the development of this kind of prototype is much higher.

Currently, there are new approaches that combine both schemas. It is the electronic paper prototyping tool. By means of this tool it is possible to have an electronic tool, with higher definition, but based on the typical paper schema. It facilitates the collaboration in the design and development phases using more interactive systems.
There are many projects where it has been study the links between the paper and the digital versions, as well as the evaluation of the best option depending on the system to evaluate.

Figure 19 Electronic paper prototyping

1.4.19.5 Recommendations

- Session between 5 and 7 users.
- It is essential to have a face-to-face meeting between the users and the designers in order to review the paper-prototype session.
- Perform the session in a controlled environment such as a usability lab.
- It is highly recommended to use this method in an iterative design process.
- Electronic paper prototyping could be more useful for the session but the user can be less comfortable. It is needed a previous study of the user to evaluate the best option to interact with.

1.4.20 Log File Analysis

This method is based on an indirect observation of the user's behaviour related to the system. This observation is focused on a technical analysis of the system to evaluate. In this case, the actions performed by the user are collected from server logs for later examination and analysis.

1.4.20.1 Objectives

The main objective of this method is the identification of usage patterns as well as potential problems present in the usage of the system. By means of log files, the different operations carried out by the user and its results are stored. This information can be later analyse and evaluated in more detail.

1.4.20.2 Methodology

The methodology for this method is based on the automatic and electronic collection of information in an invisible way to the user. He will perform a series of tasks and technical data is stored in some files for later examination.

1.4.20.3 Advantages and Disadvantages

The advantages that this method presents are:

- Provides a historical trace of usage traffic for a system
- Quick, easy way to gather data on user behaviour without having to actually recruit users.
- Completely transparent to the user

The disadvantages that this method presents are:

- Log files do not indicate why users made certain actions or avoided making others
- Log files do not indicate if and how users recovered from errors

1.4.20.4 Tools

Several automatic log tools can be used depending on the application to evaluate. It is very common the usage of log file tools in the field of web applications. There are many examples that can be found in the web such as AWStats or Swatch.

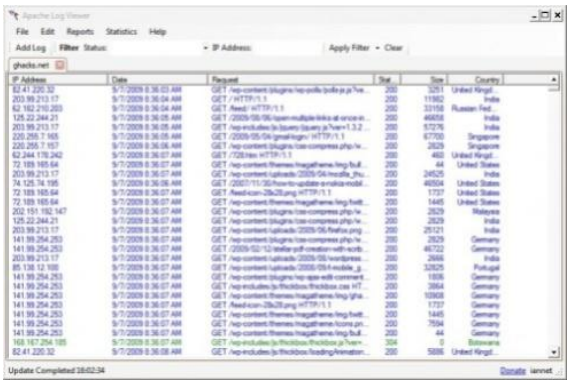

Figure 20 Log File Analysis

1.4.20.5 Recommendations

- This method could be very useful to evaluate technical features of the system, but to gather the point of view of the user it should be complemented by other and qualitative methods.
- As many files to analyse you have as much information you will get.

1.4.21 Workshops

Workshops are meetings of a small group people to demonstrate and discuss their current work in a subject or work package activity. Over a short period of time, the members of the workshop concentrate on a defined area of concern. Workshops can have different purposes. In the scope of VERITAS, workshops are conducted to inform the partners, and to support each other in solving specific problems together.

1.4.21.1 Objectives

Workshops are a great opportunity for brainstorming, interactive learning, problem solving and to build and foster relationships between the partners. In workshops, ideas can be discussed, generated and combined as well as problems discussed and resolved.

1.4.21.2 Methodology

The following steps inform about the planning and conduction of workshops:

Define the goals of the workshop as clear as possible – Do you want to inform each other about the current stage of a specific activity? Do you search for a solution of a difficult problem? Do you need to discuss different solutions to

a problem to find and decide for the best one? Do you want to generate ideas to a certain issue? etc.

Who needs to attend the workshop – Make a list of attendees that have be there (as specific as possible). Ideally, the amount of key attendees should not exceed 10.

Decision on the Location – Depending on the amount of participants and sessions that might be run in parallel, the right environment for the workshop needs to be chosen. Also consider the logistics and practical details of the location, e.g., Is it easy to reach for everybody? Does the venue provide catering facilities? What technology might be needed for the workshops (projector, screens, teleconference equipment, etc.)? If attendees come from a long way, accommodation needs to be organized.

Set an agenda as detailed as possible – What is planned to get achieved in the workshop? What needs to be articulated/ communicated to the partners? What are the main topics and sub-topics that need to be discussed? Here, visual aids (e.g. power point presentation slides) help the attendees to focus their attention. Which group discussions and activities are needed? How much time should be allowed for these?

Give and gather feedback at the end – At the end of the workshop all important decisions and plans the partners agreed on during the workshop should be communicated. To improve future workshops, questionnaires can be handed out to all participants at the end giving them the opportunity to share their opinions.

1.4.21.3 Advantages and Disadvantages

The advantages that this method presents are:

- Provide a corporate view when there are representatives of all WPS and activities related to the discussed topic.
- Workshops encourage co-operation between partners/participants.
- Different points of views get heard.
- Certain issues might get resolves easier when all responsible partners are present.
- Ideas are discussed, which encourages creativity. Partners can build on the thoughts and ideas of others.

The disadvantages that this method presents are:

- Group dynamic might make some participants anxious. They may be afraid to speak up and voice their opinion.
- Time commitment is required by each partner.

1.4.21.4 Recommendations

- Workshops should be ideally hold at the beginning or end of VERITAS project meetings to keep the time and costs involved partner have to commit to these meetings to a minimum.
- Make sure all relevant partners/participants can and will attend the workshop.
- Consider that the planning of workshops is time consuming.
- The amount of participants per workshops shouldn't extent 10 (training and education workshops excluded).
- A series of workshops can be offered that can build on each other.
- The length and frequency of session is flexible. Depending on the complexity of an issue of discussion, more than one workshop session might be needed.
- Everyone needs to participate.
- Many people are nervous about speaking up in an unfamiliar group. If you plan group exercises, keep the size of each group small, so people are more comfortable talking and interacting.
- Determine how you'll record the ideas during the workshop.
- The workshop's goal should be at the centre of all planning.

1.4.22 Wizard of Oz

Wizard of Oz is a method which enables designer and developer to evaluate an unimplemented technology by using a human to simulate the response of a system. The "wizard" is a person (e.g., designer or developer) who simulates the behaviour of a computer application. This can be done either with informing the user about the "person" who is interacting in place of the computer system, or can be hidden to her/him. If the user thinks s/he communicates with the computer interface the whole interaction might encourage more natural behaviours and helps to gather information about the nature of interaction.

1.4.22.1 Objectives

To observe the usage and effectiveness of a concept of a computer application or user interface by the end users, rather than to measure the quality of an entire system.

1.4.22.2 Methods

The "wizard" takes place in a different room where s/he can observe the user (e.g. through camera) but not necessarily the other way around. The "wizard" simulates the response the application or user interface would generate responses to the observed manipulations in real time. Therefore, the "wizard" has to react quick and very accurate to the input of the user. This might be the easiest, if the user input is done by voice or hand movements. This also

requires a simple way of generating the output the “wizard” is giving back to the user.

If users were unaware about the wizard and her/his role, they have to get a debriefing that the session was not real after the test is completed.

1.4.22.3 Advantages

- Wizard of Oz method can provide valuable information as base for future designs
- Allows evaluating an application at an early stage in the design process.
- Observation of the user through interacting with her/him provides a unique insight into the user's actions.
- Good for the comparison and evaluation of different design concepts.

1.4.22.4 Disadvantages

- Wizards need to be trained (additional costs)
- Not a very controllable test environment
- Difficult for the evaluation of large UIs.
- System performances or recognition rates cannot be assessed with this method.

1.4.22.5 Recommendations

- Prepare a session guide for the wizard to follow
- There is the risk that the end user her/himself improvises the responses of the system beyond the test concept (investigator biases). Therefore it would be recommended to train a third person to become the wizard.
- Being the “wizard” can be exhausting leading to changes in behaviour and reaction times. Schedule short sessions and allow breaks in between to reduce cognitive fatigue.

2 UCD process of VERITAS

All partners involved in VERITAS should be aware of the user-centred methodology proposed in this Deliverable. It is highly recommended to apply the suggested UCD methods in the respective phase of the design and development process by the responsible partners.

Table 19 gives a broad overview over UCD methods planned to be applied within the different WPs of the VERITAS design and development process.

Table 19 Overview of UCD methods planned to be applied within the different WPs of VERITAS.

WP	UCD and evaluation methods applied in the respective WP	User group involved
WP1 - User groups, benchmarking, needs - User models - Multi-sensorial Platform - Use cases	- (online) Questionnaire - Interview - (online) Survey - Focus group - User workshop - User forum - Expert evaluation - Usability test - Task analysis - System test - Performance measurement - Measurement (e.g. physical behaviour, multi-sensorial platform) - Prototype evaluation - Standards inspection	End user and beneficiaries
WP2 - Open Simulation Platform - Solutions for application Scenarios - Interaction Tools	- Interview - Questionnaire - Survey - Contextual inquiry - Usability test - (paper) Prototyping - Storyboarding - Expert evaluation/review - Standards inspection - Guided walkthrough - Think aloud - Participatory design - User workshop - User forum - Measurement of specific user behaviour - Performance measurement	End user and beneficiaries
WP3 - Test applications - Pilot testing	- Usability test - Questionnaire - Interview - Log file analysis - Expert review - Performance measurement - User forum - User workshop	End user and beneficiaries
WP4 - Project management - Training - Dissemination - Business Case and Exploitation	- Training: Preparing the users of the pilots & Evaluation of training materials - Dissemination: pan-European Workshop focused towards designers/developers, but also considering people with disabilities who will benefit from VERITAS in the long end	End user and beneficiaries

In the following, the suggested UCD methods are linked closely to the VERITAS activities, as they are mentioned in the VERITAS description of work and are updated by the responsible partners in the course of the project. The mapping of the UCD methods and evaluation activities to the VERITAS activities is a gradual process throughout the whole VERITAS project and thus will be updated regularly. To monitor the implementation of the recommended UCD methods within the respective activities of the project, a checklist will be handed out to each partner every 6 months, following this Deliverable. This checklist is shown in Table 20. A detailed description of the UCD activities in VERITAS, distinguished according to VERITAS users (end users and beneficiaries) as well as VERITAS designer and developer, as defined in Section 1.2, can then be found in the Sections 2.1- 2.5.

Table 20 Checklist to monitor adherence to the UCD and evaluation methods.

WP	Activity (Partner)	Task	UCD method or Evaluation applied	VERITAS user involved	Start/ End Month	Current state
1.1	A1.1.1 (MCA)	Identification and definition of VERITAS stakeholder	☐ Online questionnaires ☐ Surveys ☐ Face-to-face interviews ☐ User workshops ☐ User forums	End user & beneficiaries	0/6-12	
1.1	A1.1.3 (Relab)	Identification and definition of industrial needs	☐ Questionnaires ☐ Interviews ☐ Surveys ☐ Expert evaluation	End user	0/6-12	
1.2	A1.2.1 (CAF)	Characterization of the nature of accessibility barriers	☐ Focus groups ☐ Interviews	End user	0-18	
1.2	A1.2.2 (SMARTEX)	Analyzing behaviour of real users with disabilities	☐ Performance measurements ☐ Questionnaires	Beneficiaries	0-18	
1.2	A1.2.3-A1.2.5 (CERTH/ ITI, UNITN)	Analyzing behaviour of real users with disabilities	☐ Measuring the physical behaviour of beneficiaries (e.g. motion capturing).	Beneficiaries	0-18	
1.2	A1.2.6 (CERTH/ITI)	Sensor management tool & visual editor	☐ Interviews ☐ Systems tests ☐ Usability tests	End user	6-24	
1.3	A1.3.3 (SMARTEX)	Measurement sessions to fine tune the physical models	☐ Measuring the physical behaviour of beneficiaries	Beneficiaries	0-18	
1.4	A1.4.3 (UPM)	Measurement sessions to fine tune the cognitive models	☐ Questionnaires	Beneficiaries	0-18	

WP	Activity (Partner)	Task	UCD method or Evaluation applied	VERITAS user involved	Start/ End Month	Current state
1.4	A1.4.4 (UPM)	Development of final parameterized VERITAS cognitive models	☐ Measurement with beneficiaries ☐ Iterative testing and fine tuning of the cognitive abstract user models as pre-training for the final models within the multi-sensorial platform	Beneficiaries	6-24	
1.5	A1.5.3 (COAT)	Measurement sessions to fine tune the behavioural and psychological models	☐ Usability test ☐ Interview ☐ Questionnaire ☐ Test with multi-sensorial platform ☐ Performance measurement	Beneficiaries	0-24	
1.5	A1.5.4 (ITACA)	Generation of human models	☐ Iterative testing and fine tuning of the behavioural and psychological abstract user models as pre-training for the final models within the multi-sensorial platform. ☐ Interviews ☐ Questionnaires	Beneficiaries	6-24	
1.6	A1.6.1 (HS)	Model platform	☐ Usability tests ☐ Standards inspection	End user	6-12	
1.6	A1.6.2 (ITACA)	Expert rules and workflows representation methodology	☐ Prototype evaluation	End user	4-12	
1.7	A1.7.1 (MCA)	Revision of the five VERITAS application areas	☐ Task analysis ☐ Evaluation in cooperation with end users who comment on their validity in face-to-face meetings	End user & beneficiaries	0-12	
1.7	A1.7.3 (CERTH/ HIT)	Definition of the VERITAS use cases, and subsequent fine-tuning	☐ User workshop ☐ User forum ☐ Iterative evaluation in WP3.7, WP3.8	End user & beneficiaries	6-18	
2.1	A2.1.3 (PERCRO)	Development of an Interaction Manager	☐ Interviews ☐ Measured objective data ☐ Expert evaluation	Beneficiaries	6-30	
2.1	A2.1.4 (USTUTT)	Analysis of how applications of virtual environments are integrated in the industrial process change	☐ Questionnaires ☐ Interviews ☐ Surveys ☐ Contextual inquiry	End user	6-30	
2.1	A2.1.5 (CERTH/ ITI)	Development of an interaction adapter	☐ System tests ☐ Interviews ☐ Usability tests ☐ Performance measurements	End user	6-30	
2.2	A2.2.1 (CRF)	Analysis of the requirements needed for the extended human models	☐ Interviews ☐ Focus groups	End user	10-21	

WP	Activity (Partner)	Task	UCD method or Evaluation applied	VERITAS user involved	Start/ End Month	Current state
2.2	A2.2.2 (HS)	Generation of simulation models	☐ Usability tests ☐ Standards inspection	End user	15-27	
2.2	A2.2.4 (HS)	Integration of simulation models in CAD/CAE simulation environment	☐ Usability tests ☐ Standards inspection	End user	21-36	
2.3	A2.3.1 (FhG/ IAO)	Analysis of virtually supported planning & decision making processes in the construction industry	☐ Questionnaires ☐ Interviews ☐ Surveys ☐ Contextual inquiry ☐ Workshops ☐ Prototyping ☐ Expert reviews	End user	10-21	
2.3	A2.3.2 (Bauunion)	Generation of simulation models	☐ Workshops ☐ Expert reviews	End user	15-27	
2.4	A2.4.1 (BYTE)	Analysis of the end-user needs for the accessible and ergonomic design of workplaces	☐ Questionnaires ☐ Interviews	End user	10-21	
2.4	A2.4.2 (HYPERTEX)	Generation of simulation models	☐ Interviews ☐ Usability test	End user	15-27	
2.5	A2.5.2 (VRMMP)	Generation of simulation models	☐ Participatory design Interviews ☐ Paper prototyping ☐ Storyboarding ☐ Guided walkthrough ☐ Think aloud	End user	15-27	
2.6	A2.6.1 (I+)	Identification of relevant accessibility, usability and acceptability aspects	☐ Questionnaires ☐ Interviews ☐ Observations	Beneficiaries	10-21	
2.6	A2.6.2 (I+)	Generation of simulation models	☐ Interviews ☐ Questionnaires ☐ Observations ☐ Performance measurements ☐ Usability tests ☐ Expert reviews ☐ Tests with multi-sensorial platform	End user	15-27	
2.6	A2.6.4 (I+)	Development of a support system	☐ Interviews ☐ Questionnaires, Observations ☐ Performance measurements ☐ Usability tests ☐ Expert reviews ☐ Tests with multi-sensorial platform	End user	21-36	

WP	Activity (Partner)	Task	UCD method or Evaluation applied	VERITAS user involved	Start/ End Month	Current state
2.7	A2.7.2 (HS)	Development of physical interaction tools	☐ Usability tests ☐ Standards inspection	End user	7-30	
2.7	A2.7.3 (UNEW)	Development of the cognitive interaction tool	☐ Usability test ☐ Interviews ☐ Think aloud	End user	7-30	
2.7	A2.7.5 (LMS)	Integration of the different interaction tools	☐ Usability tests ☐ Expert evaluations ☐ Performance measurements	End user	7-30	
2.7	A2.7.6 (PERCRO)	Development of VR devices to support the interaction tools	☐ Interview ☐ Measured objective data ☐ Expert evaluation	Beneficiaries	7-30	
2.8	A2.8.2 (CERTH/ ITI)	Creation of connecting interaction models	☐ System tests ☐ Interviews ☐ Usability tests ☐ Performance measurements	End user	7-30	
2.8	A2.8.3 (CERTH/ ITI)	Development of framework	☐ System tests ☐ Interviews ☐ Usability tests ☐ Performance measurements	End user	7-30	
2.8	A2.8.5 (UoS)	Iterative testing and optimization of the multimodal interface tool set	☐ Expert review ☐ Usability test	End user	24-36	
3.7	A3.7.2 (Fhg/ IAO)	Conducting the pilot tests with developers and designers	To be planned and defined within A3.7.1 ☐ Usability tests ☐ Expert evaluations	End user	12-25	
3.8	A3.8.2 (CRF)	Pilot testing for automotive spaces	To be planned and defined within A3.8.1 ☐ Usability tests ☐ Expert evaluations ☐ Performance measurements	End user & beneficiaries	12-25	
3.8	A3.8.3 (Bauunion)	Pilot testing for smart living spaces	To be planned and defined within A3.8.1	Beneficiaries	21-48	
3.8	A3.8.4 (BYTE)	Pilot testing for office spaces	To be planned and defined within A3.8.1 ☐ Usability tests ☐ Questionnaires ☐ Log file analysis ☐ Expert reviews	Beneficiaries	21-48	
3.8	A3.8.5 (UNEW)	Pilot testing for infotainment spaces	To be planned and defined within A3.8.1 ☐ Usability tests ☐ Performance measurements	Beneficiaries	21-48	

WP	Activity (Partner)	Task	UCD method or Evaluation applied	VERITAS user involved	Start/ End Month	Current state
3.8	A3.8.6 (MCA)	Pilot results consolidation	☐ User forum ☐ Focus groups ☐ Evaluation questionnaires ☐ Face-to-face interviews	Beneficiaries	42-48	

The following Table 21 gives an overview of VERITAS activities which either do not involve users or those where the UCD and evaluation methods are not yet defined by the respective project partner. Most of the activities presented below are part of the implementation stage of VERITAS. They encompass the development of the VERITAS applications and tools as well as the integration of different software and system components. These developments are based on the requirements and tasks identified within the requirements engineering phase and include mainly formative system evaluations by experts and performance measurements.

Table 21 VERITAS activities without/ not yet defined end user involvement.

WP	Activity (Partner)	Task	UCD method or Evaluation applied	End user groups involved	Start/ End Month	Current state
1.1	A1.1.2 (LMS)	Benchmarking	none	none	0-15	
1.2	A1.2.3 (CERTH/ITI)	Design of the multisensory platform	Evaluation of the functionality (Efficiency, interoperability) through: ☐ Performance measurements	none	0-18	
1.3	A1.3.4 (LMS)	Development of final parameterized VERITAS physical models	☐ Expert evaluation of efficiency and accessibility	none	6-24	
1.6	A1.6.3 (ATOS)	Intelligent avatar	none	none	10-21	
1.6	A1.6.4 (CERTH/ ITI)	Interoperability requirements and interfaces between user models	Evaluation of the functionality (Efficiency, interoperability) through: ☐ Performance measurements	none	6-30	
2.1	A2.1.1 (CERTH/ ITI)	Development of the core simulation platform	Evaluation of the functionality (Efficiency, interoperability) through: ☐ Performance measurements	none	6-30	
2.1	A2.1.2 (USTUTT)	Development of the immersive virtual reality simulation environment	none	none	6-30	
2.1	A2.1.6 (VRMMP)	Development of virtual user and simulation models adapter	The effectiveness will be evaluated through ☐ Expert reviews ☐ Interviews	none	6-30	

WP	Activity (Partner)	Task	UCD method or Evaluation applied	End user groups involved	Start/ End Month	Current state
2.2	A2.2.3 (USTUTT)	Integration of simulation models into the VERITAS simulation environment	none	none	10-21	
2.3	A2.3.3 (DOMOLOGIC)	Development of a 3D modelling and real time simulation tool	none	none	21-36	
2.3	A2.3.4 (DOMOLOGIC)	Development of a library editor	none	none	18-30	
2.3	A2.3.5 (USTUTT)	System integration	none	none	21-36	
2.4	A2.4.3 (USTUTT)	Integration in the VERITAS core VR environment	☐ Interviews with other VERITAS developers ☐ Workshops with other VERITAS developers	none	21-36	
2.4	A2.4.4 (CERTH/ ITI)	Tools for integration in external CAD simulation environments	Evaluation of the functionality (Efficiency, interoperability) through: ☐ Performance measurements	none	21-36	
2.5	A2.5.1 (CERTH/ITI)	Requirements analysis and analysis of needs of the end-users for accessible virtual world communities utilising the virtual user models	Evaluation of the functionality (Efficiency, interoperability) through: ☐ Performance measurements	none	10-20	
2.5	A2.5.3 (VRMMP)	Integration in the VERITAS core VR environment	Iterative testing and optimization of the simulation environment with the virtual user models and evaluation of effectiveness through: ☐ Expert review ☐ Interviews	none	21-36	
2.5	A2.5.4 (CERTH/ ITI)	System-integration	Evaluation of the functionality (Efficiency, interoperability) through: ☐ Performance measurements	none	21-36	
2.6	A2.6.3 (USTUTT)	Integration of simulation models into the available VR system	none	none	21-36	
2.7	A2.7.1 (PERCRO)	Analysis of the user disabilities and the definition of specifications/concepts to implement interaction tool	none	none	7-30	
2.7	A2.7.4 (COAT)	Development of behavioural and	none	none	7-30	

WP	Activity (Partner)	Task	UCD method or Evaluation applied	End user groups involved	Start/ End Month	Current state
		psychological interaction tools				
2.8	A2.8.1 (CERTH/ ITI)	Analysis and modelling of the interaction process related to different user interfaces	none	none	7-30	
2.8	A2.8.4 (CERTH/ ITI)	Integration of the multimodal interaction tools into the VERITAS VR Testing and Evaluation Environment	Evaluation of the functionality (Efficiency, interoperability) through: ☐ Performance measurements	none	24-36	

2.1 Requirements Engineering

To design and develop VERITAS tools and applications that are effective, efficient and satisfying to the VERITAS users (end user and beneficiaries) requires as a first step an in-depth understanding of the VERITAS users, their tasks and the different application contexts (here: automotive, infotainment, office workplace, healthcare, smart living). Thus, the first step of the VERITAS UCD approach contains the requirements elicitation and engineering phase of VERITAS. Within this phase all the relevant requirements and information that is necessary to develop the VERITAS applications and tools are identified. In particular questionnaires, interviews, surveys, focus groups, observations inside the real work context and task analysis will be applied in this early stage of VERITAS.

This step consists of the work packages defined in SP1 (WP1.1, WP1.7 for end users and WP1.2-Wp1.6 for beneficiaries) as well as the first activity of each work package in SP2, i.e. WP 2.1.1 – WP 2.8.1 as well as WP2.1-WP2.5 according to the VERITAS open simulation platform.

A detailed description and a mapping of the methodology and methods to the work packages and activities defined in VERITAS are addressed in the next sections.

For each step of the UCD approach we distinguished the three roles: VERITAS developers and the two user groups of VERITAS: end users and beneficiaries.

2.1.1 Involvement of VERITAS end users in the requirements engineering

The following table shows all the activities that are relevant for the requirements engineering for VERITAS end users.

The UCD methods elaborated in Table 22 are to be applied during the respective activities they are mapped to.

Table 22 Requirements engineering for VERITAS end users.

Work package	Requirements engineering Phase	Resp. partner	User centred Design phase – Which methods will be applied?
WP1.1	**A1.1.1** Identification and definition of VERITAS stakeholder	**MCA**	**Requirements engineering** Online surveys and questionnaires, and face to face interviews were used for the collection of user requirements (input from A1.1.2 and A1.1.3). Here not only end users are involved, but also beneficiaries. **Evaluation** This is done through the workshops and user forums we organize in the project. The overall findings are presented at the user forum and workshops so that there is chance to comment it. In addition, this is also a public deliverable and any feedback received can be added to an updated version (General feedback through public availability of the data). Here again, end users as well as VERITAS beneficiaries are involved.
WP1.1	**A1.1.3** Identification and of industrial needs A1.1.3 is informed by A1.7.1 which identifies the specific user tasks + interactions per application area	**Re:lab**	**Requirements engineering** Application of interviews with stakeholders according to the five application scenarios to define industrial needs, questionnaires for stakeholders according to the five application scenarios to define industrial needs and surveys involving end users. **Evaluation** Expert evaluation (accessibility, user satisfaction/ experience).
WP1.2	**A1.2.1** Characterization of the nature of accessibility barriers	**CAF**	**Requirements engineering** VERITAS application developers are in dialog with and end users and beneficiaries e.g. through doing focus groups and interviews **Evaluation** not yet defined by partner
WP1.7	**A1.7.1** Revision of the five VERITAS application areas and decomposition in specific user tasks + interactions → task analysis for each application sub-domain and for each type of user addressed in VERITAS Definition of the task models + implementation	**MCA**	**Requirements engineering** The tasks analysis has been conducted in cooperation with both end users and beneficiaries through face/to/face meeting whereby end-users commented on the validity of the tasks. **Evaluation** All tasks identified in the task analysis

Work package	Requirements engineering Phase	Resp. partner	User centred Design phase – Which methods will be applied?
			have been cross-checked with end-users, and will also be open to further feedback as it is provided as a public deliverable (General feedback through public availability of the data). Here again, end user as well as VERITAS beneficiaries are involved.
WP1.7	**A1.7.3** Definition of the VERITAS use cases, and subsequent fine-tuning	**CERTH/HIT**	**User centred design** The Use Cases of VERITAS have been extracted from the Use needs and requirements and have been formatted and expressed in a way to fully represent the outcomes of WP1.1 **Evaluation** VERITAS end users and beneficiaries have been invited and participated to the 1st VERITAS workshop and user forum. The Use Case were presented and explained to them and finally they were asked to prioritise them according to their needs and expectations Also the Use Cases will be used for the evaluation of the VERITAS tools by the designers during the pilot phase of the VERITAS project.
WP2.1	**A2.1.4** Analysis of how applications of virtual environments are integrated in the industrial process change (Data conversion problems? Requirements of the target fields?)	**USTUTT**	**Requirements engineering** Application of interviews, questionnaires, surveys, contextual inquiry to analyse workflows of designers/developers. **Evaluation** Not at this stage.
WP2.2	**A2.2.1** Analysis of the requirements needed for the extended human models, considering both the needs of the interested actors (users, engineers, product managers) and relevant performance (physical and cognitive);	**CRF**	**Requirements engineering** Analysis of the requirements of end-users and of technology providers for ergonomic design with respect to humans with limited functionalities + Analysis of usability and technological requirements through Interviews and focus groups with end users and ergonomists. Expert analysis during design stage. **Evaluation** Not yet defined by partner.
WP2.3	**A2.3.1** Analysis of virtually supported planning & decision making processes in the construction industry; Identification and documentation of typical business processes for private homes and business buildings for several European countries; Record & documentation of currently used IT	**FhG/IAO**	**Requirements engineering** Application of interviews, workshops, surveys, contextual inquiry to analyse workflows of end users. **Evaluation** Verification of the requirements and integrated toolset, their effectiveness and acceptability with end users

Work package	Requirements engineering Phase	Resp. partner	User centred Design phase – Which methods will be applied?
	tools to support those processes		through workshops, prototyping but also expert reviews.
WP2.4	**A2.4.1** Analysis of the end-user needs for the accessible and ergonomic design of workplaces ranging from typical offices to complex workstations	**BYTE**	**Requirements engineering** This activity aims to extract the end users ' needs for the accessible and ergonomic design of workplaces and collaborative tools. It does this through an analysis of literature and of existing products, relevant guidelines / standards and through questionnaires and interviews with end users of accessible workplaces or collaborative tools. **Evaluation** Evaluation will be performed within WP3.3 and A3.8.4.
WP2.5	**A2.5.1** Requirements analysis and analysis of needs of the end-users for accessible virtual world communities utilising the virtual user models	**CERTH/ITI**	**Requirements engineering** These are core development, integration tasks that do not require the involvement of user interaction. **Evaluation** Evaluation of the functionality (Efficiency, interoperability) through performance measurements.

2.1.2 Involvement of VERITAS beneficiaries as end users in the requirements engineering

The following table shows all the activities that are relevant for the requirements engineering for beneficiaries.

The UCD methods elaborated in Table 23 are to be applied during the respective activities they are mapped to.

Table 23 Requirements engineering for beneficiaries of VERITAS

Work package	Requirements engineering Phase	Resp. partner	User centred Design phase – Which methods will be applied?
WP1.1	**A1.1.2** Benchmarking of existing models, standards and problems	**LMS**	**Requirements engineering** Development of initial framework regarding the existing approaches towards the modeling (physical, cognitive, behavioral and psychological) of beneficiaries based on survey output of A1.1.1. **Evaluation** Not at this stage.
WP1.2	**A1.2.1 – A.1.2.5** Analyzing behaviour of real users with disabilities (laboratory & natural settings) through:	**CAF** **CERTH/ITI** **SMARTEX** **UNITN**	**Requirements engineering** Measuring the physical behaviour of beneficiaries with handicaps. The measuring is restricted to the

Work package	Requirements engineering Phase	Resp. partner	User centred Design phase – Which methods will be applied?
	- Wearable sensing interfaces (SMARTEX) - Motion tracking (CERTH/ITI) Capturing, labelling and classifying of user motion according to the range of impairments (physical, sensory and cognitive) and application scenarios; In particular: Automatic extraction of behaviour patterns & analysis and identification of irregular motion patterns to tune and parameterize the VUMs		physical user model. Cognitive and behavioural models are traced based on physical behaviour (motion) under predefined cognitive and psychological conditions. **Evaluation** Not at this stage.
WP1.3	**A1.3.3** A series of measurement sessions with the beneficiaries to fine tune the physical models as well as their standards, guidelines and rules identified based on the multi-sensorial platform developed + provision of data for parameterization of the models	**SMARTEX**	**Requirements engineering** Measurement sessions with beneficiaries. **Evaluation** Not at this stage.
WP1.4	**A1.4.3** A series of measurement sessions with the beneficiaries to fine tune the cognitive models as well as their standards, guidelines and rules identified based on the multi-sensorial platform developed + provision of data for parameterization of the models	**UPM**	**Requirements engineering** Questionnaires with beneficiaries will be applied. **Evaluation** No evaluation at this stage.
WP1.5	**A1.5.3** A series of measurement sessions with the beneficiaries to fine tune the behavioural and psychological models as well as their standards, guidelines and rules identified based on the multi-sensorial platform developed + provision of data for parameterization of the models	**COAT**	**Requirements engineering** Application of usability tests, questionnaires and interviews with beneficiaries. **Evaluation** Evaluation of the validity of user models via matching the model performance and the actual users' performances (through performance measurements). Test will be conducted with the multi-sensorial platform.
WP1.5	**A1.5.4** Generation of human models, Development of final parameterized VERITAS behavioural and psychological models	**ITACA**	**Design** This task will use the multi-sensorial platform for training of the behavioral and psychological abstract user models. The result of this activity is the parameterized model, which is not directly used by the user. This activity applies interviews with beneficiaries as well as questionnaires.The measurements with beneficiaries will be performed in A1.5.3.The tool will be developed in WP1.6. **Evaluation**

Work package	Requirements engineering Phase	Resp. partner	User centred Design phase – Which methods will be applied?
			The evaluation of the correctness of the model will be done in the context of the pilot sites and application scenarios. Here derivations of the models will be evaluated against real users (beneficiaries) through measurements with the multi-sensorial platform.
WP2.6	**A2.6.1** Identification of the main aspects affecting the accessibility, usability and acceptability of the solutions by patients when they are outside the clinical setting with specific focus on beneficiaries; Identification of attributes related with the physical models, the cognitive models and the behavioural and psychological models of the users elaborated in SP1.	**I+**	**Requirements engineering** Analysing the needs of the beneficiaries selected based on the targeted disabilities. Methods applied are interviews and questionnaires with beneficiaries and observations. **Evaluation** Evaluation of the resulting VERITAS tools/solutions through usability tests (involving beneficiaries), performance measurements, expert reviews and tests with the multi-sensorial platform. The main aspects to be evaluated are accessibility, effectiveness and efficiency!
WP2.7	**A2.7.1** Analysis of the user disabilities and the definition of the specifications and the concepts for the implementation of the novel interaction tools	**PERCRO**	**Requirements engineering** Architecture definition of Interaction Tools developed in WP2.7 has planned the extraction of parameter for the design of IT that will require a set of pre-pilots test involving beneficiaries (not conducted in this activity, but in other activity correlated with the activity of IT development). Mostly interviews will be used and when it's possible measured objective data. **Evaluation** Effectiveness tests comparing beneficiaries and designers responses. Acceptability is evaluated in designer tests. Expert evaluation in the first phase. Pre-pilots with beneficiaries for IT parameters settings are conducted, not in this activity, but ion a correlated activity of IT development.

2.2 Design phase of the VERITAS process

The second step depicts the design phase of the VERITAS tools. The required models are defined. The tools are defined and designed. This stage starts early during the requirements engineering to identify the information required to

design the VERITAS tools and applications. Thus, during the design phase, the requirements identified are incorporated in design solutions. VERITAS users are involved in the design process of the VERITAS tools and applications as well as in formative evaluations of design solutions and developments. It is a streamlined design process, which allows the inclusion of iterations based on the extended waterfall process model suggested for VERITAS (see Figure 5).

2.2.1 Early design process involving VERITAS application developer and end users within formative evaluations

The table shows all the activities that are relevant for the requirements engineering for VERITAS application developers.

The UCD methods elaborated in Table 24 are to be applied during the respective activities they are mapped to.

Table 24 Design phase involving VERITAS application developer.

Work package	Design Phase	Resp. partner	User centred Design phase – Which methods will be applied?
WP1.2	**A1.2.3** Design of the multisensory platform	**CERTH/ITI**	**Design** These are core development, integration tasks that do not require the involvement of user interaction **Evaluation** Evaluation of the functionality (Efficiency, interoperability) through performance measurements
WP1.2	**A1.2.6** Design of sensor management tool to configure the multi-sensorial platform; Design of a visual editor for the construction of workflows	**CERTH/ITI**	**Design** Inclusion of end users in the iterative implementation through system tests and interviews. **Evaluation** Evaluation of the functionality (Efficiency, interoperability and user satisfaction) through performance measurements and usability tests with end users.
WP1.3	**A1.3.4** Generation of human models; Development of final parameterized VERITAS physical models	**LMS**	**Design** User involvement takes place within the generation of Virtual User Model which is based on the measurement involving the beneficiaries as well as in the iterative testing and fine tuning of the physical abstract user models (A1.3.1-A1.3.3) as pre-training for the final models within the multi-sensorial platform. **Evaluation** Evaluation of the development through experts and usability test according to efficiency and accessibility but without direct user involvement at this stage.

Work package	Design Phase	Resp. partner	User centred Design phase – Which methods will be applied?
WP1.4	**A1.4.4** Generation of human models; Development of final parameterized VERITAS cognitive models	**UPM**	**Design** Not yet defined by partner**.** **Evaluation** Measurement with beneficiaries; Iterative testing and fine tuning of the cognitive abstract user models as pre-training for the final models within the multi-sensorial platform
WP1.6	**A1.6.1** Development of an appropriate model platform that can be used for the implementation of the physical, cognitive, psychological and behaviour 3D models	**HS**	**Design** Design is informed by interviews with end users for the extraction of requirements in the requirements engineering stage **Evaluation** In usability tests with end users and through standards inspection, the user satisfaction and system acceptability through users will be evaluated.
WP1.6	**A1.6.2** Specification of appropriate methodology for the elicitation of the user action rules and workflows that can be used for the final implementation of user models within A1.3.4, A1.4.4 and A1.5.4.	**ITACA**	**Design** This task will develop a specification for the UsiXML file format and a tool for translating the ontology-based models in the UsiXML file. End user will be evolved to test prototypes and evaluate the concept. **Evaluation** The evaluation of the effectiveness of the tool will be done in the context of the pilots sites and application scenarios. Here, the usability, effectiveness and efficiency of the tool will evaluated through user tests involving end users.
WP1.6	**A1.6.3** Development an intelligent avatar that can be used for the instantiation of the virtual user models	**ATOS**	**Design** Not at this stage. This activity is an internal development and the resulting application will not be manipulated by end users. No user interaction takes place. The Intelligent avatar takes as input a number of configuration files which have been set using the simulation platform. A1.6.3 takes these file to produce the Avatar, which is displayed (as output) on the desk top application. **Evaluation** Not at this stage.
WP1.6	**A1.6.4** **Interoperability requirements and interfaces between user models-**	**CERTH/ITI**	**Design** These are core development, integration tasks that do not require the involvement of user interaction.

Work package	Design Phase	Resp. partner	User centred Design phase – Which methods will be applied?
			Evaluation CERTH/ITI; Evaluation of the functionality (Efficiency, interoperability) through performance measurements

2.2.1 Early design process involving VERITAS beneficiaries

The following table shows all the activities that are relevant for the early design process of the VERITAS application and that involve VERITAS beneficiaries.

The UCD methods elaborated in Table 32 are to be applied during the respective activities they are mapped to.

Table 25 Design phase involving VERITAS beneficiaries.

Work package	Design Phase	Resp. partner	User centred Design phase – Which methods will be applied?
WP1.2	**A1.2.2** Design of wearable sensing interfaces for motion capturing	**SMARTEX**	**Design** At this stage of work, no UCD method is applied. **Evaluation** Evaluation of the functionality (Efficiency, interoperability) through performance measurements. In a second stage it could be possible to propose a questionnaire to beneficiaries to evaluate the unobtrusiveness of the system.

2.3 Implementation phase of the VERITAS process

The VERITAS tools are implemented iteratively. The designs and requirements are evaluated during the development process using formative evaluations.

2.3.1 Involvement of VERITAS application developer in the implementation stage

The following table shows all the activities that are relevant for the implementation of VERITAS applications through VERITAS application developer.

The UCD methods elaborated in Table 26 are to be applied during the respective activities they are mapped to.

Table 26 Implementation of VERITAS applications through developer

Work package	Implementation Phase	Resp. partner	User centred Design phase – Which methods will be applied?
WP2.1	**A2.1.1** Development of the core simulation platform that will be the infrastructure for all VERITAS simulations that will take place	**CERTH/ITI**	**Implementation** These are core development, integration tasks that do not require the involvement of user interaction **Evaluation** Evaluation of the functionality (Efficiency, interoperability) through performance measurements
WP2.1	**A2.1.2** Development of the immersive virtual reality simulation environment for realistic and iterative testing providing simultaneous multimodal (visual, aural, etc.) → feedback to the end users as well as the potential for immersive realistic simulation and virtual user testing by putting the developer in the position of the user through virtual/augmented reality simulation; Definition of required simulation functions	**USTUTT**	**Implementation** No application of UCD method within this stage of the development process. **Evaluation** Not at this stage.
WP2.1	**A2.1.6** Development of virtual user and simulation models adapter	**VRMMP**	**Implementation** The implementation is informed by questionnaires, interviews and task analysis. No end users are involved at this stage. **Evaluation** The effectiveness will be evaluated through expert reviews and interviews. No end users are involved at this stage.
WP2.2	**A2.2.3** Integration of simulation models into the VERITAS simulation environment (the resulting system allows a real human to interact with a virtual environment in the context of the immersive simulation platform)	**USTUTT**	**Implementation** No application of UCD method within the development process. **Evaluation** Not at this stage.
WP2.3	**A2.3.3** Development of a 3D modelling and real time simulation tool for smart device networks making it possible to optimize configuration parameters (e.g. control algorithms) and connections between smart devices before installation Testing will be supported by a pattern editor, allowing to develop test patterns that are checked automatically against requirements of the targeted users	**DOMOLOGIC**	**Implementation** Not at this stage. **Evaluation** Not at this stage.
WP2.3	**A2.3.4** Development of a library editor for	**DOMOLOGIC**	**Implementation** Not at this stage.

Work package	Implementation Phase	Resp. partner	User centred Design phase – Which methods will be applied?
	simulation models of smart		**Evaluation** Not at this stage.
WP2.3	**A2.3.5** System integration	**USTUTT**	**Implementation** No application of UCD method within this stage of development process. **Evaluation** Not at this stage.
WP2.4	**A2.4.3** Definition of an applicable interface between the core VR system and added modules for cluster environments will be defined Technical tests of the core side of the interface will be performed in A2.4.3.; Technical tests of the modules are done in the respective Activities	**USTUTT**	**Implementation** Interviews, Workshops with other VERITAS developers. **Evaluation** Not at this stage.
WP2.4	**A2.4.4** The simulation models will be integrated in an external CAD simulation platform	**CERTH/ITI**	**Implementation** These are core development, integration tasks that do not require the involvement of user interaction **Evaluation** Evaluation of the functionality (Efficiency, interoperability) through performance measurements
WP2.5	**A2.5.3** Integration of the gaming user and simulation models within the VERITAS core VR environment; Several application specific parameters will be evaluated including VR environmental variables like illumination, avatar and virtual object level of detail, cross-modal transformations, etc.	**VRMMP**	**Implementation** Tasks will be analysed. This does not include end users at this stage. **Evaluation** Iterative testing and optimization of the simulation environment with the virtual user models and evaluation of effectiveness through expert review and interviews. No end users are involved at this stage.
WP2.5	**A2.5.4** Integration of system developed within A2.5.3 in an external game application	**CERTH/ITI**	**Implementation** These are core development, integration tasks that do not require the involvement of user interaction. **Evaluation** Evaluation of the functionality (Efficiency, interoperability) through performance measurements
WP2.6	**A2.6.3** Integration of A2.6.2 simulation models into the available VR system	**USTUTT**	**Implementation** No application of UCD method within this stage of the development process. **Evaluation** Not at this stage.
WP2.7	**A2.7.4** Development of behavioural and	**COAT**	**Implementation** Not at this stage.

Work package	Implementation Phase	Resp. partner	User centred Design phase – Which methods will be applied?
	psychological interaction tools		**Evaluation** Not at this stage.
WP2.8	**A2.8.1** Detailed analysis of interaction mechanism of HCI solutions for user interfaces currently used (e.g. touch, voice control, speech output, gesture, GUIs, etc.) and linking of each of the identified steps of the process to the sensorial capabilities needed for its execution	**CERTH/ITI**	**Implementation** These are analysis task that do not require the involvement of user interaction. **Evaluation** Widely used assistive devices will be identified and analyzed in terms of several parameters like their input and output modalities, mobility, robustness, etc. SOA of multimodal interfaces for older people and people with disabilities will be analyzed.
WP2.8	**A2.8.4** Integration of the multimodal interaction tools into the VERITAS VR Testing and Evaluation Environment	**CERTH/ITI**	**Implementation** These are core development, integration tasks that do not require the involvement of user interaction. **Evaluation** Evaluation of the functionality (Efficiency, interoperability) through performance measurements

2.3.2 Involvement of end users in the implementation stage

The following table shows all the activities that are relevant for the implementation of VERITAS applications involving end users.

The UCD methods elaborated in Table 27 are to be applied during the respective activities they are mapped to.

Table 27 Implementation of VERITAS applications involving end users

Work package	Implementation Phase	Resp. partner	User centred Design phase – Which methods will be applied?
WP2.1	**A2.1.5** Development of an interaction adapter	**CERTH/ITI**	**Implementation** Inclusion of end users in the iterative implementation through system tests and interviews. **Evaluation** Evaluation of the functionality (Efficiency, interoperability and user satisfaction) through performance measurements and usability tests with end users.
WP2.2	**A2.2.2** Generation of simulation models for the description of users posture characteristics and physical constraints of impaired and older	**HS**	**Implementation** The implementation is informed by interviews with end users for the extraction of requirements in the requirements engineering stage

Work package	Implementation Phase	Resp. partner	User centred Design phase – Which methods will be applied?
	people		**Evaluation** In usability tests with end users and through standards inspection, the user satisfaction and system acceptability through users will be evaluated.
WP2.2	**A2.2.4** Integration of simulation models in CAD/CAE simulation environment	**HS**	**Implementation** The implementation is informed by interviews with end users for the extraction of requirements in the requirements engineering stage **Evaluation** In usability tests with end users and through standards inspection, the user satisfaction and system acceptability through users will be evaluated.
WP2.3	**A2.3.2** Generation of simulation models for the description of smart living spaces scenario	**Bauunion**	**Implementation** Not at this stage. **Evaluation** Evaluation of effectiveness and acceptability through expert review and workshops involving end users.
WP2.4	**A2.4.2** Generation of simulation models for the description of workplace scenario	**HYPERTECH**	**Implementation** Interviews with end users of workplaces **Evaluation** Test of correctness of simulation models through usability tests with end users
WP2.5	**A2.5.2** Generation of simulation models for the description of automotive & smart living spaces	**VRMMP**	**Implementation** End users are involved in this stage through participatory design, interviews, paper prototyping, storyboarding. **Evaluation** The effectiveness, and accessibility of the developments will be tested as well as user satisfaction through guided walkthrough and think aloud. End users are involved in the evaluation too.
WP2.6	**A2.6.2** Generation of simulation models for the description of different materials/textural structures, locations, shapes, comfort levels, movement freedoms, various mono- and multimodal interaction approaches etc. in healthcare (I+)	**I+**	**Implementation** Methods applied are interviews and questionnaires with end users and observations. **Evaluation** Evaluation of the resulting VERITAS tools/solutions through usability tests (involving end users), performance measurements, expert reviews and tests with the multi-sensorial platform. The main aspects to be

Work package	Implementation Phase	Resp. partner	User centred Design phase – Which methods will be applied?
			evaluated are accessibility, effectiveness and efficiency!
WP2.6	**A2.6.4** Development of a support system for personal healthcare products	**I+**	**Implementation** Methods applied are interviews and questionnaires with end users and observations. **Evaluation** Evaluation of the resulting VERITAS tools/solutions through usability tests (involving end users), performance measurements, expert reviews and tests with the multi-sensorial platform. The main aspects to be evaluated are accessibility, effectiveness and efficiency!
WP2.7	**A2.7.2** Development of physical interaction tools	**HS**	**Implementation** The implementation is informed by interviews with end users for the extraction of requirements in the requirements engineering stage **Evaluation** In usability tests with end users and through standards inspection, the user satisfaction and system acceptability through users will be evaluated.
WP2.7	**A2.7.3** Development of the cognitive interaction tool.	**UNEW**	**Implementation** No involvement of end users at this stage. The development is based on research findings in the literature and available parameters in user studies involving the VERITAS target beneficiaries. **Evaluation** Evaluation of the effectiveness and efficiency of the tool through usability tests (interviews, think aloud) with end users aside of performance measurements.
WP2.7	**A2.7.5** The aim of this activity is the integration of the different interaction tools in a comprehensive system.	**LMS**	**Implementation** No application of UCD methods, it is simply an integration process of the tools developed within WP2.7. Specifications of the tools are defined within A2.7.2-A2.7.4. **Evaluation** The effectiveness, efficiency and accessibility of the system will be evaluated through expert evaluations, performance measurements and usability tests involving end users.
WP2.8	**A2.8.2** Creation of interaction models connecting the virtual user model,	**CERTH/ITI**	**Implementation** Inclusion of end users in the iterative implementation through system tests

Work package	Implementation Phase	Resp. partner	User centred Design phase – Which methods will be applied?
	developed in the SP1, to the virtual prototype of the product/solution to be tested		and interviews. **Evaluation** Evaluation of the functionality (Efficiency, interoperability and user satisfaction) through performance measurements and usability tests with end users.
WP2.8	**A2.8.3** Development of a modality compensation and replacement framework	**CERTH/ITI**	**Implementation** Inclusion of end users in the iterative implementation through system tests and interviews. **Evaluation** Evaluation of the functionality (Efficiency, interoperability and user satisfaction) through performance measurements and usability tests with end users.
WP2.8	**A2.8.5** Various testing sessions will be planned and executed to validate the developed Multimodal Interaction Tools and verify the effectiveness of the overall VERITAS framework in testing multimodal interfaces → Refinement and optimization of the design of the toolset & Generation of a set of indicators to automatically define the level of usability and acceptability of the multimodal interface solution under test	**UoS**	**Implementation** Not at this stage. **Evaluation** Evaluation of usability, user satisfaction and user experience through expert reviews and usability test that ideally include end users.

2.3.1 Involvement of beneficiaries in the implementation stage

The following table shows all the activities that are relevant for the implementation of VERITAS applications involving beneficiaries.

The UCD methods elaborated in Table 28 are to be applied during the respective activities they are mapped to.

Table 28 Implementation of VERITAS applications involving beneficiaries.

Work package	Implementation Phase	Resp. partner	User centred Design phase – Which methods will be applied?
WP2.1	**A2.1.3** Development of an Interaction Manager to handle and coordinate the various interaction tools for simulating the different disabilities (it's a software module allows the designer to perform different accessibility tests by selecting among available user models)	**PERCRO**	**Implementation** The interaction Manager (IM) will have the role of management for the Interaction Tools (IT) developed in WP2.7. The settings of the parameter for such IT will require a set of pre-pilots test on beneficiaries. These tests encompass mostly interview and when it's possible measured objective data.

Work package	Implementation Phase	Resp. partner	User centred Design phase – Which methods will be applied?
			Evaluation Effectiveness tests comparing beneficiaries and designers responses. Acceptability is evaluated in designer tests. Expert evaluation in the first phase. Pre-pilots with beneficiaries for IT parameters settings.
WP2.7	**A2.7.6** Development of VR devices to support the interaction tools	**PERCRO**	**Implementation** The development of the VR tools include the preparation of a set of pre-pilots test on beneficiaries for the extraction of parameter for their design. In the pilot tests interviews will be applied and when it's possible measured objective data. **Evaluation** Effectiveness tests comparing beneficiaries and designers responses. Acceptability is evaluated in designer tests. Expert evaluation in the first phase. Pre-pilots with beneficiaries for IT parameters settings. End users are not directly involved in this activity but in the related activities.

2.4 Pilot testing with designers/developers and beneficiaries

The next step contains the testing of the VERITAS applications. In order to test the VERITAS tools these should be applied in the defined application scenarios (automotive, health care, infotainment, work space, smart living).

For the pilot tests, test projects are setup (WP3.1 - WP3.5) and conducted in order to evaluate the applicability and usability of the VERITAS tools through an iterative evaluation process with the targeted VERITAS user groups (end users and beneficiaries).

Results of the pilots support the development of VERITAS virtual user modelling, simulation and testing tools.

2.4.1 Involvement of designers/developers in the pilot testing

The table shows all the activities that are relevant for the Pilot testing involving end users (WP3.7) of the VERITAS project.

The UCD methods elaborated in Table 29 are to be applied during the respective activities they are mapped to.

Table 29 Pilot testing involving end users

Work package	Pilot testing Phase	Resp. partner	UVERITAS evaluation phase – Which methods will be applied?
WP3.7	**A3.7.2 & A3.7.3** Conduction of the pilot tests (with end users) for each application field in different countries Data analysis and evaluation of the pilot tests with end users	**FhG/IAO** **Brunel**	**Evaluation** Will be defined through the Pilot plan in A3.7.1. In order to be able to test the VERITAS tools with designers test scenarios are constructed. The scenarios will be based on user tests and define a set of parameters to be evaluated by all partners conducting the usability tests. This ensures that the results of the usability tests are comparable and can be used to enhance the VERITAS tools in future iterations. The structure and the amount of planned tests will follow the proposal already done in the DoW A3.7.2; and encompasses a total of 140 designers of the five different application areas. So far, the evaluation will mainly focus on user satisfaction/experience, and users acceptance of the systems through usability tests and expert evaluation.

2.4.2 Involvement of VERITAS beneficiaries in the pilot testing

The following table shows all the activities that are relevant for the Pilot testing involving VERITAS beneficiaries (WP3.8).

The UCD methods elaborated in Table 30 are to be applied during the respective activities they are mapped to.

Table 30 Pilot testing involving beneficiaries

Work package	Pilot testing Phase	Resp. partner	VERITAS evaluation phase – Which methods will be applied?
WP3.8	**A3.8.2** Pilot testing for automotive spaces	**CRF**	**Evaluation** In order to be able to test the VERITAS tools with designers test scenarios are constructed. The scenarios will be based on user tests and define a set of parameters to be evaluated by all partners conducting the usability tests. This ensures that the results of the usability tests are comparable and can be used to enhance the VERITAS tools in future iterations. Aside of beneficiaries, end users will be included in the evaluation.

Work package	Pilot testing Phase	Resp. partner	VERITAS evaluation phase – Which methods will be applied?
			Designers are involved in the usability and user experience test. Beneficiaries evaluate the accessibility, suitability and user experience of the designs. Methods to be applied are expert evaluation / usability tests including performance measurements where applicable (e.g. in usability of on board info-telematics). For the evaluation of the accessibility of car interiors equipment end users are involved, for the evaluation of the accessibility of on board info-telematics, beneficiaries will be involved.
WP3.8	**A3.8.3** Pilot testing for smart living spaces	**Bauunion**	**Evaluation** Will be defined through the Pilot plan in A3.8.1. In order to be able to test the VERITAS tools with designers test scenarios are constructed. The scenarios will be based on user tests and define a set of parameters to be evaluated by all partners conducting the usability tests. This ensures that the results of the usability tests are comparable and can be used to enhance the VERITAS tools in future iterations.
WP3.8	**A3.8.4** Pilot testing for office spaces	**BYTE**	**Evaluation** This activity will focus on the evaluation of the developed office workplace design tools and collaborative working tools through usability tests, questionnaires, log file analysis and expert reviews. Evaluation criterions are: memorability, low error rate, user satisfaction, accessibility, and acceptability. The testing will be performed with various users belonging in the several target disability groups of VERITAS.
WP3.8	**A3.8.5** Pilot testing for infotainment spaces	**UNEW**	**Evaluation** In order to be able to test the effectiveness of the VERITAS tools with designers test scenarios are constructed. The scenarios will be based on user tests and define a set of parameters to be evaluated by all partners conducting the usability tests. This ensures that the results of the usability tests are comparable and can be used to enhance the VERITAS tools in future iterations.

Work package	Pilot testing Phase	Resp. partner	VERITAS evaluation phase – Which methods will be applied?
			Performance measurements and comparison will be applied.
WP3.8	**A3.8.6** Pilot results consolidation; Performance of a small analysis by panels of users, stakeholders and experts, to assess the main strengthens and weakness, opportunities and threats of the VERITAS services	**MCA**	**Pilots with beneficiaries** Data will be collected from all pilot sites where beneficiaries will be brought together to collect their findings and cross-check them with the expected results. Final findings will also be checked with beneficiaries during the user forum after the pilots. Methods that will be applied are: Focus groups, evaluation questionnaires, direct interviews and face to face sessions with beneficiaries. **Evaluation** All outcomes of the different pilot sites will be assessed and evaluated and findings cross-checked with the involved beneficiaries. Cross-checks will be applied between test scenarios and outcomes, as well as questionnaires that will be provided to all participating beneficiaries. Equally, they will be presented at the user forum to ensure all pilot sites can comment on all findings.

2.5 Test applications to be developed with VERITAS

The test applications within the UCD process are developed following the proposed UCD Model by ISO 13407 (see Figure 3).

The accessibility, usability, versatility, and reliability of the VERITAS tools are evaluated through the development, analysis and cyclic testing (pilots, cf. WP3.7 and WP3.8) of the applications developed in WP3.1-WP3.5.

Identified constraints and interaction issues of design solutions, derivations from the simulation models as well as further results of the evaluation of the VERITAS tools and environments will feedback indications for further developments in VERITAS. Results will be reported using the EARL language.

First specifications of the test applications can be found in Table 31.

Table 31 Specifications of the test applications

Area	Test applications	VERITAS tools, user models and environments used	Real user involved	Evaluation criteria

Area	Test applications	VERITAS tools, user models and environments used	Real user involved	Evaluation criteria
Automotive **WP3.1 (CRF)**	4-wheels vehicle interior design (virtual interior model) **Partner: CRF**	VERITAS Physical and/or cognitive simulation models integrated in external ergonomics simulation environment.	Motor impairment users; Cognitive impairment users; Hearing impairment users; End users	Personal mobility: Usability of the interior equipment (e.g. storage spaces, instrument cluster) Key features: understanding, reach, visibility, usability
	Motorcycle human machine interface design (as conventional instrument cluster and space manager) **Partner: PIAGGIO**	VERITAS Physical and/or cognitive simulation models integrated in external ergonomics simulation environment.	Motor impairment users; Cognitive impairment users; Hearing impairment users; End users	Correctness, utility and usability of the multimodal system (visual, acoustic, haptic) during driving (adapting/tuning according to the context) Motorcycle: Usability
	Accessible version(s) of UI for Assistance and Information Systems in cars (driver interfaces) **Partner : CAF**	VERITAS Cognitive and/or behavioural simulation platform including model of the system, for designer pilots. For users pilots, developed system integrated in driving simulation environment.	Older people; Motor impairment users; Cognitive impairment users; Hearing impairment users; End users	Accessibility and Adaptiveness of the UI: Usability of the assistance and information system
Smart Living Spaces **WP3.2 (INDESIT)**	Interior design of a building through virtual reality (VRfx) system **Partner: Bauunion**	Test, validation and integration of the VERITAS interaction tools early specified	Blind and low-vision users; Motor impairment users; Hearing impairment users; Speech impairment users End users (architects & consultants of Bauunion)	Test of accessibility; Identification of derivations from the simulation models; Interaction analysis
	Domotics and home applications **Partner: INDESIT**	Test, validation and integration of the VERITAS interaction tools	Blind and low-vision users; Motor impairment users; Hearing impairment users; Speech impairment users End users	Providing feedback for use case definitions; Evaluation of the accessibility, versatility and reliability of the VERITAS interaction tools Test of accessibility; Identification of derivations from the simulation models; Interaction analysis

Area	Test applications	VERITAS tools, user models and environments used	Real user involved	Evaluation criteria
"Office" Workplace **WP3.3 (BYTE)** .	Workplace design **Partner: Bauunion**	VERITAS simulation platform in the external CAD application; Virtual users (of the VERITAS platform) for extensive, iterative test of the design	Blind and low-vision users; Motor impairment users; Cognitive impairment users; Hearing impairment users; Speech impairment users	Adaptability of design for different disability categories; Accessibility of the workplace; User acceptance Test of accessibility; Identification of derivations from the simulation models; Interaction analysis
	Collaborative tools utilizing multimodal interfaces **Partner: BYTE** The requirements analysis is performed within WP2.4. UCD methods will be followed during the design and development process. The methods to be followed are prototyping, wizard of Oz trials, questionnaires and possibly log files analysis	VERITAS simulation platform (its design, content, functionality and interfaces); Virtual users (of the VERITAS platform) for extensive, iterative test of the design	Blind and low-vision users; Motor impairment users; Cognitive impairment users; Hearing impairment users; Speech impairment users The prototypes will be evaluated with end users	Adaptability of design for different disability categories; Accessibility of the workplace; User acceptance Test of accessibility; Identification of derivations from the simulation models; Interaction analysis The evaluation of the final software design will be performed within A3.8.4.
Info-tainment and games **WP3.4 (CERTH/ ITI)**	Accessible metaservers **Partner: CERTH/ITI**	VERITAS simulation platform, gaming simulation models; Virtual users (of the VERITAS platform) ; real game scenario with real external participants	Blind and low-vision users; Motor impairment users; Cognitive impairment users; Hearing impairment users; Speech impairment users End users	Adaptability of design for different disability categories; Accessibility
	Collaborative Games for older people	VERITAs simulation platform and	Blind and low-vision users; Motor impairment	Adaptability of design for different disability categories;

Area	Test applications	VERITAS tools, user models and environments used	Real user involved	Evaluation criteria
	Partner: AIJU	simulation models ; Older people Virtual user (of the VERITAS platform)	users; Cognitive impairment users; Hearing impairment users; Speech impairment users End users	Accessibility and Education for older people
Personal healthcare and wellbeing solutions **WP3.5 (I+)**	Design of remote patient monitoring solutions **Partner: I+**	Iterative testing with VERITAS user models; real user test; considering beneficiaries	Low-vision users; Motor impairment users; Mild cognitive impairment users; Hearing impairment users; Speech impairment users End users	Adaptability of design for different disability categories; Usability; Accessibility; Acceptability of system
	Design of mobile device to be used by older users (or people with physical impairments) to interact with personal health solutions **Partner: I+**	Iterative testing with VERITAS user models	Low-vision users; Motor impairment users; Mild cognitive impairment users; Hearing impairment users; Speech impairment users End users	Usability; Portability; comfortable use (‘familiar and friendly look and feel’); Accessibility
	Design solutions for medical education and health coach **Partner: I+**	Iterative testing with VERITAS user models	Low-vision users; Motor impairment users; Mild cognitive impairment users; Hearing impairment users; Speech impairment users End users	Adaptability of design for different disability categories; Usability; Accessibility; Test and refining of CAD system (A2.6.4)

Table 32 gives an overview about the amount of pilots conducted for the evaluation of the test applications and the VERITAS tools and environments as well as the amount of end users (end users and beneficiaries) involved in this process.

Table 32 Amount of End user and Beneficiaries involved in the pilots per application area.

Area of test application	End user involved in testing	Beneficiaries involved in testing
Automotive	End user: 3 pilots, 30 participants	Beneficiaries: 2 pilots, 60 participants
Smart living spaces	End user: 3 pilots, 50 participants	Beneficiaries: 3 pilots, 90 participants
Office workplace	End user: 3 pilots, 30 participants	Beneficiaries:3 pilots,90 participants
Infotainment and games	End user: 2 pilots, 20 participants	Beneficiaries: 3 pilots, 90 participants
Personal healthcare and well-being	End user: 1 pilots, 10 participants	Beneficiaries: 1 pilots, 90 participants
Total	**140**	**380**

The last step of the VERITAS UCD approach is reached after the defined requirements are matched and the identified problems have been addressed.

3 UCD Ethics Integration

D4.1.4 discusses the ethics of applying the UCD design methods. This allows partners to understand the general ethical procedure and associated tasks and the general legal framework that surrounds those tasks. Table 33 in this document reproduces the specific ethical concerns detailed in this document for the convenience of partners and reviewers. By referencing this table, it will be possible for designers to understand the implications of their chosen design activities.

Table 33: UCD Methods and their ethical implications

Method	Ethical Impact
Questionnaires	The most important Ethical issues with regard to the questionnaires are: Ethical significance of method (Permission of the LREC is mandatory), anonymisation and the use of data. These three can be categorized into seven Sub-headings: 1. Whether the participation of the subject is truly voluntary; 2. Whether consent to participate in the study has been obtained or proxy consent is required (e.g. for children – most likely not the case in VERITAS; 3. Whether consent to participate has been obtained from “authentic” participants and their privacy is protected; 4. Whether participants are fully informed before they consent to participate; 5. Whether the validity of questionnaire-based research has been determined in terms of its possible harm to the participants; 6. How the roles of the Local Research Ethics Committees are defined (Permission is required within VERITAS!); 7. What content should be presented in reports, articles and Deliverables. In terms of information to provide for respondents, it is probably desirable to include on the questionnaire a reminder that respondents do not need to answer any question which they consider inappropriate. They should be informed about mechanisms for storing the data, and for how long it is intended to keep it. It may also be relevant to explain which people will have access to the data, and broadly speaking how the data will be used. It is also important to mention where the participants can get feedback about the results. Smith & Leigh (1997) recommend especially for online researchers to achieve informed consent in the following manner: 1. After reading the informed-consent information on the survey Web page, subjects enter their e-mail address.

Method	Ethical Impact
	2. The host server for the survey automatically generates a unique password and sends it to the subject's e-mail address. 3. The subject enters the password in order to provide their consent and access the survey (the informed consent form includes the information that, by using this password, they are giving informed consent and that they are capable of giving informed consent). Smith, M. A., & Leigh, B. (1997). Virtual subjects: Using the Internet as an alternative source of subjects and research environment. *Behavior Research Methods, Instruments, and Computers, 29,* 496–505.
Interviews	Questions about approaching potential interviewees, on-going and retrospective consent, and the confidentiality of participants and third parties will be discussed in the next sections. **Ensure Voluntary Participation**. The right to privacy and informed consent usually give people the right to refuse to be surveyed or interviewed, or to not answer specific content. Bradburn and Sudman (1988) state that all professional civilian survey organizations recognize this right. **Maintain Confidentiality and Non-Attribution**. As Sieber (1992) and Salant and Dillman (1994) point out, there is a distinction between anonymity and confidentiality. Anonymity is best, but cannot always be promised, and may not be believed. There is a subtle "can not" versus "will not" distinction concerning the identity of respondents. Interviews are almost always not anonymous since they are typically face to face. If a survey is *anonymous*, no information is collected which could link data to individual respondents. If it is *confidential*, researchers *can* link data back to individual respondents or small groups, but agree not to. The linkage could be direct via an assigned code, a social security number or due to face-to-face interaction. Survey and interview professionals have an obligation not to harm respondents or diminish their dignity. Improperly protected data could do both. In the wrong hands, survey or interview data, especially data expressing proscribed views or behaviors, would be damaging if linked to individuals. Researchers using surveys and interviews determine the incidence of attitudes or behaviors in groups. They should examine aggregated rather than individual data. To gain cooperation, explain in a cover letter, or in introductory comments, how survey or interview data will be used, the benefits to respondents (e.g., being consulted, positive change) and how privacy will be safeguarded. It is important to mention that data are shared with management or other clients in aggregate form. Avoid asking for name or social security number. If such information must be collected, assign random codes and substitute them for identifying information in your data file. **Limit Objectionable or Very Intrusive Content**. It is recommended that potentially objectionable, threatening, or very intrusive questioning shall be limited, but not necessarily eliminated. Such content may be legitimate since is it important to study controversial issues to deal with them effectively. Arvey and Sackett (1993) caution that requesting information which invades privacy will be perceived as less fair in a selection situation (e.g., on an application form) than information which is not so invasive. If such items are included, the commitment to confidentiality should be

Method	Ethical Impact
	emphasized. **Ethical Implications for Prospective Participants.** According to Watson (1996) the participants have the right to decline to participate by not responding to the survey or interview or to specific items or questions, if they believe any of the following conditions are true: - The survey or interview is not voluntary: respondents are told they must respond and they desire not to, or other forms of coercion are used, such as the threat of punishment. - Insufficient information is given upon which participants could come to a decision based on informed consent. - The survey or interview is requested as a part of one's job, but some or all content is not job relevant, including questions about job irrelevant organizational memberships or privileged information the respondent desires not to share. - Privacy may not be protected: the survey is not anonymous, confidentiality may be breached, analysis and reporting of non-narrative data may occur at the level of the individual respondent or at a level of disaggregation which might permit disclosure of identity, or personal identifying information may not be excised from narrative data, except where the identity of a prominent individual (e.g., a CEO or Commander) would be difficult to conceal. - The requested information may be used to discriminate unfairly against respondents, harass them or harm them in other ways. - The items or questions are needlessly intrusive, or they are too offensive. Lit.: Arvey, R. D., & Sackett, P. R. (1993). Fairness in selection: Current developments and perspectives. In N. Schmitt & W. C. Borman (Eds.). *Personnel Selection in Organizations*. San Francisco: Jossey-Bass. Bradburn, N. M., & Sudman, S. (1988). *Polls and surveys: Understanding what they tell us*. San Francisco: Jossey-Bass. Salant, P., & Dillman, D. A. (1994). *How to conduct your own survey*. New York: John Wiley & Sons. Sieber, J. (1992). *Planning ethically responsible research: A guide for students and internal review boards.* Newbury Park, CA: Sage. Watson, T. W. (1996). *Guidelines for conducting interviews*. (AL/HR TR-1997-0043) Brooks AFB, TX: Cognition and Performance Division, Human Resources Directorate,

Method	Ethical Impact
	Armstrong Laboratory.
Surveys	See Interviews!
Contextual Inquiry	An observation evaluation can be a stressing event for the participant. The person might feel a pressure to perform, or experience feelings of inadequacy or even competition with other subjects Therfore itis mandatory within VERITAS to follow the following golden rules: 1. Do not waste the user`s time 2. Use Pilots to debug 3. Have everything ready ahead of time 4. Make users feel comfortable: empasize that the system is evaluated not the user 5. Acknowledge that the software might have problems 6. Let users know that they can stop at any time 7. Maintain privacy: let user know that results will be kept completely confidential: no disclosure to any other than VERITAS partners in a coded manner.
Focus groups	Ethical considerations for focus groups are the same as for most other methods of social research (Homan 1991). Also see: “Interviews”. For example, when selecting and involving participants, researchers must ensure that full information about the purpose and uses of participants’ contributions is given. Being honest and keeping participants informed about the expectations of the group and topic, and not pressurising participants to speak is good practice. A particular ethical issue to consider in the case of focus groups is the handling of sensitive material and confidentiality given that there will always be more than one participant in the group. At the outset moderators will need to clarify that each participant’s contributions will be shared with the others in the group as well as with the moderator. Participants need to be encouraged to keep confidential what they hear during the meeting and researchers have the responsibility to anonymise data from the group. Homan .R (1991) *Ethics in Social Research*. Harlow: Longman.
Card Sorting	See “Focus groups” and ”Interviews”
Participatory Design	Accordning to Marc Stehen (2011), Participatory Design is based on *encounters* between people, which, according to ethics-of-the-other are ethical encounters; Participatory Design is a *process* of articulating a problem and developing solutions, which, according to pragmatist ethics, is an ethical process; and Participatory Design participants’ attitudes, choices and actions are critical to Participatory Design, which, according to virtue ethics, involves ethical questions about one’s character. Conclusions as well as advices are summarized in the table below, in relation to two elements of design thinking: 1) generating ideas and developing knowledge (a perceptive, curious, inward motion); and 2) making decisions and creating things (a conceptive, creative, outward motion). Of course these conclusions may also be implied to “interviews” and “surveys”. Table: Different forms of ethics in relation to design thinking, and the ethical qualities of participatory design.

<table>
<tr><th>Method</th><th>Ethical Impact</th></tr>
<tr><td></td><td>
<table>
<tr><th></th><th>Generating ideas and developing knowledge</th><th>Making decisions and creating things</th></tr>
<tr><td>Ethics-of-the-other — encounter</td><td>Tendency to grasp the other. Attempt to welcome the other (desire)</td><td>Tendency to program invention. Attempt to welcome otherness (passivity)</td></tr>
<tr><td>Pragmatist ethic— process s</td><td>Joint inquiry, with perception, sharing of experiences and empathy</td><td>Joint inquiry, with conception, cooperation and learning</td></tr>
<tr><td>Virtue ethics— character</td><td>Cultivate an appropriate form of curiosity (mean or middle)</td><td>Cultivate an appropriate form of creativity (mean or middle)</td></tr>
</table>

Lit:: Marc Steen 2011, Nordic Design Research Conference 2011, Helsinki</td></tr>
<tr><td>Heuristic Evaluation</td><td>- Usability evaluation of user interface by small sample of experts using certain heuristics. No end-users (beneficiaries are included)
- Constrained by the evaluator’s knowledge, the domain and of the target user group
- No special or additional “Ethical precautions” have to be taken. Of course the experts shall join voluntarily, data should be kept secured etc…</td></tr>
<tr><td>Cognitive Walkthrough</td><td>- No special or additional “Ethical precautions” have to be taken. Of course the experts shall join voluntarily, etc…
Biggest problems (but not really “ethical problems”):

- important problems may get missed

- many trivial problems are often identified</td></tr>
<tr><td>Expert Review</td><td>- No special or additional “Ethical precautions” have to be taken. Of course the experts shall join voluntarily, etc…
No end users envolved.</td></tr>
<tr><td>Storyboarding</td><td>- No special or additional “Ethical precautions” have to be taken. Of course the beneficiaries shall join voluntarily, etc…</td></tr>
<tr><td>Usability Testing</td><td>It is an ethical issue to apply only safety tested equipments to human participants – nevertheless safety testing involves technical aspects to be provided by our partners. Partners have to provide a full qualification of the components developed so far. E.g. to verify/improve equipment final performances from the Electromagnetic compatibility (EMC) point of view. Laboratory tests shall be conducted to validate the performances of each components of the measurement loop. Those parts that are intended for clinical or close to clinical use have to be assessed for their compliance with the relevant standards. In this case full testing that is required for the final product phase is beyond</td></tr>
</table>

Method	Ethical Impact
	the scope of a research project. However, smaller scale tests for research prototype - type of applications are still needed. These include basic safety assessmen, according to the requirements given in the standard IEC60 601-1-2 for interference with medical devices. The following declaration could be used: On behalf of _____ (Company), I _____(responsible person) declare (with respect to the data collection/ pilot planning) for the product:_____the following: 1. I guarantee that only common and certified technologies are used. Therefore no harm to the participants can be foreseen. In detail: there should be no harm due to: • Allergenic reaction of the skin • Electromagnetic compatibility • Biological or other adverse effects • Electrical\Burn hazards 2. The above only applies if the system is used under supervision during the pilots. 3. During the development we were aware of the Medical device Directive (MDD 93/42/EEC). 4. We feel strongly committed to the well-being, welfare and health of our potential participants and the Ethical Code of Conduct defined in the VERITAS Ethics Manual _____ (Name, Date, location,) (Signature) co-signed by VERITAS Ethical Supervisor:_____ Beside the technical security, datamanagment issues have to be taken into

Method	Ethical Impact
	consideration for usability testing as well: **Technical Security Requirements** The following requirements will guarantee that Privacy Issues will be handled with highest technical standards: - Physical integrity - Logical integrity - Element integrity - Access control/User authentication - Availability - Auditability Description: - Physical integrity: the data of the VERITAS system is immune to physical problems, such as power failures, so that it is possible to reconstruct e.g. a database if it is destroyed through a catastrophe - Logical integrity: the structure of the VERITAS database is preserved with logical integrity; a modification to the value of one field does not affect other fields - Element integrity: the data contained in each element is accurate - Access control, different users can be restricted to different modes of access (e.g., read or write) - User authentication, in order to be sure that every user of the VERITAS database platform is positively identified, both for the audit trail and for permission to access certain data - Availability, the users can access the VERITAS system in general and all the data for which they are authorized - Auditability, possiblity to track who has accessed (or modified) the elements in the VERITAS databases
Task Analysis	See “Usability Testing” and “Interviews”
Feature/ Consistency/ Standards inspection	See “Focus groups”, ”Usability Testing” and “Interviews”

Method	Ethical Impact
Think Aloud Protocol	See “Focus groups” and “interviews”
Prototyping	See “Usability Testing”
Paper Prototyping	See “Focus groups” and “interviews”
Co-Discovery Method	See “Contextual Inquiry” and ”Perfomance measurment”
Performance measurement	“Contextual Inquiry”and “Participatory Design”
Wizard of Oz ➢ Qualitative results	See “Contextual Inquiry”, ”Perfomance measurment”
Log-files ➢ Quantitative results	User has to be informed and s/he has to give consent that data are collected. See also ”Perfomance measurment”, “Contextual Inquiry”and “Participatory Design”
Workshops ➢ Qualitative results	See “Focus groups” and “interviews”

4 UCD Applicability Review

This section examines the applicability of the VERITAS UCD method by evaluating the ways in which it has been applied across the VERITAS project so far. This report is compiled of activities completed up till Month 18 and, as such, it is not a complete list of all the work that has been performed in the project.

This section outlines the questionnaire that was sent out to all of the developers, work done on a Work Package to Work Package basis and then goes on to look at some of the common issues that have been encountered and the ways in which they are relevant to other application developers.

4.1 Questionnaire

The questionnaire that was designed for the purpose of VERITAS UCD reporting is outlined below. The full questionnaire can be seen in Appendix C. The explanatory text is provided here that was given to all application developers to evaluate the impact of the UCD process on their work:

Work Package: ??	**Activity Number: ??**	**Partner: ??**
1) User centred design methods used: *(Please list the user centred design methods that this activity has been involved in based upon Table 20 and Table 21 of D1.1.2. If a UCD method from Table 20 has not been applied please explain why in question 5 on impact below)*		
2) Users Involved: *(Please list groups and profiles of each group member: age, gender and disability or professional role a sapplicable)*		
3) Process followed: *(For each type of user centred design method you identified in question 1 please briefly describe the process that you followed including the challenges you faced and successes you had)*		
4) Output: *(For each user centred design activity please describe the output from the process, if their is forma documentation of this then please include it)*		
5) Impact: *(Please describe in some detail how following each of the different methods you identified in question 1 has impacted on your work. If you have not followed any of the methods listed in D1.1.2 then please explain why here)*		
6) Contact person: *(Please provide a name, a phone number and email address for a group member who can answer any further questions if necessary)*		

4.2 SP 1

This section presents the findings of the SP1 partners who have engaged in UCD so far (up until month 18). The full set of techniques expected in SP1 can be found in Table 20 and 21.

Work Package: 1.1	Activity Number: A1.1.1	Partner: MCA
1) User centred design methods used: *Face-to-face interviews* *User forums*		
2) Users Involved: Users involved: • Upper limb impaired (age groups 25-35, 4 male and 2 female) • Lower limb impaired (age groups 25-35, male and female) • Vision impaired (age groups 25-35, 2 male and 6 female) • Hearing impaired (age groups 25-35, 1 male and 1 female)		
3) Process followed: *Face-to-face interviews: individual people with disabilities were contacted personally and were then interviewed, whereby every aspect of the task analysis was addressed. This was needed to describe the exact movements someone makes when e.g. starting a motorbike when only having 1 leg.* *The users were from Belgium, Greece and Bulgaria.* *User forums: where we had diversifications in ways people e.g. drive cars, or were walkinga round in houses, we had the opportunity to bring together 17 people. These were presented with all tasks, which were discussed one by one. The outcome was the task analysis as is now.*		
4) Output: See task analysis VERITAS_D1.7.2_final, and VERITAS_ID1.7.1_final with its annexes.		
5) Impact: This was the only possible manner to describe each of the tasks. This has in fact substantially helped in delivering a high quality task analysis.		
6) Contact person: Karel Van Isacker (veritas@marie-curie-bg.org)		

Work Package: WP1.1	Activity Number: A1.1.3	Partner: RELAB
1) User centred design methods used: • Online survey and questionnaires (217 surveys collected); • interviews (21 interviews performed).		

2) Users Involved:

- "End users" have been involved in the activity. Find below some details about users' profile (for more details about personal data, job and professional knowledge or users' profile see "D1.1.1, 8.4 Industrial needs of designers and developers"):
    - designers and developers (100%)
        - junior designers (17,86%)
        - junior developers (25,00%)
        - senior designers (21,43%)
        - senior developers (25,00%)
        - other (10,71%)
    - age
        - 25-35 (56,67%)
        - 35-45 (20,00%)
        - 45-55 (16,67%)
        - >55 (3,33)
    - education field
        - industrial design (10,00%)
        - engineering (83,33%)
        - human factors / ergonomics (16,67%)
        - other (6,67%)

3) Process followed:

- The data presented within D1.1.1 are based on the gathered surveys and interviews.
- Online survey and questionnaires.
    - Users were invited to complete the survey through relevant questionnaires that were designed in order to identify their industrial user needs in terms of procedures followed for the design and development of new products and their potential relation with older people and people with disabilities. The collected data will form the basis to implement appropriate tools and methodologies in order to increase awareness and need for accessibility in the five selected areas.
- Interviews (21 interviews performed).
    - Per application area, 4 face-to-face interviews were scheduled.

4) Output: Deliverable presents the descriptive statistical analysis of each item of the survey with tables of results and charts.

- Relevant results are presented per sector when necessary.
- The survey among developers and designers in the different application areas, revealed how accessibility is currently, or not addressed and what tools are being used in this process.
- Results have been plotted and parameterized according to defined statistical criteria and methods common in social science analyses and in human factors techniques for users' requirements definition.
- Results are presented in details in the "Chapter 8 Industrial needs per sector" of Veritas deliverable *D1.1.1 UCD-based user requirements extraction.*

5) Impact:

- Online survey and questionnaires;
- interviews.

Both methods identifies users' profile, expertise in design and development process. They pointed out their expectations about Veritas tools and accessibility of new design solutions. Users' needs should be considered for any further activity, analysis and development activities in Veritas project. The collected data will form the basis to implement appropriate tools and methodologies in order to increase awareness and need for accessibility in the five selected areas.

The aim of the VERITAS development chain is to involve end users throughout the development chain, from the early design phases on. The project requires a detailed understanding of end-users' wants, needs and expectations in the VERITAS fields of application. The survey allows project partners to collect a huge basis of information to define users' needs according to SP1 - WP1 work in progress. It is suitable to deepen user modelling providing a benchmark between working areas.

According to Human Factors studies, questionnaires and interviews have been selected as most suitable and efficient methods to be perfomed in VERITAS in order to collect and investigate users' requirements. Users have been contacted in distance (web-based questionnaires) and they have been able to provide information anonymously.

6) Contact person: Please, for any further questions to end users involved in the survey contact RELAB, Elisa Landini, e.landini@re-lab.it, 0039 (0)522 2663.

Work Package: WP1.2	Activity Number: A1.2.1	Partner: CAF

1) User centred design methods used:

The aim of Continental developments within WP1.2.1 was to develop a vision based measurement module to be integrated into the VERITAS multisensorial platform. This vision module aimed to rebuild the 3D position of the users hand/elbow with a quite good accuracy in a given working space. We assume that users are seated on driver seats or in front of working spaces. So this work has not focused on specific users' groups but exclusively on the effficiency of the measurement system to address and rebuild all the potential position of the user arms inside the given working area whatever the users' limitations. This measurement system cannot be considered has a specialized tool but as a general measurement tool with a large application spectrum. Applying this tool for VERITAS purpose will allow to easily reconstruct the user movements and then to address accessibility limitations. The preliminary perfomance evaluation of this tool has been performed with normal users moving their arms in the overall working space.

Following the UCD recommendations the development of the vision measurement tool was considering the two following methods:

- Performance measurement
- Prototype evaluation

2) Users Involved:
3) Process followed: Performance measurement has been performed evaluating the detection and reconstruction capbility of the video measurement tool as well as the accuracy of the 3D position of the observed hands and arms. The prototype evaluation was concerned with the efficeincy of the tool to detect arm and hand inside the overall operating domain, in order to guarantee that the 3D reconstruction will be always effective. This evaluation has been performed for various experimetal conditions close to those of the VERITAS pilots
4) Output: The vision measurement tool ouputs 3D positions of the hand, elbow, as well as charactreristic vectors of the before arm and velocities. More details are given in deliverable 1.2.1
5) Impact: Measurement performance as well as prototype evaluation have obviously a direct impact on the design of the tool. Impact on the camera integration scheme but also on the image processing algorithm.
6) Contact person:

Work Package: WP1.2	Activity Number: A1.2.2	Partner: SMARTEX
5) Impact: The aim of the activity is to develop a set of wearable systems as part of the multisensorial platform. The multisensorial platform belongs to the first phase of the VERITAS project in which it was necessary to identify all the requirements, and develop all the instruments necessary for the definition and the tuning of the abstract user model. The final aim is to extract from the observation and measurements of movements the necessary metrics for the abstract user model. The beneficiaries will be involved directly in this latter part, for this reason during the engineering phase, the iterative process of the performance tests and evaluation of the different prototypes were conducted on healthy people.		

Work Package: 1.2	Activity Number: A1.2.3 – 1.2.5	Partner: CERTH/ITI
1) User centred design methods used: Measuring the physical behaviour of beneficiaries (e.g. motion capturing).		

2) Users Involved: *Users with mild walking disabilities:*

- *31, M*
- *37, M*
- *30, M*
- *28, M*
- *33, M*

3) Process followed: *Measurement of several gait related disability parameters and identification of the ground truth.*

4) Output: *Ground truth of measurements and related estimates of the motion tracking module.*

5) Impact: *Very high impact for the tuning of several algorithmic parameters so as to optimize system performance and accuracy.*

6) Contact person: Konstantinos Moustakas, +302311257723, moustak@iti.gr

Work Package: 1.2	**Activity Number: A1.2.6**	**Partner: CERTH/ITI**

1) User centred design methods used: System tests and usability analysis based on direct interviews

2) Users Involved:

Designers and engineers:

- *30, M*
- *34, M*
- *38, M*
- *27, M*
- *34,F*
- 32, M
- 37, M

3) Process followed: System tests with several modules and subsystems of the multisensorial platform manager and workflow engine. Usability issues at the workflow engine have been identified that were related to the quality of the overview of the user on the workflows and on the run-time state of the workflow during normal operation. These tests led to the adoption of a graphical interface for representing the workflow and the dynamic, interactive update based on the sensor network status, by providing the respective visual feedback to the user.
4) Output: Usability issues identified were directly used to implement the updated version of the sensor network manager and workflow engine
5) Impact: Very high impact for the usability of the workflow engine that will ease the implementation of the MSP capture sessions.
6) Contact person: Konstantinos Moustakas, +302311257723, moustak@iti.gr

Work Package:1.3	**Activity Number: 1.3.3**	**Partner: SMARTEX**
1) User centred design methods used: Measuring the physical behaviour of beneficiaries		
2) Users Involved: The user involved in the measurements has to be defined in term of age and gender. The disabilities chosen are: Parkinson Multiple Sclerosis Stroke (specific degree) Cerebral Palsy Hand Osteoarthritis Coxarthritis Gonarthritis Elderly Visual Impairment (to be confirmed) Hearing Impairment		
3) Process followed: The measurement sessions still have to be done.		
4) Output: Is not yet possible to describe the outcome of this activity (see point 3)		
5) Impact: A series of measurement sessions with the beneficiaries, to fine tune the abstract user model, will be performed in different sites. The measurements, taken by the multisensorial platform, will aim to collect all the needed parameters as defined in A1.1.3 and A1.2.3 for the classes of disabilities selected. These sessions will take place in controlled environments, following well defined protocols, in order to obtain the best accuracy possible from the measurements.		
6) Contact person:		

Work Package: 1.6	Activity Number: 1.6.1	Partner: HS

1) User centred design methods used: Usability tests

2) Users Involved: Age: 18-70, Gender: male, female, disablities are not adressed in this activity (see A1.6.5)

3) Process followed:

Usability tests:

The graphical user interfaces have been specified on base of the user requirements. These specifications are taken into account for the first software implementation. This implementation has been tested and evaluated in several basic use cases. During this evaluation usability problems regarding the graphical user interfaces have been reported. Finally corresponding interface improvements have been specified and implemented.

4) Output:

Usability tests:

Graphical user interfaces proofed to be usable with respect to basic use cases

5) Impact:

Usability tests:

The modifications of graphical user interface features, based on the evaluation of the first software implementation, caused some additional implementation efforts not planned at the beginning. But the final usability could only be effectively tested on a first version of the software. It would have been taken more time to address all usability issues in the first specification phase.

Standards inspection:

This method has not been followed, because it is not established at partner (HS) internal processes.

6) Contact person: Hans-Joachim Wirsching, +49-6313035600, hans-joachim.wirsching@human-solutions.com

Work Package: 1.6	Activity Number:A1.6.2	Partner:ITACA

1) User centred design methods used:

Prototype Evaluation with designers.

2) Users Involved:

Involvement of engineers and experts in user modeling in the three domains: physical aspects, cognitive aspects and psychological and behaviour aspects.

3 experts/domain for testing the MOUSI tool.

3) Process followed:

Step 1)First mock-up design

Step 2) Evaluation of the Mock-up with two designers: the application is first shown, and then the end-users perform simple tasks to test the usability. After that the experts evaluate the application and give suggestions for improvement. (Complete)

Step 3) Refinement of the application with the first evaluation. (Complete)

Step 4) Creation of the MOUSI application (Under development)

Step 5) Final evaluation of the application with 9 experts: Fullfillment of a usability questionnaire that goes through the basic functionalities of the MOUSI application. If usability scores are under 3/5, then a second iteration will be performed.

Step 6) Debugging and incorporation of last suggestions.

4) Output: *The output of the process will be the different questionnaires fullfilled by the experts and a brief analysis of the evaluation of the application with the possible recommendations for the application.*

5) Impact: *The methodology followed allows creating a simplified and useful tool for the designers, that just have to incorporate the values, and forget about the complexity of the process of creating a UsiXML schema. The tool is user-friendly and allows the use for different experts with limited knowledge about ontologies and XML.*

6) Contact person: *annacer@itaca.upv.es*

Work Package: 1.7	**Activity Number: A1.7.1**	**Partner: MCA**

1) User centred design methods used:

Face-to-face interviews

User forums

2) Users Involved: Users involved:

- Upper limb impaired (age groups 25-35, 4 male and 2 female)
- Lower limb impaired (age groups 25-35, male and female)
- Vision impaired (age groups 25-35, 2 male and 6 female)
- Hearing impaired (age groups 25-35, 1 male and 1 female)

3) Process followed: *Face-to-face interviews: individual people with disabilities were contacted personally and were then interviewed, whereby every aspect of the task analysis was addressed. This was needed to describe the exact movements someone makes when e.g. starting a motorbike when only having 1 leg.* *The users were from Belgium, Greece and Bulgaria.* *User forums: where we had diversifications in ways people e.g. drive cars, or were walkinga round in houses, we had the opportunity to bring together 17 people. These were presented with all tasks, which were discussed one by one. The outcome was the task analysis as is now.*
4) Output: See task analysis VERITAS_D1.7.2_final, and VERITAS_ID1.7.1_final with its annexes.
5) Impact: This was the only possible manner to describe each of the tasks. This has in fact substantially helped in delivering a high quality task analysis.
6) Contact person: Karel Van Isacker (veritas@marie-curie-bg.org)

4.3 SP 2

This section presents the findings of partners in SP 2 so far (up until month 18). The full set of techniques expected in SP2 can be found in Table 20 and 21.

Work Package: 2.1	**Activity Number: A2.1.5**	**Partner: CERTH/ITI**
1) User centred design methods used: System tests with some available modules and usability analysis of the architecture through interviews. Performance measurements will take place after the first prototype of the interaction adaptor has been finalized.		
2) Users Involved: *Designers and engineers:* – *38, M* – *37, M* – *32, M* – *32, M* – *25, M* – *29, F*		
3) Process followed: *Identification of usability gaps based on the targets of the interaction adaptor.*		
4) Output: *Guidelines for system development including modules, interfaces and link to the application domains.*		
5) Impact: *Impact on the user centred design of the interaction adaptor and the optimization of the interfaces and interaction paradigms.*		
6) Contact person: Konstantinos Moustakas, +302311257723, moustak@iti.gr		

Work Package: WP2.2	Activity Number: A2.2.1	Partner: CRF

1) User centred design methods used: A focus group with CRF engineers final users has been carried out in order to sort out the specific simulation aspects to be considered for the specific analysis to be performed with the VERITAS desktop tools.

Interview have been felt to be not necessary at this stage, since a representative sample of the ergonomics engineers (see 2) that are operating in FIAT has been involved (and had been involved in the User needs analysis of WP1.1)

2) Users Involved: Team of ergonomics engineers within the User Interaction and Project Management Depts of CRF, featuring:

- Several engineering competences - mechanical, physics, biomedical and computer science, project management for ergonomics methodologies.

- Extensive use of vehicle packaging SWs (including proprietary) and ergonomics analysis SWs (including Ramsis and Jack).

- Application of tools and related methods to vehicle innovation and to product development, with consistent knowledge of the population and product characteristics.

- Development of proprietary packaging tool and of SW procedures sitting on ergonomics simulation SWs.

3) Process followed: Based on User Needs analysis (to which they participated) and an analysis of the VERITAS Use Cases for the relevant applications, face-to-face meeting bringing to a shared set of relevant simulation aspects. Forward to the production of ID2.2.1

4) Output: Input to VERITAS ID2.2.1., particularly for analysis of Industrial needs and Application Requirements.

5) Impact: The method adopted, which is customary in this teamwork, has supplied valuable results for the required task.

6) Contact person: Giuseppe Varalda

giuseppe.varalda@crf.it | +39 011 9083458

Work Package: 2.4	Activity Number: 2.4.1	Partner: BYTE

1) User centred design methods used:

- Review of relevant standards and guidelines

- Physical observation of task analysis of office workers with disabilities while performing office tasks.

- Questionnaire survey

2) Users Involved:

Physical observation

8 office workers, employees in a company designing office workplaces and selling office equipment in Athens Greece, 4 males and 4 females. Professional role: 1 secretary, 1 accountant, 2 salespersons, 4 designers.

Questionnaire survey

We collected 33 completed questionnaires. 16 of the respondents were male and 17 female and their mean age was 35 years. All of them were office workers, and their occupations were: 5 Accountants, 2 Cashiers, 1 Communication Manager, 2 Economists, 10 Engineers, 2 Lawyers, 1 Psychologist, 8 Secretaries, 1 Salesperson, 1 Software developer.

3) Process followed:

Physical observation

The experimentator was sitting next to each workspace without intervening with the observed person and every 5 min he was noting on a tabular sheet the task or tasks performed by the observed person at this specific moment.

Questionnaire survey

A specific questionnaire has been designed and was made available online at http://veritas-project.eu/2011/04/usage-of-collaborative-tools-among-office-workers/ and at http://www.disabled.gr/lib/. The questionnaire has been also sent as hard copy to associations of disabled persons in Greece.

4) Output:

Physical observation

We got a total of 96 observations for each of the 8 persons and from this we calculated the frequency of each task as the total number of observations of this task by the total number of observations.

Questionnaire survey

We concluded to a frequency of use of collaborative tools among the sample and to the perceived usefulness of the tools. Unfortunately, we got very few responses on problems encountered when using such tools and on ideas for their improvement.

5) Impact:

Physical observation

We concluded to a prioritisation of office tasks that consume most of the time of office workers in the area of workplace design.

Questionnaire survey

According to the derived frequency of use and perceived usefulness of collaborative tools among the sample, we established a priority list for future developments within the project.

6) Contact person: Georgios Venianakis, Konstantinos Palamaras (BYTE) +302109002000, email: bezerianos@byte.gr

Work Package: 2.4	Activity Number: A2.4.2	Partner: CERTH/ITI
1) User centred design methods used: Evaluating the interaction models, including multimodal interfaces and assistive devices.		
2) Users Involved: *Users with disabilities and assistive technology designers:* – *42, M* – *35, M* – *28, M*		
3) Process followed: Interviews, usability tests and mock-up system tests. Performance tests will be carried out when the Multimodal interface toolbox is available.		
4) Output: Identification of a common general VERITAS interaction models as well as instances for the supported application domains.		
5) Impact: Very high impact for the support of assistive devices and multimodal interfaces in the VERITAS simulation platform.		
6) Contact person: Konstantinos Moustakas, +302311257723, moustak@iti.gr		

Work Package: WP2.6	Activity Number: A2.6.1	Partner: I+
1) User centred design methods used: Interviews and Observation		
2) Users Involved: *Beneficiaries:* designers of medical devices and software applications for remote monitoring services. *Experts working with end users:* physicians, caregivers and service providers		

3) Process followed: The process with beneficiaries started from the observations of their current solutions for healthcare remote monitoring services, in order to identify *usability* and *accessibility* reference parameters (especially for motor impairments people), also according to their experience. Then beneficiaries suggested also references of state of the art in usability and accessibility requirements especially for elderly and disabled people using healthcare solutions. During the interview they enhaced that very few simulation tools are available in this domain to design accessible and usable solutions.They think these instruments could be very useful to enhance the solution's performance also from the usability and accessibility point of view. Infact using data collected from a wider set of individuals to validate the simulation environment, there is a greater confidence that our system will function for a broader segment of the population. A second advantage is to more rapidly perform feasibility studies and decrease the number of iterations that a prototype must go through before it has the desired functionality according to the specified requirements. The process with experts working with end users was based on interviews to identify useful parameters for *acceptability* of innovative systems in healthcare remote monitoring, starting from their direct experience with end users.
4) Output: Identification of keys parameters of usability, accessibility and acceptability, references of guidelines and metrics
5) Impact: Interviewes and Observations with beneficiaries have been crucial to identify usability and accessibility requirements and to collect references of the state of the art reported in the Internal Deliverable ID2.6.1. Interviews with experts had a relevant impact to analize the Acceptability issues of remote monitoring solutions for personal healthcare domain. In addition to these points, interviews and observations with beneficiaries and experts allowed to update Veritas tasks analysis in Personal Healthcare domain, so that every task's description includes also proper usability, accessibility and acceptability parameters.
6) Contact person: Beneficiaries contact person: Eng. Alberto Rugnone, +39 055 354829 a.rugnone@i-piu.it Expert contact: dr. Tullio Biondi tulbio@tiscali.it +39 3398724833

Work Package: 2.8	**Activity Number: A2.8.2**	**Partner: CERTH/ITI**
1) User centred design methods used: Evaluating the interaction models, including multimodal interfaces and assistive devices.		
2) Users Involved: *Users with disabilities and assistive technology designers:* – *42, M* – *35, M* – *28, M*		
3) Process followed: *Interviews, usability tests and mock-up system tests. Performance tests will be carried out when the Multimodal interface toolbox is available.*		

4) Output: *Identification of a common general VERITAS interaction models as well as instances for the supported application domains.*
5) Impact: *Very high impact for the support of assistive devices and multimodal interfaces in the VERITAS simulation platform.*
6) Contact person: Konstantinos Moustakas, +302311257723, moustak@iti.gr

Work Package: 2.8	**Activity Number: A2.8.3**	**Partner: CERTH/ITI**
1) User centred design methods used: Mock-up usability tests and interviews. System tests and performance measurements will be performed when the first version of the multimodal interface toolbox is available		
2) Users Involved: *Designers and engineers:* – *37, M* – *27, M* – *28, M* – *34, M* – *31, M*		
3) Process followed: *List of supported multimodal interfaces and assistive devices. Description on the situated disabilities for the application domains and the areas where modality compensation would provide added value.*		
4) Output: *Definition of the modality compensation module and multimodal interfaces architecture.*		
5) Impact: *High impact for providing a realistic, simple and usable modality compensation framework.*		
6) Contact person: Konstantinos Moustakas, +302311257723, moustak@iti.gr		

4.4 SP 3

Work package three takes place later in the VERITAS project and it has not yet completed any UCD design activities. As they are completed, relevant activities can be entered into this section of the documents. The full set of techniques expected in SP3 can be found in Table 20 and 21.

4.5 General Review of Applicability

This section presents a high level examination of the uptake of UCD design methods in the VERITAS project. Our findings suggest that the UCD approach

has been extremely successful in terms of reach, applicability and impact on partners work.

4.5.1 Statistics

23 activities completed before Month 18 in the project have reported on their UCD activities. Of those 23 activities, 21 have successfully completed UCD activities with positive impact on their process and 2 others intend to complete their UCD process as soon as possible. This suggests that the VERITAS UCD approach has been widely adopted by the partners that are engaged in the project.

More than 26 beneficiaries have been worked with in the first 18 months of the project and worked with directly.

More than 60 users of the system engaged with in UCD directly.

More than 310 users have been engaged with through surveys providing a broad base of users who have had a wide range of impacts on the partners work.

The approach was applied with a roughly representative group of male and female users and beneficiaries of mixed ages.

4.5.2 Diversity of Techniques

The wide range of techniques documented in the previous section (22 in all) is reflected in the diversity of techniques applied in the work of the partners. The techniques are not all used but the bulk of the UCD activity is yet to be performed so this issue is understandable. BY the end of the VERITAS project we expect that all of the techniques that are described in the deliverable will be applied.

No partner has mentioned needing to develop their own UCD approach to date which suggests that the list provided in this deliverable is comprehensive for this project and does not need to be further expanded at present.

However, the characteristics of the work being performed will change over time and as such it is important that this document remains “alive” which is to say that it is open to including new techniques should they be required.

4.5.3 Quality and Impact of the UCD methods

When describing the impact of the VERITAS UCD methods many partners noted positive impacts from the process. Comments from the partners noted:

- the large base of users that the process allowed them to reach
- the improvements in the quality of the designs that were produced by the partners

- the improvements in the quality of the products that were made
- the ability for the UCD process to allow partners to establish Ground Truth in their field of work
- the possibility for tuning their design approach based upon the feedback received from other partners
- the improvements that were made in the usability of the applications that were being produced

This feedback all points to the UCD process being highly applicable for the partners that have used it so far and of it having a significant impact on the quality of the output from the VERITAS project.

4.5.4 Observed Issues with UCD Methods

Three main areas that are problematic or interesting are revealed in the analysis of the output from the design sessions.

4.5.4.1 Time Frame

Of the three Activities that reported non-completed UCD processes, 2 felt that they would perform the activity at some point in the future but had not done so yet.

Our first comment on this is that, across 23 activities only encountering 3 issues (13%) is an excellent success rate. The process of engaging with users is remarkably problematic and avoiding the associated timetabling issues is very rare.

Secondly, it may be that the scheduling of some of these UCD activities is not entirely appropriate for the partners experiencing issues performing the activities. If the process is to inform later activities then there is little urgency required in completing them and, in the future, a tighter integration between the designers of the UCD methods and the other partners may alleviate some of these issues.

Re**commendation:** *In the future all partners need to be more tightly integrated into the process of constructing UCD requirements and the linkage of UCD activities to the activities themselves might need to be weakened to allow the partners the flexibility they need t complete their UCD activities as appropriate.*

4.5.4.2 Internal Process Integration

The process of integrating the UCD process into partners own working practice needs to be carefully considered.

Where partners are not familiar with the process that is being proposed (e.g. activity 1.6.1 – Standards Inspection) they can report issues with their ability to implement the process (although A1.6.1 did perform other UCD activities).

In contrast, several partners have reported particularly smooth operation of their UCD process when working with techniques that they are already familiar with.

The wide number of activities that were reviewed in this deliverable was intended to, in part, allow partners the flexibility to choose to follow the appropriate methods. Clearly in the future this need to be more strongly emphasised and partners need to be made aware of the possibility of receiving training from the UCD team if they do not know how to perform a given activity.

Recommendation: *This finding suggests that the type of activity being performed and the partner performing the activity need to be considered when determining the UCD method which is to be applied rather than solely considering the type of finding that we wish to develop.*

4.5.4.3 Ethical Approval Process

None of the partners have reported that they have been unable to complete the process of performing UCD because of issues arising from their ethical approval boards (see Section 3 or D1.4.4 for more information on the ethical approval process of the VERITAS partners).

This is of note due to the considerable emphasis that has been placed upon the approach to ethics in the VERITAS process and suggests that the process has been successful.

Recommendation: *In the future, the VERITAS ethical approval process may be considered adequate for avoiding issues associated with ethical approval for considering UCD based issues.*

4.6 UCD Applicability Summary

The UCD approach proposed for VERITAS has been widely used without trouble with 87% of partners who have used the approach to date reporting that their use has been beneficial. This is an extremely good result when working with a method as volatile as user centred design and meeting with end users.

The large number of people engaged in the process suggests that the process is being thoroughly applied as well. The discrepancy between some partner numbers is mainly attributable to the methods employed differing (e.g. the survey methods that are employed allow a much wider uptake than individual interviews).

However there are some partners reporting issues and where the process has encountered issues, we have identified the problem and suggested how this might be rectified in the future.

As the project moves into its next stage there are no reasons to think that the other activities will struggle in applying the VERITAS UCD approach in their work.

5 UCD Product life-cycle approach

Following the development of the VERITAS application and tools is the launch and exploration of these. This goes beyond the UCD process needed for the design, development and evaluation of the VERITAS tools. Figure 21 displays the product life-cycle of VERITAS by adding an additional iteration to the process depicted in Section 1.1.2. After the launch and exploitation stage, the developed VERITAS applications are applied by end user. Market research with those end users allows the extraction of usability issues and additional requirements that future designs and developments of VERITAS could address. End users satisfactions with the tools provided could be evaluated. This again can support the improvement of the VERITAS applications.

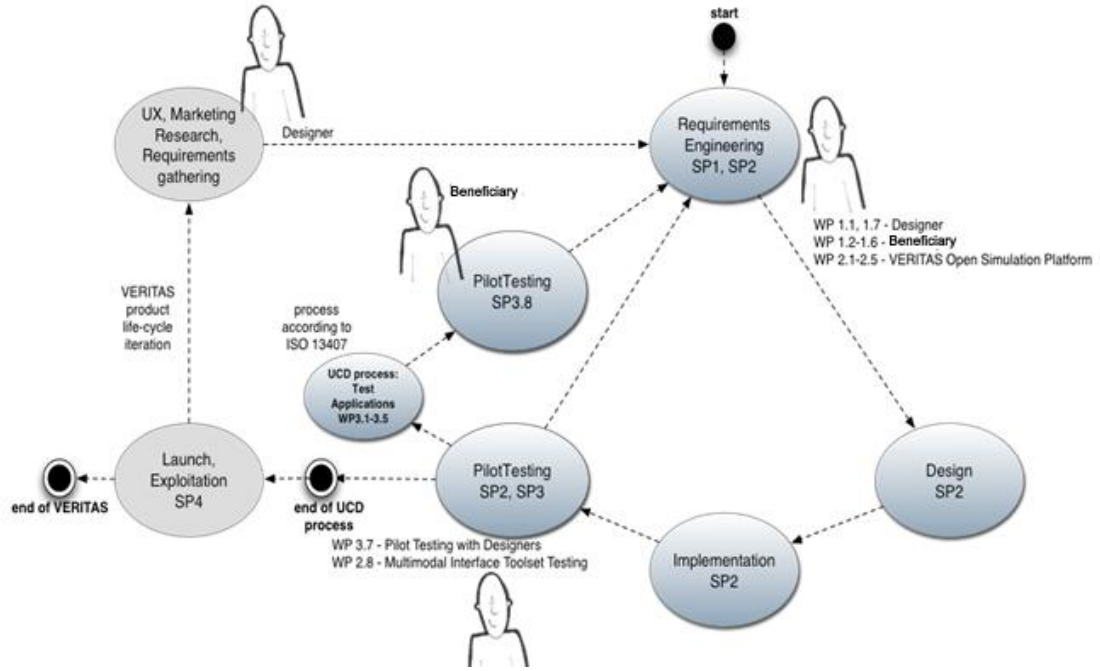

Figure 21 VERITAS UCD product life cycle approach

5.1 Launch/ Exploitation SP4

In this step the VERITAS tools are launched. The launch and exploitation phase of the VERITAS tools incorporates the development of all the materials (training, marketing, etc.) necessary to bring the VERITAS tools to the market. The phase further contains an exploitation plan which comprises a business plan to properly exploit the tools and prepare the tools to be ready for the market.

This phase is not part of the UCD process.

5.2 Market Research and UX Research

Requirements and enhanced functionalities of the VERITAS tools may be identified through proper marketing research and user experience research.

This phase may find requirements and new findings that lead to further iterations of the VERITAS tools and thus completes the product life-cycle approach depicted in Figure 21 (cf. Mayhew, 1998 and Nielsen, 1992 on usability engineering lifecycle). The further step added to the VERITAS UCD development process includes the evaluation of the final product through

a) Summative usability evaluations

b) User experience evaluations

c) Marketing research

While a summative usability evaluation provides us with means to enhance the usability of the tools thus enhance the user experience of the end user when designing using the VERITAS tools.

The user experience of the VERITAS tools goes beyond usability and additional user experience parameters like design factors (for further information on user experience and its measurement see for instance Tullis & Albert, 2008; Unger & Chandler, 2009). User expectations for instance are evaluated to collect information about the potential usage of the VERITAS tools and in the following to generate new requirements for future iterations and releases of the tools.

Marketing research allows us to obtain further requirements not covered through usability and user experience evaluations and is crucial for an iterative enhancement and exploitation of the VERITAS tools as a product.

6 Conclusion

This document, entitled D1.1.3: “UCD design revision manual” presented the user centred design approach to be followed within the VERITAS project and the impact that approach has had upon the partners who followed it alongside the ethical and legal issues that surround the project..

The concept of the UCD methodology as enhanced waterfall model (based on the ISO Standard 13407) with formative and summative evaluations including VERITAS users at each stage of the design and development process has been presented. This process was then mapped onto the different work packages, activities and application areas of the VERITAS project. Guidelines as to how to select appropriate methods for a UCD process in the respective project stage are provided and each of these methods described in detail.

The legal and ethical issues that the project has faced, as surmised in other deliverables, has also been presented here for the sake of completeness so that partners can refer to this document easily.

Finally, the impact and applicability of the process over the first 18 months of the project has been assessed and the impact has been shown to be large on many partners with over 26 beneficiaries directly engaged and over 310 users engaged.

The current document will constitute a “living” document throughout the VERITAS project, and updated according to the process made in the course of the design and development process.

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Appendix A

Overview about all methods for a UCD process in VERITAS:

Method	Main Objectives and how they get achieved	Advantages	Disadvantages	Amount of end users	Costs
Questionnaires ➢ Quantitative results	➢ Information regarding some specific issues (e.g. knowledge about area, demographic data) with prefixed possible answers. ➢ Prompt the participants by asking direct questions.	➢ Appropriate technique for large samples (huge amount of target users can be reached) ➢ Answer's objectivity ➢ Systematic analysis possible presents a good relation information-cost ➢ Much data can be acquired in short time ➢ User facilities are provided concerning when and where to answer it	➢ Response rate is very low unless the questionnaire is distributed by mail ➢ Reliability of the answers is not very high ➢ No personal contact with users ➢ Truthfulness of the answers uncontrolled ➢ It may be user's inhibition answering some questions ➢ Less flexible than interview ➢ Method should measure the variable that is intended to be measured	min. 10 per area under investigation	Low
Interviews ➢ Qualitative results	➢ As many additional information that has not been gathered through fixed question from face to face session with the user ➢ Duration per interview: approx. 45 - 60 minutes	➢ Users' preferences and attitudes can be obtained ➢ More detailed information from the user than through questionnaires ➢ More adaptability of questions to context and user responses than through questionnaires ➢ Is very effective for high level evaluations (e.g. getting information regarding the users' preferences, impressions and attitudes) ➢ High response rate ➢ Great reliability of the data collected	➢ Many economic and personal resources are needed to carry out the interviews ➢ Possible lack of objectivity and bias ➢ Difficult to apply to disperse populations	Approx. 5-7	Medium

Method	Main Objectives and how they get achieved	Advantages	Disadvantages	Amount of end users	Costs
		➢ The user's real needs of information can be known ➢ It is possible to solve user's doubts during the interview due to the direct relation between the interviewer and the user ➢ Very useful method for users with low cultural level and with difficulties to express their ideas in writing ➢ Useful method to find not foreseen problems in the design phase			
Surveys ➢ Quantitative results	➢ Quantitative information regarding users' preferences, habits, attitudes, etc. ➢ Duration to fill out the survey: approx. 5 - 10 minutes	➢ Less biased (no interviewer effects) ➢ Less tendency to lie since anonymous (in particular in large online studies) ➢ Objective measurement ➢ Easy to apply useful in describing the characteristics of a large population (larger samples feasible; statistically significant results) ➢ Can be administered from remote locations using mail, email or telephone ➢ Many questions can be asked about a given topic giving considerable flexibility to the analysis ➢ Flexibility in how questions are administered (face-to-face, phone, email, etc.) ➢ Standardized questions make measurement more precise (uniform definitions upon the participants are enforced) ➢ Usually high reliability	➢ as it relies on standardization, it forces the researcher to develop questions general enough to be minimally appropriate for all respondents, possibly missing what is most appropriate to many respondents ➢ large sample needs to be available and has to reply ➢ survey research as opposed to interviews can seldom deal with "context"	Large scale of participants	Low

Method	Main Objectives and how they get achieved	Advantages	Disadvantages	Amount of end users	Costs
Contextual Inquiry ➢ Qualitative results	➢ Understanding user's needs, preferences for certain tools or real life problems by observing them in their work context ➢ Duration: several hours up to several days per user	➢ Direct measurement of behaviour, no biased report of intentions or narratives ➢ More valid (user behaviour less prone to lies)	➢ Step from data collection to design requirements is hard; requires experience and expertise ➢ Requires long times of observation ➢ Blind to cognitive or affective variables ➢ Data is not generalizable	Approx. 3	Medium
Focus groups ➢ Qualitative results	➢ Information from the user by means of an open discussion among a few users lead by a moderator ➢ users are asked to share their opinions, thoughts and ideas about a specific subject ➢ Duration: approx. 1-2 hours per focus group session	➢ Moderator in face-to-face session can motivate the discussion and engage participants to reveal their opinion ➢ New thinking about a topic can be stimulated through group discussion (more in-depth and intense form of discussion) ➢ Trustworthy naturalistic data that also lead to important insights about human behaviours by allowing all participants to say anything they would like in front of the whole group ➢ Rather natural discussion evolves ➢ A well-designed guide encourages group members to relax, open up, think deeply, and consider alternatives	➢ Evaluation of the gathered "discussion data" is rather complicated ➢ It is possible to gauge a groups' overall reaction to educational materials, but not on an individual basis. ➢ Focus groups do not produce reliable data on topics that produce extremely strong feelings ➢ No generalizations possible ➢ Not objective ➢ Moderator needs to be experienced	Approx. 6-12	Medium
Card Sorting ➢ Quantitative results	➢ Sorting of cards by users and naming of each resulting pile to express the common characteristics of these cards ➢ The aim is to discover the optimal organization of the information from the user's point of view	➢ Quick and cheap ➢ No technology required, so highly portable ➢ Feedback early in the design process ➢ This method can support paper prototype ➢ Useful to categorize information. It enables designers and developers to understand how target users	➢ Challenging to capture results from a complex session ➢ Does not reveal interface problems ➢ Different people call the same thing by different names	➢ 25-30 to gain useful results	Low

Method	Main Objectives and how they get achieved	Advantages	Disadvantages	Amount of end users	Costs
		group the items ➢ Identifies terms that are likely to be misunderstood and/or difficult to categorize			
Participatory Design ➢ Qualitative results	➢ Users are involved in the design process of an application (e.g. in making a paper prototype) ➢ Duration: Approx. 1-2 hours per session	➢ better understanding of final users needs and the tasks that need to be fulfilled ➢ Opportunity for users to influence design decisions ➢ Increase users' acceptance of the final system through inclusion of user ➢ Methods are east to apply	➢ Time intense ➢ Availability of target users (e.g. users with disabilities, ethical approvals)	Approx. 3-5 per session	High
Heuristic Evaluation ➢ Qualitative results	➢ Usability evaluation of user interface by small sample of HCI experts using certain heuristics ➢ Duration: approx. 1-2 hours per user	➢ quick, and easy way to identify usability problems ➢ Experience from different evaluators (different points of view, several usability problems can be identified)	➢ Constrained by the evaluator's knowledge of HCI, the domain and of the target user group ➢ Not sufficient on its own	No end users; but approx. 3-5 usability or domain experts	Low
Cognitive Walkthrough ➢ Qualitative results	➢ Users have to use a designed/ developed early prototype to perform a specific task and thereby test the system's usability by answering usability questions ➢ use system specifications, scenario-based role play ➢ Duration: approx. 1-2 hours per user	➢ Quick resolving of usability problems ➢ Does not require a high-fidelity prototype ➢ Can reveal attitudes and expectations that the user might not otherwise express	➢ Subjective point of view will keep developers from recognizing some problems ➢ User performance may be biased by observation ➢ Does not address user satisfaction or efficiency ➢ The designer may not behave as the average user when using the application	Approx. 3-5 end users; or designer themselves	Low
Expert Review ➢ Qualitative results	➢ Evaluation of a system or application by means of experts given useful comments and suggestions based on	➢ Resolves some issues that users should not have to worry about in later usability testing	➢ Constrained by the experts knowledge of the audience for which the system is intended ➢ Not sufficient on its own	No end users; Approx. 3-5 experts	Low

Method	Main Objectives and how they get achieved	Advantages	Disadvantages	Amount of end users	Costs
	their expertise				
Storyboarding ➢ Qualitative results	➢ Validation of a design through paper sketches showing episodes and sequences of the interaction with the system	➢ Simple and cheap ➢ Users can evaluate the direction that the interface is heading ➢ Useful for applications with a complex structure of information	➢ Novice designers do not like this technique because they still find challenges in its creation	Approx. 5-7	Low
Usability Testing ➢ Qualitative results	➢ improve of the usability of a product by applying a set of methods	➢ small number of users sufficient to identify numerous problems in short time ➢ More real problems are found than with other methods such as heuristic evaluation.	➢ observation biases ➢ The meaningfulness of the data collected rests on the authenticity of the users and tasks involved ➢ Time consuming to plan and analyse ➢ does not cover all interface features ➢ laboratory condition ➢ not generalizable	Min. 10	High
Task Analysis ➢ Qualitative results	➢ This method aims to better understand what people are doing and why do they do specific actions to perform a particular task	➢ Can reveal new information that is exploitable in the software design	➢ Can be time consuming to do ➢ Need expert user to be observed (complete tasks need to be covered) ➢ Observation of expert users obtain risk to oversee problems specific to beginners	Min. 5 expert users	Low - Medium
Feature/ Consistency/ Standards inspection ➢ Qualitative and Quantitative results	➢ Analysis of certain product features for their availability, understandability, and general usefulness ➢ Use scenario-based end results to be obtained	➢ Necessary to guarantee the consistency of the features used in similar systems ➢ Standardized	➢ Expert knowledge needed ➢ Checklist of features to be checked needs to be as complete as possible ➢ Only few on what is important from a designers/ developers'	No end users; approx. 1-3 designers	Low

Method	Main Objectives and how they get achieved	Advantages	Disadvantages	Amount of end users	Costs
	from the use of the product		point of view ➢ Only useful for common systems or applications where features can be compared to standards		
Think Aloud Protocol ➢ Qualitative results	➢ vocalise thoughts, feelings and opinions whilst performing tasks ➢ Duration: max 2-3 hours per session	➢ Rapid and high-quality user feedback ➢ access to relation between doing, thinking and feeling ➢ Direct observation of behaviour in relation to preferences ➢ The method might help some participants to concentrate on the tasks while falling into a rhythm of working and talking throughout the evaluation ➢ Gaining an understanding of the user's mental model	➢ Observation bias effects ➢ Slowed down usage process through thinking aloud ➢ Unnatural situation of using a product or system ➢ Increased mindfulness might prevent errors that might have normally occurred in the actual work setting. ➢ Verbalization of thoughts while performing a specific task is exhausting ➢ Elevator needs to be trained	Approx. 5-7	Low-Medium
Prototyping ➢ Qualitative results	➢ To test a model of the intended product or system in its early stage before it is finally developed.	➢ allows to identify usability problems (and risks) and to analyze their cause with the users at an early stage of the design or development process (reduces costs and increases quality of the final product) ➢ allows the test of different aspects of the model: the design, help gather feedback, and show ideas and features ➢ helps users understand the idea and concept of the final product or system and thereby increases user involvement ➢ fast test and quick feedback from users during development cycle	➢ not suitable for large applications (too complex to for easy prototyping) ➢ attachment of producer to early drafts of products or systems can be problematic ➢ organizational needs of the producers might get out of focus ➢ development of prototype takes time ➢ implementation of prototype can be expensive ➢ prototypes can be confusion to users (as	Approx. 3-7	Low – High (depends on kind of prototype)

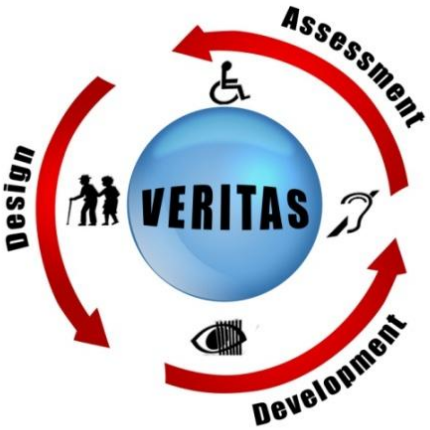
Method	Main Objectives and how they get achieved	Advantages	Disadvantages	Amount of end users	Costs
			they are incomplete) ➢ prototypes allow only a partial analysis for the final product or system		
Paper Prototyping ➢ Qualitative results	➢ To explore early problems in the design, allowing the user to express his ideas with minimal costs and high effectiveness	➢ Allows quick testing of individual components of a software design without the investment of actual coding ➢ Low fidelity encourages users to freely comment and suggest changes (unlike a polished product which may seem like it is already finished) ➢ Allows the detection of usability problems in early in the design process.	➢ It is de-contextualized; individual components should be tested again in the real product ➢ Can be difficult to accommodate designs that offer users multiple paths ➢ prototypes can be confusion to users (as they are incomplete	Approx. 5-7	Low
Co-Discovery Method ➢ Qualitative results	➢ Observe a pair of participants performing tasks together	➢ Detailed information ➢ Fast and easy approach ➢ Rather natural style of interaction ➢ In particular good for applications where people work together	➢ Many participants needed ➢ Can be of discomfort if the rules and goals of co-participation are not clear enough ➢ Analysis of qualitative data difficult ➢ Inter-individual differences: One participants might dominate and overpower the others and the session	Usually 2, max. 4 end users per session	Low

Method	Main Objectives and how they get achieved	Advantages	Disadvantages	Amount of end users	Costs
Performance measurement ➢ Quantitative results	➢ To test certain parameters of a system (e.g. performance time of a system the error rate)	➢ Effectiveness and Efficiency can be measured objectively	➢ User satisfaction can't be assessed with this method ➢ Is alone not enough: needs to be complemented by other and more qualitative methods.	Approx. 3-5 for qualitative results, min. 8 for reliable measurements	Low
Wizard of Oz ➢ Qualitative results	➢ To observe the usage and effectiveness of a concept of a computer application or user interface by the end users, rather than to measure the quality of an entire system.	➢ Wizard of Oz method can provide valuable information as base for future designs ➢ Allows to evaluate an application at an early stage in the design process. ➢ Observation of the user through interacting with her/him provides a unique insight into the user's actions. ➢ Good for the comparison and evaluation of different design concepts.	➢ Wizards need to be trained (additional costs) ➢ Not a very controllable test environment ➢ Difficult for the evaluation of large UIs. ➢ System performances or recognition rates cannot be assessed with this method.	Approx. 3-5	Medium
Log-files ➢ Quantitative results	➢ To identify usage patterns as well as potential problems present in the usage of the system by collecting user data	➢ Provides a historical trace of usage traffic for a system ➢ Quick, easy way to gather data on user behaviour without having to actually recruit users. ➢ Completely transparent to the user	➢ Log files do not indicate why users made certain actions or avoided making others ➢ Log files do not indicate if and how users recovered from errors	Ideally a large scale of users	Low
Workshops ➢ Qualitative results	➢ Allow brainstorming, interactive learning and problem solving of within activities and between the VERITAS partners	➢ Provide a corporate view when there are representatives of all WPS and activities related to the discussed topic. ➢ Workshops encourage co-operation between partners/participants. ➢ Different points of views get heard.	➢ Group dynamic might make some participants anxious. They may be afraid to speak up and voice their opinion. ➢ Time commitment is required by each partner.	Ideally not more than 10 partners per session	Low - HIgh

Method	Main Objectives and how they get achieved	Advantages	Disadvantages	Amount of end users	Costs
		➢ Certain issues might get resolves easier when all responsible partners are present. ➢ Ideas are discussed, which encourages creativity. Partners can build on the thoughts and ideas of others.			

Appendix B: Full UCD reporting form

Accessible and Assistive ICT



VERITAS

UCD Activity Reporting Form

This form is a template all VERITAS partners should use to report on how they have followed the UCD design process that is detailed in deliverable D1.1.2. The precise nature of the User Centred Design activities that each activity is expected to have followed is presented in Table 20 and Table 21 of this deliverable.

When completed these forms will be used to help demonstrate that the VERITAS project has followed an appropriately user centred approach. As such, it is vital that all partners complete the form and provide as much detail as possible. Any supplementary design documents (for example internal documents that analyse meetings with users) would also be gratefully received when you return this form. These forms will be integrated into deliverable D1.1.3, the User Centred Design Revision Manual.

All partners need to complete this form for each activity they have and return it to Stephen Lindsay at UNEW (s.c.lindsay@ncl.ac.uk) as they complete their activities. If any partner has problems completing the form then please contact UNEW for help.

Work Package:	**Activity Number:**	**Partner:**
1) User centred design methods used: *(Please list the user centred design methods that this activity has been involved in based upon Table 20 and Table 21 of D1.1.2. If a UCD method from Table 20 has not been applied please explain why in question 5 on impact below)*		
2) Users Involved: *(Please list groups and profiles of each group member: age, gender and disability or professional role a sapplicable)*		
3) Process followed: *(For each type of user centred design method you identified in question 1 please briefly describe the process that you followed including the challenges you faced and successes you had)*		

4) Output: *(For each user centred design activity please describe the output from the process, if their is forma documentation of this then please include it)*
5) Impact: *(Please describe in some detail how following each of the different methods you identified in question 1 has impacted on your work. If you have not followed any of the methods listed in D1.1.2 then please explain why here)*
6) Contact person: *(Please provide a name, a phone number and email address for a group member who can answer any further questions if necessary)*