TECHNOLOGY ACCEPTANCE OF BUSINESS MEETINGS IN A 3D VIRTUAL ENVIRONMENT SUPPORTED BY A CONTENT MANAGEMENT SYSTEM

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MASTER THESIS

CONFIDENTIAL

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PREFACE

The past six months have been an interesting period and the final step in finishing my master Business Information Technology at the University of Twente. I would like to thank everyone who helped me during my research.

Starting off, I would like to thank Frank Rulof for providing and supporting this interesting assignment at Thales in Hengelo. It was a great experience and I have learned a lot on 3D virtual environments and their possibilities. The assignment consisted of a large practical part offering me a lot of freedom and the use of creativity, which I really enjoyed.

Second, I would like to thank my supervisors from the University of Twente. Maurice van Keulen and Hans Moonen, for their guidance throughout the research and their feedback. It took me quite some time to find supervisors at the university, since not everyone supported or understood the assignment given to me from Thales.

During my time as a student at the University of Twente I met a lot of great people. My gratitude goes out to those who made my time as a student in Enschede unforgettable.

In addition, I would like to thank Marco Jutten for reviewing my thesis and his feedback on virtual meetings. Also, my gratitude to Laurens Hellemons, who took the time to evaluate all the virtual possibilities and even assisted in finding participants.

Finally, I would like to thank the people dearest to me. I would like to thank my parents for always being there for me, even though we live on opposite sides of the country. Last but not least, I would like to thank my girlfriend for supporting me and keeping me motivated.

I hope that you will enjoy reading my thesis. If any questions remain or if you have any comments, please do not hesitate to contact me.

Niels Witte

MANAGEMENT SUMMARY

Organizations are spread across the globe and work together virtually. However, working together through electronic media decreases the richness of the communication, is often perceived as impersonal and building trust can be difficult. While technology advances new possibilities present themselves for cooperative work over distance. One of these possibilities is using 3D virtual environments.

Currently little is known about these virtual environments and their possibilities for cooperative work in a business setting. The majority of the existing research on virtual worlds focusses on education and the few papers on virtual environments in a business setting do not provide any scientific evidence why some solutions work and others do not.

This research focusses on using a 3D virtual environment for the purpose of business meetings and attempts to reach a high level of usability. From existing literature and experiences of users, the current issues, challenges and best practises are identified. These results are enriched with literature on meetings and working together virtually to create a list with requirements for the system. From these requirements a web-based content management system (CMS) and a virtual environment are created. The main research question which needs to be answered is:

> Will the use of a 3D virtual environment supported by a CMS be accepted for performing a virtual meeting?

A prototype is designed, created and validated based on the requirements. The prototype is empirically tested and evaluated by using the best fitting technology acceptance theory, in this case the Unified Theory of Use and Acceptance of Technology (UTAUT). 35 users participated and 22 of them completed the questionnaire. The majority of the users is highly educated and has a technical background. UTAUT managed to explain 78.8% of the variance in behavioural intention and the overall attitude towards the system is positive.

The results of this research are summarized below:

- It can be argued that many of the experienced difficulties would diminish or even disappear at a second use of the system.
- Age does not influence effort expectancy when users have a highly educated and technical background.
- Participants of this research predict that there is a future for meetings in a 3D virtual environment.
- Students can be used as surrogates for professional users.
- Virtual environments are perceived as interesting and fun.
- Highly experienced users perceive the system as easier to use than users with less experience.
- The CMS provides a useful addition to the virtual environment.

The overall conclusion of this research is that users like the concept of working together virtually in a 3D environment. Some even indicated that they liked it more than solutions such as Skype.

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ACRONYMS

API	Application Programming Interface
CSCW	Computer Supported Cooperative Work
CMS	Content Management System
CRUD	Create, Read, Update and Delete
C-TAM-TPB	Combined TAM and TPB
FR	Functional Requirement
GMT	Greenwich Mean Time
GSS	Group Support System
HRM	Human Resource Management
HTML	HyoerText Markup Language
HTTP	HyperText Transfer Protocol
HTTPS	HyperText Transfer Protocol Secure
ICS	iCalendar
IDT	Innovation Diffusion Theory
IP	Internet Protocol
JPEG	Joint Protographic Experts Group
JSON	JavaScript Object Notation
LMS	Learning Management System
LSL	Linden Scripting Language
MIME	Multipurpose Internet Mail Extensions
MM	Motivation Model
MPCU	Model of Personal Computer Utilization
NR	Non-functional Requirement
ODF	Open Document Format
PDF	Portable Document Format
PHP	PHP: Hypertext Pre-processor
REST	REpresentational State Transfer
RGB	Red, Green and Blue
SCT	Social Cognitive Theory
SEM	Structural Equation Modelling

SLT	Second Life Time zone
SLURL	Second Life viewer Uniform Resource Locator
SOAP	Simple Object Access Protocol
TAM	Technology Acceptance Model
TAM2	Technology Acceptance Model 2
TAM3	Technology Acceptance Model 3
TPB	Theory of Planned Behaviour
TRA	Theory of Reasoned Action
UTAUT	Unified Theory of Acceptance and Use of Technology
UTAUT2	Unified Theory of Acceptance and Use of Technology 2
UTC	Coordinated Universal Time [1]
URI	Uniform Resource Identifier
URL	Uniform Resource Locator
USB	Universal Serial Bus
UUID	Universally Unique IDentifier
VLE	Virtual Learning Environment
WIFI	Web Interface For... I
WoW	World of Warcraft
XML	Extensible Mark-up Language

[1] Unofficial English meaning Universal Time Coordinated. Compromise between the English CUT (Coordinated Universal Time) and the French TUC (Temps Universel Coordonné)

1 INTRODUCTION

Over the past decade the increasing speed and connectivity of broadband internet connections enabled new forms of computer supported cooperative work (CSCW), sometimes also referred to as computer supported collaborative work (Schaf, Müller, Pereira, & Bruns, 2008) and group support systems (Rutkowski, Vogel, Van Genuchten, Bemelmans, & Favier, 2002). Communication systems try to bring remotely located people together, an example is the TelePresence system of Cisco. This system offers high quality audio and video communication, and in addition the rooms are designed to make local and remote meeting participants feel as if they are in the same room (The Network, 2009).

These systems created options for new ways of working. Instead of going to work, the work became location independent. The removal of distance as a barrier decreases traveling time and costs. This increased the flexibility of employees and even their job satisfaction (Kelliher & Anderson, 2010). However, these systems have their limitations, they reduce the communication richness compared to face-to-face meetings and are often perceived as boring and impersonal (Hedlund, Ilgen, & Hollenbeck, 1998; Hertel, Geister, & Konradt, 2005; A. M. Kaplan & Haenlein, 2009).

Advanced solutions exist to tackle this issue. For example, creating identical meeting rooms and connect them through video and audio. This gives the impression to the users on both locations as if they are in the same room. However, this is a quite expensive solution and still bounds users to a physical location, the meeting room. Skype meetings or other videoconferencing solutions can will become unorganized when the group size increases.

1.1 MOTIVATION

With modern technology we can go a step further than the existing virtual collaboration systems, a three-dimensional (3D) virtual environment can be created to bring people together from all over the world (Tate et al., 2010). In such a virtual world people use a virtual representation of themselves, an avatar, which they can use to participate in meetings and brainstorm sessions. During these meetings chat and audio can be used to communicate, and interactive elements, such as PowerPoint presentations, websites and videos, can be included to support the process.

A. M. Kaplan and Haenlein (2009) addresses five different opportunities virtual worlds offer for companies. One of these opportunities includes organizing meetings and using the environment for knowledge exchange. Thales already uses virtual worlds for cooperative work such as meetings and sharing information, but also for training and simulation of products. In particular they use the open-source package OpenSimulator, or short OpenSim[2]. OpenSim is an open-source virtual world server similar to Second Life. The created virtual environment, where the units of Thales experiment, is called the Thales Grid. For managing the Thales Grid the management system supplied with OpenSim is used. However, the functions and flexibility offered by the system are limited, especially when using the virtual environment for cooperative work. The SIMIAN[3] project offers an additional layer based on existing technologies for managing the OpenSim environment. A suggested solution from Thales is to create a link between SIMIAN and a content management system (CMS) to enable web-based management and increase the usability.

A similar project, the I-Room by Tate et al. (2010), required a significant amount of specialized effort to be realized. When the amount of effort is too high this influence the acceptance of the technology. With the theories for technology acceptance, such as the Technology Acceptance Model (TAM) of

[2] OpenSim - http://opensimulator.org/
[3] SIMIAN Grid - http://code.google.com/p/openmetaverse/wiki/SimianGrid

Davis Jr (1986) and the Unified Theory of Acceptance and Use of Technology (UTAUT) by Venkatesh, Morris, Davis, and Davis (2003), the acceptance of a technology can be explained and predicted.

A. M. Kaplan and Haenlein (2009) asked the following question in their research: “When do you think your assistant will be capable of navigating and setting up meetings in Second Life with the same ease as using the phone?” The bottleneck for many of these systems is the amount of effort required to setup such a virtual environment and use the environment. According to the Principle of least effort an user will chose the solution that requires the least effort (Zipf, 1949). This also applies for technology, therefore the amount of effort required should be as low as possible to allow a technology to be successful. Just like Thales, Korolov (2009) uses a company grid based on OpenSim and also Korolov would like to be able to use a CMS to manage the company grid. Korolov mentions a list with functionalities for the CMS which are similar to the functionalities Thales mentions in their assignment description (Rulof, 2013). But will the use of CMS lead to an increase in usability? More important, will people work with a 3D environment for virtual meetings?

1.2 DOCUMENT STRUCTURE

Section two describes research methodology, the focus of this research and addresses the problem statement. From where research questions are introduced and the methodology to answer these questions is explained. Followed by the validation methods that will be used to guaranty the quality of the results. The next section, section three, dives into the background of working together virtually and explains the current research done on 3D virtual environments. After this, section four provides knowledge on meetings in general, why meetings are chosen as the focus for this research and what the content management system needs to support. From the gathered knowledge requirements will be derived and explained in the next section. In addition section five also describes the design and the prototype implementation. The design is validated in section six. Section seven introduces a number of popular the technology acceptance models and compares them to find the best model for this research. In section eight, the experiment is described, hypotheses are introduced and the results are evaluated. Followed by the final section, section nine, the discussion and conclusion. Which contains the limitations, recommendations, contributions and future work.

2 RESEARCH METHODOLOGY

In this chapter the focus of the research and methodology will be explained. Based on the problem statement and research focus, questions need to be answered following the described methodology. In addition the findings need to be validated to guarantee a sufficient degree of quality.

2.1 RESEARCH FOCUS

This research will focus on increasing the usability of a 3D virtual environment, when setting up a virtual meeting and the technology acceptance of the solution. The virtual environment will be based on the open-source OpenSim platform, which is consistent with the scope of Thales. To increase the usability of the virtual environment a CMS will be developed. Based on a technology acceptance model the usability of the CMS will be empirically measured in the context of holding a virtual meetings.

The primary focus of the CMS will be on preparing a business meeting. The term business meeting is used since the meeting needs to be formal. Therefore a meeting needs to have an agenda and the participants have different roles. For example, someone has to be chairman and lead the meeting and another participant needs to take the role of secretary and make notes. The preparations include scheduling the meeting, and making all required documents available. During the meeting tools in the virtual world will be used to access the CMS data and provide feedback to the CMS. These tools are based on usability increasing requirements. The perceived usability by the users will be measured and the expected intention to use the system will be predicted. The effectiveness of the meeting itself is outside of the scope of this research and will be for future work.

2.2 PROBLEM STATEMENT

Meetings are often seen as boring, mandatory business events. Globally operating companies spend a lot of money and time on traveling costs for their employees to attend meetings all over the world. To limit these expenses virtual collaboration systems are used, such as teleconferencing. However, these system have their limitations, especially with large groups.

Currently only little is known about using virtual environments in a business setting outside of the purpose of simulation. Virtual environments enable all sorts of new collaboration opportunities. The high amount of instructiveness of the virtual world allows users to create and share information on multiple levels. However, using a 3D virtual environment for cooperative work requires a lot of effort, especially during the preparations, which decreases the perceived usability and the actual usage. Too much effort will even make people search for alternatives and abandon the technology.

The usability has to be increased before people will start using this new collaboration method. However, convincing people of the benefits of virtual meetings in a 3D virtual environment over the already known methods can be a challenge. Therefore research needs to be performed on this subject in order to identify and tackle the current issues, and improve virtual meetings.

2.3 RESEARCH QUESTIONS

This research will focus on the usability of a 3D virtual environment when preparing and performing a virtual meeting. Which will be done by creating a CMS for the virtual environment and measure the perceived usability and usage intentions. Therefore the main research question is:

> **RQ1:** Will the use of a 3D virtual environment supported by a CMS be accepted for performing a virtual meeting?

From theory and practice the current problems and challenges for collaboration in a 3D virtual environment need to be identified. These issues need to be resolved or at least the impact needs to be minimal. The gathered information will be used to derive the requirements from. Which leads to the following two sub questions:

> **SQ1:** What are the current problems, challenges and solutions when using a 3D virtual environment for cooperative work?
>
> **SQ2:** What are the requirements for the CMS to support group work in a 3D virtual environment?

To answer the main research question on technology acceptance of a 3D virtual environment for the purpose of meetings, a technology acceptance model will be used measure, amongst others, the usability. With a CMS in place the technology acceptance model is used to predict the intention to use the system. However, there are many models available. Therefore the following question needs to be answered:

> **SQ3:** Which technology acceptance model can be used best to measure the perceived usability when using a CMS to set up a virtual meeting in a 3D virtual environment?

2.4 METHODOLOGY

For each question, a specific method is used. Table 1 provides an overview of the research question, sub questions, the methods used to answer the question and the corresponding chapter. The steps required to answer the question are explained in the following paragraphs. The validation is mentioned in the next sub chapter.

	Question	Method	Chapter
RQ1	Will the use of a 3D virtual environment supported by a CMS be accepted for performing a virtual meeting?	Hypotheses, statistics, discussion, questionnaire and feedback.	8, 9
SQ1	What are the current problems, challenges and solutions when using a 3D virtual environment for cooperative work?	Literature study, interviews with stakeholders, references from OpenSim/Second Life community	3, 4
SQ2	What are the requirements for the CMS to support group work in a 3D virtual environment?	Derived from the answers of SQ2	5
SQ3	Which technology acceptance model can be used best to measure the perceived change in usability when using a CMS compared to not using a CMS for a 3D virtual environment?	Literature study	7
V1, V2, V3	Design validation	Internal validation, external validation and validate trade-offs.	6

TABLE 1: RESEARCH QUESTIONS AND THEIR CORRESPONDING METHOD.

The research framework in Figure 1 is based on the technique described by Verschuren, Doorewaard, and Mellion (2010). A research framework is defined as a "schematic representation of the research objective and includes the appropriate steps that need to be taken in order to achieve it" (Verschuren et al., 2010). The double-headed vertical arrows show the confrontation between the elements it passes, the horizontal single-headed arrows stand for 'from this will be concluded or deducted that.' For example, in Figure 1 the use of literature, interviews and preliminary research will lead to a design for the CMS.

The figure broadly shows the path to the main research goal, the conclusion on whether or not a CMS for preparing meetings improves the usability of a 3D virtual environment. To achieve this goal, the first phase (a) provides an overview of the sources from which the research perspective will be developed. The second phase (b) indicates to which research objects the research perspective will be applied. The third phase (c) shows how the analysis of the objects is related. The fourth and final phase (d) shows the research objective. The complete process will be described in more detail below.

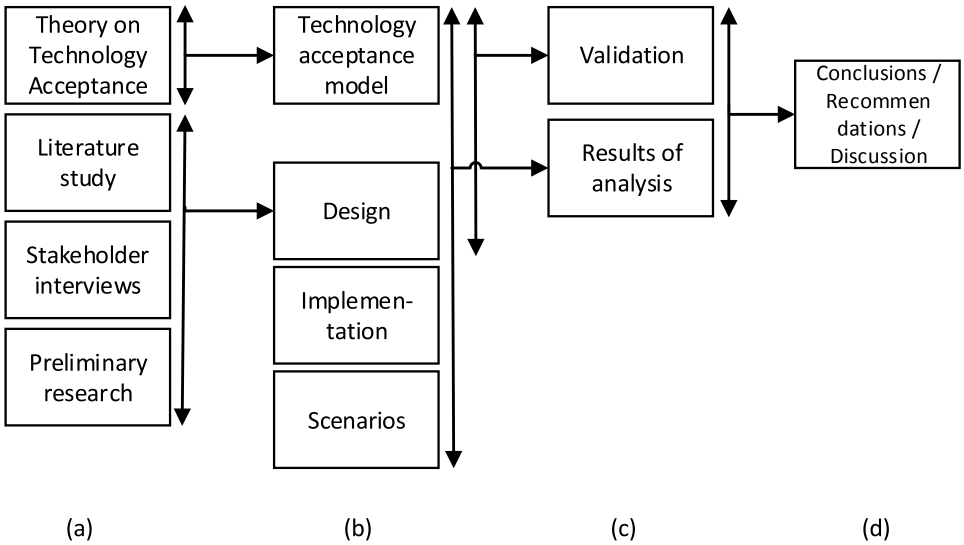

FIGURE 1: RESEARCH FRAMEWORK

2.4.1 PHASE A: GATHERING INFORMATION

This research will be an empirical study to see if a 3D virtual environment for virtual meetings supported by a CMS to increase the usability will be accepted and perceived useful. Before a design can be made for the CMS, the challenges and difficulties need to be identified. This will be done by looking into similar projects from the literature, for example the I-Room of Tate et al. (2010), experiences from people who already worked with 3D virtual environments at Thales or through online communities. All gathered information will be combined and used to answer SQ1.

The first phase of the research will also be used to gather information from the literature on technology acceptance. This will serve as the foundation for this research and be used to answer SQ3 in the next phase. There are many technology acceptance theories available at present. However, with the limited amount of time available for this research only one can be used. The goal is to find the model which suites best for the given situation, the use case. Although the exact implementation of the CMS is unknown at this point, the theories can be compared based on existing results and reviews available.

2.4.2 PHASE B: RESEARCH OBJECTS

The knowledge gathered from the first sub question will be used to create requirements and form a solution to these challenges. This will provide an overview of which functionalities will be most important for the CMS to function or will have the biggest impact on the usability. For ordering the requirements the knowledge gathered from the previous phases will serve as base, which can be extended by interviews with stakeholders. However, time is also an important factor which could influences the feasibility of some functions.

With the requirements SQ2 can be answered. Based on the requirements a CMS will be implemented which support the scenarios that will be used to measure usability. For these scenarios hypotheses will created and validated. The scenario involves using a 3D virtual environment with the aid of the CMS to setup a meeting. The experiment will focus on usability for novice users of the system. That is, users with little to none experience with cooperating in a 3D virtual worlds. However, test subjects will get some form of basic training and instructions to get started.

The information gathered in the first phase on technology acceptance will be used to select, based on the requirements, issues, scenarios and implementation, the technology acceptance model with the best fit for this research.

2.4.3 Phase C: results of analysis

To ensure the quality of CMS is sufficient the CMS itself need to be tested and validated before being used in the experiment. Besides, measurement methods and ways to gather information from the tests need to be developed. This will be done based on the questionnaires that come with the selected technology acceptance model and internal test rounds to detect any flaws before the actual experiment begins. In addition the design will be validated.

The results will be gathered from the users by letting them perform predefined tasks and by using questionnaires to measure their experiences. Due to time constraints only one round of tests will be performed.

2.4.4 Phase D: conclusions

After collecting the data, it needs to be analysed and validated, so conclusions can be derived from it and the hypotheses can be proven or disproven. The analysis of the information gathered from questionnaires will be done by calculating statistical significance, using the selected technology acceptance model. The validation process is described in more detail below.

In addition the results will be discussed, including the limitations of this research. Followed by the contributions to the literature and to practice. The research will end with future work and recommendations to Thales.

2.5 VALIDATION

Because of the empirical character of this research and the limited time available. The probability that the sample size and/or the variety will be limited is quite likely. Therefore validation is required to ensure the quality of the results. The results of the questionnaire will be validated by using Cronbach's Alpha (Cronbach, 1951). Which measures the internal consistency of a test scale. Internal consistency describes to which extent all items in a test measure the same concept or construct (Tavakol & Dennick, 2011).

The hypotheses which are tested will be validated based on their strength and significance. The strength of the relationship between two variables is indicated by the correlation coefficient (r). However, the actual strength is measured by using the coefficient of determinant (R^2). In addition the significance of the relationship is tested, which tells how unlikely a given correlation coefficient will occur given no relationship in the population. This is expressed in probability levels (p). For example, significant at $p < 0.05$ means that the chance of the tested hypothesis to be false and still get the same results is less than 5 percent. In short, the larger the correlation, the stronger the relationship and the smaller the p-level, the more significant the relationship.

The results from the used model will be validated with linear regression to measure the relationship between the variables. This will help making predictions of the likely values of the dependent variable and answer the main research question.

There are two ways of design validation, which are internal validation and external validation. Internal validation shows that the solution actually works. Where external validation shows that the solution still works when the environment changes (Wieringa, 2009). In addition Wieringa (2009) suggest using trade-off, also known as sensitivity analysis, to evaluate choices that need to be made during the design.

2.5.1 INTERNAL VALIDATION

According to Wieringa (2009) a solution theory is internally valid if a correct implementation of the design solves some practical problem for a stakeholder. This can be done by answering the following questions:

> V1 **Internal validity:** Would the design, implemented in this problem context, satisfy the criteria identified in the problem investigation?

Wieringa (2009) adds the following two sub questions to answer V1. When a design is made, the final implemented solution does not exists, yet. Therefore only predictions can be made on the effectiveness of the solution. The additional the following effect questions, E1 and E2, are used to validate the design:

> E1 **Causal question:** In problem domain D, would solution S have effects E?

> E2 **Value question:** Do E satisfy stakeholder criteria C?

The problem domain D is defined by Wieringa (2009) as "the part of the world with which the solution will interact, such as the phenomena experienced as problematic by stakeholders or the entities with which the solution will interact in order to achieve certain effects."

In this research the most important stakeholders are the users of the virtual environment. Internal validation will be done by looking at the design of the CMS and evaluate whether or not the requirements are satisfied. A valid design is required for predicting if it will improve the usability of a 3D virtual environment when using it for meetings. Sub question E2 validates if the CMS has the desired effects and satisfies the stakeholder criteria.

2.5.2 TRADE-OFFS

During the design choices need to be made on how to solve certain problems or achieve functionality. These choices, trade-offs, can influence the effect of the solution. Wieringa (2009) uses the following question to compare different designs.

> V2 **Trade-offs:** How would slightly different designs, implemented in this context, satisfy the criteria?

Choices made during the design of the CMS in this research will be explained by comparing solutions and their effect on reaching the criteria derived from stakeholders and literature.

2.5.3 External validity

External validity is also known as sensitivity analysis, which is analysing if the design still satisfies the criteria when being implemented in a slightly different context. From Wieringa (2009) knowledge question V3 is used.

> V3 **External validity**: Would this design, implemented in slightly different contexts, also satisfy the criteria?

The design will be tested as a proof-of-concept, within a limited scope. However, it is important to know whether the design is still valid outside this 'safe' environment. For example, will the system still work when significantly increasing the number of users?

2.6 CONCLUSION

In this chapter the research approach, research methods and validation are discussed. The main goal of this research is to see whether using a 3D virtual environment for meetings supported by a CMS will be accepted by the users. Information on what the CMS needs to support will be gathered from interviews and literature, based on existing challenges and issues. The design of the CMS will be validated based on the validation methods of Wieringa (2009). By performing an experiment and using technology acceptance theories, the perceived usability will be measured and the eventual intention to use the system will be predicted.

3 WORKING TOGETHER VIRTUALLY

Over the years a lot of research has been done on working in globally distributed teams. The global Internet enables numberless combinations of groups of every size to work together. Technology extends our capabilities, however it is human to do things together (Lipnack & Stamps, 2008). This chapter will introduce the concept of working together aided by computers and compare the different popular virtual worlds.

3.1 BACKGROUND

According to Palmer and Fields (1994) CSCW refers to: "people working together on a product, research area, topic or scholarly endeavour with help from computers." The medium, which often consists of physically dispersed computers, is a computer supported collaborative environment (CSCE).

Such virtual environments need to be equipped with tools for different types of interactions between the users. These interactions can be social, educational, training or work related (Schaf et al., 2008). Virtual environments are used in a broad range of industries, for example cutting costs for the training of astronauts, pilots (Ellis, 1994) or surgeons (Gallagher et al., 2005). But also for manufacturing complex systems in the aerospace and automotive industry (Poltrock & Engelbeck, 1999), this manufacturing technique is called virtual prototyping (Zorriassatine, Wykes, Parkin, & Gindy, 2003).

However, the quality of the output when using a CSCE highly depends on the available tools and implemented processes. Research can be found on the effectiveness of working in teams (Cohen & Bailey, 1997), distributed teams (Hinds & Mortensen, 2005) and virtual teams (Powell, Piccoli, & Ives, 2004). Virtual teams are defined as "groups of geographically organizationally and/or time dispersed workers brought together by information and telecommunication technologies to accomplish one or more organizational tasks" (Townsend, DeMarie, & Hendrickson, 1998).

Martins, Gilson, and Maynard (2004) state that all organizational teams today are virtual to some extent. Virtual teams have the ability to cross traditional constraints, such as time, location, social networks, and organizational boundaries. For their communication and collaboration virtual teams use all sorts computer-mediated tools, from fax and e-mail to chat and videoconferencing (Gibson & Cohen, 2003). However, virtual teams seldom meet in person (Maznevski & Chudoba, 2000). This can make it difficult to build trust between team members (Gibson & Cohen, 2003) and requires the virtual team members to learn new ways to express themselves and to understand others. In addition virtual team members require superior team participation skills (Townsend et al., 1998).

3.2 3D VIRTUAL WORLDS

Using a 3D virtual world can add elements from face-to-face communication to virtual teams (Kantonen, Woodward, & Katz, 2010) to limit this issue. A virtual world is a computer-based, simulated multi-media environment. Users can interact with others through their own graphical self-representations, so called avatars. Such a virtual world can be considered as a 3D social network, like a 3D version of Wikipedia, where people can collaboratively create and edit objects in the virtual world (Boulos, Hetherington, & Wheeler, 2007).

There are many different virtual environments, for this research the focus lays on virtual collaboration in a corporate setting. Virtual worlds can be divided in two types, namely virtual game worlds and virtual social worlds. Virtual game worlds, such as World of Warcraft (WoW), often follow a story and the avatar is bound to certain restrictions. For example in WoW, an avatar of the class mage will never be as good in melee fighting as a warrior, and in return the warrior will never be as good in ranged magic as the mage. In virtual social worlds the options for interactions and behaviour of avatars are equal (A. M. Kaplan & Haenlein, 2009). Therefore, the following section will only contain virtual environments which are social and realistic to some extent. In addition the virtual world needs to offer high levels of customization.

A. M. Kaplan and Haenlein (2009) identified five ways how companies can make use of virtual social worlds. First, companies can set up stores representing their real life products. The example given by authors is a car company, which runs a virtual store to show virtual editions of their latest models. Other examples are using advertising space in virtual malls or radio stations or sponsoring of virtual event. An example given by the authors is sponsoring a virtual music festival. Besides, positive impact in the virtual world by such activities could result in a positive image in the real world.

The second method which companies could use is virtual product sales, called v-commerce. Which is e-commerce on a virtual channel (A. M. Kaplan & Haenlein, 2009). This can be done by selling virtual versions of an existing real life product. An example given by the authors is a telecom company selling a tool which enables avatars to call each other and exchange text messages. Other ways of using v-commerce could be using services that bridge the virtual and real world. For example, selling real life products in the virtual world store and ship them to the user's home in the real world. Basically creating a 3D web shop with a high level of interaction (A. M. Kaplan & Haenlein, 2009). However, the authors also indicate that is unlikely that a lot of money will be earned within virtual worlds in the short run.

Another option, number three, identified by A. M. Kaplan and Haenlein (2009) is to use virtual worlds for the purpose of marketing research. Virtual environments allow standard marketing research with lower costs. Costs can go down with about 50% when conducting quantitative virtual surveys and approximately 33% can be saved when using qualitative focus groups. Besides, the virtual world offers higher degree of interactivity and impressiveness compared to most other media. Companies can use the creativity of the other virtual world residents by letting them contribute to the design and customization process. The authors also provide a note that content created in the virtual world may not work as well in the real world, due to difference in taste and preferences between different user groups. Therefore it is important to perform a thorough reality test for each product created by a virtual community, before actually releasing it to the public (A. M. Kaplan & Haenlein, 2009).

A fourth option mentioned by A. M. Kaplan and Haenlein (2009) are related to human research management (HRM) and recruiting. Virtual worlds enable companies to reach highly creative and technologically advanced people with minimal effort. In addition establishing good communication with virtual world residents may result in a more positive company image in the real world. However, the authors emphasize that recruiting may not be so beneficial after all. Recruiters cannot be sure who the real person is controlling an avatar. Besides, virtual recruiting should be used to complement existing activities, not replace them (A. M. Kaplan & Haenlein, 2009).

Finally, the fifth method is using virtual worlds for internal process management. A. M. Kaplan and Haenlein (2009) describe a platform for organizing internal meetings and knowledge exchange. An example given by the authors is The Crowne Plaza hotel chain, which allows companies to book a virtual meeting room in Second Life Crowne Plaza (A. M. Kaplan & Haenlein, 2009). Additional examples of using virtual worlds for meetings and knowledge exchange will be given in the following sections.

3.2.1 OPEN WONDERLAND

One example of a 3D virtual world which supports high levels of customization is Open Wonderland[4]. Open Wonderland is a 100% Java open-source toolkit for creating collaborative 3D virtual worlds. Originally Open Wonderland was called Project Wonderland. The project was funded by Sun

[4] Open Wonderland - http://code.google.com/p/openwonderland/

Microsystems, however after Oracle acquired Sun (Tillman, 2010) the funding was ceased (Wonderland, 2012).

The program is written in Java and is developed by the community since it was dropped by Oracle. Open Wonderland supports many 2D applications to be used in the 3D world. There is support for two types of 2D applications. The first type consists of 2D Java applications for multiple users. Examples are a whiteboard, slide show viewer for Portable Document Format (PDF) documents and a webcam viewer. These applications are called “share-aware” in Open Wonderland since they can be used by multiple users at the same time.

The second type consists of X11 applications. X11 or just X is the window system which is used by many UNIX-like operating systems. This enables popular applications, such as a web browser or a text editor, to run inside Open Wonderland. In contrast to the first group, these programs only support control by one user at a time, while the other users can watch (Wonderland, 2012).

J. Kaplan and Yankelovich (2011) used Open Wonderland in their research to achieve three main goals. The first goal was enabling collaboration with a focus on synchronous interaction. Their second goal was providing an extensible toolkit based on open standards. The third goal was putting in place the infrastructure for federation to enable the 3D web (J. Kaplan & Yankelovich, 2011).

However, their research does not contain any results only their designed architecture. Their design uses a modular setup which uses a web service Application programming interface (API) to communicate from the browser to the Open Wonderland environment and vice versa (J. Kaplan & Yankelovich, 2011).

3.2.2 Second Life and OpenSim

Probably the most popular virtual world platform for cooperation is Second Life. Second Life is an online virtual world developed by Linden Lab and launched in June 2003 ("History of Second Life," 2014). Users can interact with other avatars in a variety of methods, some examples are using chat, gestures, voice, notecards, streaming video, and streaming audio. The virtual environment, known as the grid, runs on a server to which users can connect with a viewer, this is mostly done over the Internet.

In recent versions of Second Life, users can buy land and build objects in the world. The system supports a procedural scripting language called Linden Scripting Language (LSL) to make objects interactive. By using external programs new 3D objects, textures, gestures and animations can be created and imported into Second Life.

In 2013 Second Life aged 10 years. Linden Lab published some numbers on the history of Second Life. A total of 36 million accounts were created, with an average of 400,000 new registrations every month. More than 1 million users visit the virtual world every month. The Second Life world has a landmass of nearly 700^2 miles, which is approximately 14 times the size of San Francisco ("Infographic: 10 Years of Second Life," 2013). These numbers show that even though the media attention of Second Life declined the past years (Collins, 2010), it is still used by a lot of people.

An alternative is the open-source OpenSimulator (OpenSim), which is written in C# and supports the core of Second Life’s messaging protocol. Therefore it is compatible with the client for Second Life. OpenSim has a large number of public grids, Korolov (2014a) gained statistics of a total of 183 public grids with a combined number of 27,313 regions have 358,965 registered users and 21,683 active users in April 2014. These numbers exclude all private grids and not all public grid admins submitted their statistics. Even though the total number of regions is declining according to Korolov (2014a), the relative popularity is not an issue. Korolov (2014a) argues that "when it comes to general-purpose social grids, the rule of thumb is: the bigger and busier, the better." This makes sense since people who are looking to make new friends will look for grids with the most users or merchants that want to sell content will look for the most potential customers (Korolov, 2014a).

Both Second Life and OpenSim are used in a variety of intuitive ways. Some examples from Boulos et al. (2007) are virtual tourism, where the user can visit the pyramids and Sphinx from behind their computer, or health education, by providing training programs and information. Salt, Atkins, and Blackall (2008) also mentions language acquisition by offering language classes and informally interacting using chat and audio with native speakers of target languages.

Other aspects the review of Salt et al. (2008) mentions are science and technology, architecture and interior design, literature and creative arts, and even training and skills development. Science and technology is about educating science and technology topics through shared interests of the users. This can be done by playing a game or even creating a virtual laboratory and using interactive objects. Second Life offers a lot of potential to architecture and interior design, by offering fast realization of working 3D prototypes. Literature and creative arts, where for example specific areas from literature are recreated or role play is performed to create short videos. The simulation capabilities of Second Life make it interesting for training and skills development. Lemon and Kelly (2009) examined the use of Second Life to train interview skills of students. Their research suggests that there is potential for education in Second Life.

Second Life is largely adopted for social, academic and business processes. In addition, research suggests that Second Life may be an optimal environment for experiential learning, because it has the ability to create complex environments and objects, relative sophisticated graphics and richness of its immersive experience. Besides, the costs are relatively low for Second Life and even lower for OpenSim (Konstantinidis, Tsiatsos, Demetriadis, & Pomportsis, 2010).

Salt et al. (2008) identified a number of strengths of Second Life. A few important strengths are that Second Life offers both synchronous and asynchronous communication and reduces race, gender and age discrimination because it has no real face-to-face interaction. Because of the support for both communication styles, Second Life has the flexibility to accommodate diverse learning styles and cultures. It provides the user with a lot of autonomy, which will likely increase the motivation to participate, especially when it is seen as fun and meaningful (Salt et al., 2008).

However, Second Life has a steep initial learning curve, which need to be taken into account when running a pilot (Salt et al., 2008). Because OpenSim is highly compatible with Second Life's communication protocols and open-source, it grants developers a lot of freedom. Having the ability to setup a private server makes it is quite suitable for research purposes. This way experiences can be tested without interfering or being influenced by other users in Second Life or by any restrictions set by Linden Lab (Konstantinidis et al., 2010).

3.2.3 IN EDUCATION

In recent years, research has been done on virtual environments focussing on using it as a learning environment in education (Bouras, Guannaka, & Tsiatsos, 2008; Kemp, Livingstone, & Bloomfield, 2009; Konstantinidis et al., 2010; Livingstone & Kemp, 2008; Salt et al., 2008; Warburton, 2009). An often used package for virtual environments in education is the Simulation Linked Object Oriented Dynamic Learning Environment (SLOODLE)[5] software. This is an implementation of Moodle[6] for Second

[5] SLOODLE - Simulation Linked Object Oriented Dynamic Learning Environment - http://www.sloodle.org/
[6] Moodle - Open-source community-based tools for learning - https://moodle.org/

Life. Moodle is according to their website: “a Course Management System, also known as a Learning Management System (LMS) or a Virtual Learning Environment (VLE). It is a free web application that educators can use to create effective online learning sites.”

Boulos et al. (2007) provide an overview of the potential of 3D virtual worlds in medical and health education. The Health Island in Second Life is a large international project with the purpose of providing health information is various forms. Second Life residents can gather information on diseases, surgical procedures, drug effects, and be provided by training programs. Users can access the information through a decision tree by using questions which lead to flash animations, PDF [7] documents and links to in-depth information (Boulos et al., 2007).

Many of the possibilities that the Health Island offers still need to be fully identified and explored in various settings and scenarios. According to Boulos et al. (2007) the virtual world offers great potential, but more research is needed. The research on virtual worlds in medical and health education needs to be refined and evaluated to identify the best practices and to avoid pitfalls, before being incorporated into daily teaching and learning activities (Boulos et al., 2007).

Kemp et al. (2009) looked at SLOODLE as a tool for combining a 3D virtual environment with a VLE. Second Life provides a powerful toolset for creating 3D models, synchronous text and voice chat in public and private channels. This requires the tutor to have extended knowledge of the virtual environment. However, usually faculty and staff are unprepared to support students when entering such a virtual environment. These technical issues can create high barriers for teaching to be productive and enjoyable (Kemp et al., 2009).

To make certain processes easier for tutors specialized objects are created. For example matching avatars to Moodle user accounts is done through a ‘registration booth’ in Second Life. Which allows the user’s details from Second Life to be passed to Moodle. This allows tutors to have a list with matched Moodle and Second Life user names in their virtual classroom. Without this, it is difficult to identify a person by its avatar name (Kemp et al., 2009).

Konstantinidis et al. (2010) looked at utilizing SLOODLE for collaborative learning in OpenSim. Some of the features SLOODLE includes are a web-intercom for users in Second Life to chat with Moodle users and vice-versa, a quiz tool and presenter. They developed a framework for the integration of SLOODLE and OpenSim for educational purpose, where the tutor can select a scenario and based on its requirements several automated actions are carried out. For example, a forum and chat room are created in Moodle, users are organized into groups and in the 3D virtual world the rooms adapt accordingly to facilities necessary for the scenario (Konstantinidis et al., 2010). Bouras et al. (2008) also suggest using predefined classrooms, which can be rearranged by the tutor if necessary.

For their design Konstantinidis et al. (2010) followed several principles from Bouras et al. (2008), because the designers’ decisions can have a significant effect on the appropriateness of the platform for education. The following eight principles were used to validate the platform’s features, philosophy and policies (Konstantinidis et al., 2010). First, the educational virtual world needs to support multiple collaborative learning scenarios. Examples are role-playing, case studies, team projects and brainstorming. Second, the way learners socialize is affected by size, architecture, facilities and the physical environment. Therefore the flexibility within a virtual space needs to be maximized. The third principle is about the augmented user’s representation and awareness. Users can share their views, thoughts and clarify points to each other by combining gestures, voice, chat, and user representation. Fourth, the learning environment should be ease and understandable, with as little as possible

[7] Portable Document Format

extraneous load on the user. Considering that supporting the learning process is the main objective for the e-learning environment. The fifth principle Konstantinidis et al. (2010) used is designing a media-learning centric virtual space. By enhancing a virtual space with multiple communication and media layers the users can communicate in a variety of ways. For example using media types like text, graphics and sound over channels, such as voice and text chat or video. Sixth, the virtual space needs to be accessible by a large audience and therefore requires an ergonomic design. Because users will have different backgrounds and level of expertise. Their seventh principle is to design the virtual place inclusive, open and user-centred. Finally, there should be different roles with different access rights (Bouras et al., 2008; Konstantinidis et al., 2010).

Many of the principles above are supported by OpenSim, since it is an open-source platform which is highly customizable and user-friendly (Konstantinidis et al., 2010). The initial goal of SLOODLE was to create a representation of the Moodle course homepage by 3D objects in Second Life. However, this solution was limited in terms of restricting use to specified locations and in the way the elements are conceptualized between the VLE and Second Life (Livingstone & Kemp, 2008).

SLOODLE uses a toolbar in Second Life, which is implemented as a heads-up-display (HUD). This allows the user to access elements of Moodle from within Second Life, like reading or updating their Moodle blog. Another well-functioning SLOODLE tool is the web-intercom. Besides enabling chat from within Second Life to the outside world, it enables secured storage of the discussions in the Moodle database without manual intervention (Livingstone & Kemp, 2008).

A key challenge in integrating a virtual environment is the development of good metaphors (Livingstone & Kemp, 2008; Rutkowski et al., 2002). Rutkowski et al. (2002) found that using the meeting metaphor in virtual collaboration helps participants to keep their attention. To support the business meeting metaphor they used terms as an agenda, deliverables and meeting reports in the virtual environment. This allowed participants without practical experience in virtual collaboration to relate to things they already know from daily business (Rutkowski et al., 2002; Tate et al., 2010). Especially in a 3D virtual environment selecting the right metaphor can be a challenge. Livingstone and Kemp (2008) let the developers choose the metaphors, which simplified implementation. Besides, users could use the developed tools and objects as examples and improve them if desired (Livingstone & Kemp, 2008). In addition, Tate et al. (2010) emphasize the advantages of identifiable real-world spaces, because they offer instant familiarity to the user.

3.2.4 The I-Room

Next to the use in education, 3D virtual environments have been used in various other situations. IBM tried to create a virtual meeting, collaborative work and training environment, called: Lotus Sametime 3D (Valadares & Lopes, 2011) and is also known as 'Virtual Collaboration for Sametime'. Despite being released in June 2009, the project was retired as of September 2011 for unknown reasons (IBM, 2011). However, IBM is still one of the largest land owners in Second Life with 24 islands, which are used for internal purposes (A. M. Kaplan & Haenlein, 2009).

Just like the previously mentioned architecture for Open Wonderland by J. Kaplan and Yankelovich (2011), another noticeable project is the I-Room of Tate et al. (2010). They combined the virtual world, with augmented reality, to the real world in their I-Room. The I-Room provides a virtual world as interaction space by simulating real-world work spaces.

Tate et al. (2010) focussed their initial effort on providing support for scheduled project meetings. The effort required for collaboration is divided into two types and dictate the involved forms of communication. The first, synchronous effort is the contemporaneous interaction of two or more participants. Second, non-synchronous effort is when participants act separately to achieve individual sub goals. These project meetings require collaboration as synchronous effort, are relatively easy to consider in conceptual terms and have identifiable objects (Tate et al., 2010).

In the virtual worlds the authors were simulating real-world work spaces, such as offices, meeting rooms and buildings, and the real collaboration tools these contain. For example a brainstorming session in a small office with whiteboards and flip charts to develop ideas. The room's additional tools that generated, manipulated or controlled information were included to support the meeting. For example, one of the tools kept track of the participants as they entered or left the I-Room (Tate et al., 2010).

Over the years the authors constructed prototype rooms based on reality. The rooms have been opened for users and the authors observed what happened as a case study. The I-Rooms were used in different applications, some were more successful than others. However, Tate et al. did not use detailed theories on how collaboration proceeds in their I-Room or why it succeeds.

3.2.5 CONTENT MANAGEMENT SYSTEM

Korolov (2009) created a wish list for an OpenSim content management system. Their system should enable companies to set up and manage their grid with little effort. Based on a template it should be possible to set up a grid with multiple regions and populate them with pre-built office buildings, conference halls, exhibition spaces and many other standard types of content (Korolov, 2009).

Another aspect that the CMS should facilitate is a teleport system, which also updates when locations move or change. The other wishes of Korolov (2009) include administration of rights, traffic monitoring, inventory management, advertising and the abilities to change the look and feel of structures and global elements to match the company's colour palettes, logos to create one coherent environment.

The CMS of Korolov (2009) focusses on the in-world objects, such as the terrain, buildings and users, to make managing an OpenSim grid as easy as possible. Which shares the same goal as this research, increasing usability of OpenSim, with a focus on the use in a corporate setting. However, the wish list of Korolov (2009) aims at the virtual world administrators, where this research focusses on the users who want to communicate and collaborate in a virtual environment.

3.3 CONCLUSION

This chapter started by briefly looking into virtual teams and the definitions of the different popular concepts, such as computer supported cooperative work and virtual teams, and their usage. This bridged working together virtually and the 3D virtual environments of the I-Room and SLOODLE. J. Kaplan and Yankelovich (2011) designed and implemented an architecture to create a collaborative virtual world. 3D virtual environments such as Open Wonderland, Second Life and OpenSim offer a lot of flexibility and opportunities to create spaces for learning, training, simulation and metaphors for difficult abstract and intangible concepts (J. Kaplan & Yankelovich, 2011; Salt et al., 2008).

Despite the research done on virtual worlds in educational settings, there is little to be found for their use in corporate setting. Even though resources are available and there is potential to run, market and manage a small business, there are only few examples of businesses in Second Life (Salt et al., 2008). To create the I-Room a lot of effort was required before the virtual environment became productive (Tate et al., 2010). Korolov (2009) created a wish list for an OpenSim CMS, focussing on administrators of an OpenSim grid to set up and manage a corporate grid with little effort. Besides the effort for setting the grid up, virtual environments have an initial steep learning curve (Salt et al., 2008).

In the educational setting one of the most difficult aspects is the technical skills level of the users, especially the tutor (Kemp et al., 2009; Konstantinidis et al., 2010). One can expect that this will apply for all users with limited experience in all settings. Which emphasises the need for a system that increases the ease of use of such an environment.

4 CONTENT MANAGEMENT SYSTEM TO SUPPORT MEETINGS

Realizing the I-Room concept by Tate et al. (2010) required a significant amount of specialized effort. This research will attempt to reduce the required effort and increase the usability, therefore a content management system (CMS) will be designed and developed. The initial design of the CMS will support functions to prepare a meeting in a 3D virtual environment. The design will be based on the knowledge gathered from the literature on virtual environments, meetings and virtual cooperation. First this chapter will explain why meetings are used for the research on cooperation in a 3D virtual environment. After that in section 4.2 the meeting cycle will be presented and explained. Followed by an example case in section 4.3, which will later on be used as a scenario for the design of the CMS.

4.1 WHY MEETINGS?

Research performed by Romano Jr and Nunamaker Jr (2001) shown that meetings are very costly in both terms money and time. Their study also showed that meetings are often quite unproductive and wasteful. However, to accomplish tasks that individuals cannot complete themselves, meetings are essential. Another trend identified by this research is the increasing frequency of telework and distributed collaboration (Romano Jr & Nunamaker Jr, 2001).

In addition meetings are an everyday situation in business, even in virtual teams. With virtual teams becoming more and more common in organizations (Martins et al., 2004), the demand for advanced communication methods will increase. In this flexible way of working people can work from home by remote connecting to the corporate network, are not bound to the traditional ‘9-to-5’ hours and use flexible work spaces instead of fixed offices. Kelliher and Anderson (2010) found that remote workers experience higher levels of satisfaction than non-flexible workers or workers with reduced hours. This is due to the element of control which was obtained by being able to work flexible.

Beside the higher job satisfaction, the commitment is also higher for people that work flexible than non-flexible workers. Remote workers also indicated that they did more when they work from home, exercising both greater intensive and extensive effort. Intensive effort relates to the physical and mental input of the worker and extensive effort is the time spent at work. Flexible workers reported “that they felt the need to be available to the business” (Kelliher & Anderson, 2010). Another explanation found by Kelliher and Anderson (2010) is that some employees also worked the travel time they saved by not commuting to work.

Companies use many technologies to save money and time, for example using teleconferencing systems. Why travel for many hours to attend a meeting somewhere around the globe when you can also meet each other in a virtual environment from the comfort of your own surroundings (A. M. Kaplan & Haenlein, 2009), for example your living room or your own office.

The main concern of remote working or other ways of working with electronic media is that it reduces the richness of the information exchange compared to face-to-face communication (Hedlund et al., 1998; Hertel et al., 2005; A. M. Kaplan & Haenlein, 2009). However, these limitations can be reduced by mixing reality with a 3D virtual environments (Kantonen et al., 2010).

Concluding, meetings are a familiar business setting to which probably everyone can relate. Besides, meetings are costly, time consuming, unproductive and essential at the same time. This leaves a lot of room for improvement.

4.2 MEETING CYCLE

A meeting is usually a three phase cycle according to Bostrom, Anson, and Clawson (1993). The first phase is the pre-meeting, preparing the meeting. For example, creating an agenda with the topics and activities to be undertaken. The second phase is the actual meeting itself. Post-meeting refers to the activities after the meeting, such as dissemination of decisions, follow-up and clarification of doubts. The cycle is displayed in Figure 2. Outcomes of the post-meeting can be material for the next cycle (Bostrom et al., 1993).

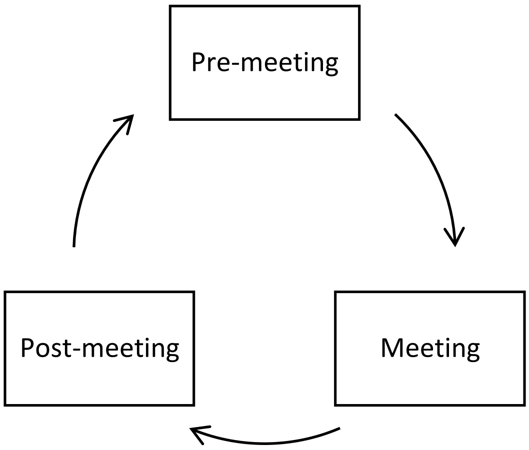

FIGURE 2: THE MEETING-CYCLE

4.2.1 PRE-MEETING

Especially when preparing a decision meeting, it is important that all information is available for the participants. Guerrero and Pino (2002) focussed on the pre-meeting phase in decision meetings. Their Pre-meeting Information Management Engine (PRIME) enabled users to prepare a meeting by making all documents available for each agenda item. In addition it enabled users to discuss the agenda items before the meeting, to remove any ambiguity and uncertainty on the agenda items.

With the use of PRIME, all participants knew the meeting agenda before the actual face-to-face meeting, compared to about half when not using PRIME. Another important finding was that two third of the participants (almost) always read the meeting material before the meeting took place, compared to only one third without using PRIME. However, most groups were unfamiliar with the pre-meeting concept, their initial reaction was that they did not need to discuss matters before the meeting (Guerrero & Pino, 2002).

Guerrero and Pino (2002) used four roles in PRIME. The first is the role of coordinator, who is responsible for the pre-meeting success. Second, the facilitator supervises the pre-meeting discussions of a particular agenda item. The third role is the one of contributor, who produces the actual discussion. Finally, the observers are those who are authorized to read, but cannot write contributions to the discussion. The work of the coordinator was found to be important. When the coordinator was involved and motivated the other participants, the discussions were most meaningful (Guerrero & Pino, 2002).

Malhotra, Majchrzak, and Rosen (2007) found that sharing draft documents before the virtual team meeting and allowing team members to comment on them makes the meeting more productive. A second important factor was ensuring all team members have a clear version of the agenda with time allocations. Besides, participants should make their progress available. This can be done by using draft documents, memos, drawings, presentations, etc.

4.2.2 During the meeting

In virtual meetings, it is often the case that team members only contacted each other asynchronously. Besides, most of their communication is exclusively task related. Therefore the leaders of the virtual teams often had the feeling that they needed to 'reconnect' the team members (Malhotra et al., 2007). The team leaders in the research of Malhotra et al. (2007) used various ways to do so. From letting all team members sharing a story about a personal event from the past week, to major events that have been in the news in members' lives.

A critical aspect of virtual meetings is keeping all members engaged, excited about their work and aligned with each other. During the meeting this can be done by using voting tools. Voting tools were used not only for finding the most popular solution, but can also be used to see if an issue is resolved to the satisfaction of the members or should continue to be discussed (Malhotra et al., 2007).

During the meeting the minutes need to be logged. This responsibility is often rotated among members. The way this is done varies from citing to only including results of the discussion. When the meeting ends, a summary of all decisions made, actions assigned and due dates will be provided to create commitment towards forward movement (Malhotra et al., 2007).

4.2.3 Post-meeting

After the meeting, the minutes are made available. The decisions are respected and assigned actions are executed. All these outcomes can form material for the next meeting and thus a new cycle begins (Bostrom et al., 1993).

Even though this seems to be an important aspect of the meeting, there is little to be found on this phase in the literature on meetings. One can imagine that this phase is important for continuing business, as the decisions made during the meeting need to be operationalized. For reference the minutes need to be made available including an overview with the decisions.

This phase is also the point where the scope of this research ends. The CMS mainly focusses on the pre-meeting phase and the virtual environment will be used during the meeting. The eventual output of a meeting does not necessary result as foundation for a following meeting. This research focusses on a single meeting cycle, which is due to time constraints.

4.3 THE CASE

Currently there are two virtual environments, grids, which Thales uses. One in Hengelo, the Netherlands and the other in Paris, France. Even with direct access to and extended knowledge on how the server works, setting up a meeting and getting all required objects in place takes a fair amount of effort. In addition, the current management facilities are not very flexible and offer limited functionality (Rulof, 2013). This will probably form a major bottleneck when using OpenSim to communicate and facilitate meetings.

Therefore a CMS will be developed which automates parts of preparation and streamlines the process of using OpenSim for virtual meetings. The CMS will primarily focus on preparing meetings and making documents available in the virtual environment. An overview of the complete process is described below, to illustrate a likely usage scenario. Users will receive a demonstration of all the available tools and a manual describing how to prepare the meeting.

4.3.1 Preparation of the meeting

Before a team can hold a virtual meeting, the team members require a virtual representations of their selves, called avatars. Therefore the first step is to set up all the required accounts for all users. From this point everyone has access to the system and the meeting preparations can begin. The available documents need to be uploaded, so everyone can access the information which will be addressed during the meeting or used for preparing the meeting. The meeting needs to be scheduled, which requires a date, time and location. To add some structure to the meeting, an agenda is required.

A predefined set of rooms will be used for the initial design. The rooms can vary in size and facilities. To prevent multiple teams from scheduling a meeting at the same time on the same virtual location, the meeting room needs to be reserved. Additional meeting rooms can be created to increase the capacity of the virtual environment when required.

During this phase participants can discuss the available information by commenting on the available data. This is based on the findings of Guerrero and Pino (2002), and Malhotra et al. (2007), early feedback is important. Every team needs to find their own fit in this process. For example set a deadline when all documents need to be available, or when the agenda is final.

4.3.2 DURING THE MEETING

When the scheduled time comes to hold the meeting, the participants need to connect to the OpenSim environment with their avatars. The avatars need to travel to the location of the meeting in the virtual environment, the reserved meeting location. This brings up issue identified by Thales and also mentioned by Korolov (2009). The time it takes to travel in the virtual world, from the location your avatar appears to the meeting room needs to be as low as possible. Users have the ability to specify a home location to return to, or enter the world at their last known location. However, it can take quite some time to travel from your entry point to the designated meeting location, especially for the novice user who struggles with the controls.

From past experience at Thales only administrators can make changes to buildings in the virtual world. This prevents unexperienced users from breaking things. For example if a user accidentally removes the presentation screen, the meeting room is basically useless. Time is precious and would be spilled by restore mistakes like this, especially since there is no undo option.

During the meeting, the documents and presentations need to be accessible. Participants can use multiple communication methods, such as text and voice chat, and if possible even video. Since the meeting is structured by the agenda, the agenda of the meeting needs to be available during the meeting. Giving the participants feedback on the progress of the meeting and the current topic. At some topics voting can be the solution to come to a verdict. All important information, such as the decisions made, need to be logged and saved as minutes to be available for future reference.

4.3.3 POST-MEETING

After the meeting, the preparations for the next meeting can begin. All participants can look up the results of the meeting in the minutes and follow up the made decisions. Because the virtual environment is highly customizable people could create their own tools to make future meetings even better, or improve existing tools.

However, this would be the case in the ideal situation. Since only one iteration will be done, this is the point where the demonstration ends. A small evaluation will be done as a recap and after wards the users will be asked to fill out a questionnaire to measure the constructs of technology acceptance.

4.4 CONCLUSION

This chapter described the case which will be used to evaluate the solution, measure the usability when using a 3D virtual environment for holding meetings and predicting the usage intention. From the literature a number of challenges and best practices have been identified. The information from this and the previous chapter, provide answers to SQ1: “What are the current problems, challenges and solutions when using a 3D virtual environment for cooperative work?”

The main issues and challenges are: (a) the steep learning curve of using a 3D virtual environment, (b) the support staff needs to have extended knowledge of virtual worlds to make it enjoyable and productive, (c) it can be difficult to identify a real person by its avatar or avatar name, (d) finding the right metaphors can be a challenge, (e) travelling to your destination within the virtual world can be time consuming, (f) working virtually reduces media richness, (g) meetings are costly in both terms of time and money, and (h) without the right preparations meetings are unproductive.

Best practices identified from previous research are: (a) using predefined scenarios to which the virtual world adapts, this limits the amount of setup work the users has to perform, (b) use the eight principles from Bouras et al. (2008) used by Konstantinidis et al. (2010) for SLOODLE where applicable, (c) use a solution similar to a web-intercom to communicate between the virtual environment and the outside, (d) create simple objects that users can extent when needed, (e) recreate real world spaces as identifiable reference, (f) keep track of users entering and leaving the room, and (g) users have different access rights, to minimize accidental damage.

For the meeting itself several solutions have been identified: (a) ensure the meeting has a clear structure and thus use an agenda, (b) share the documents before the meeting and allow users to submit feedback, (c) ‘reconnect’ team members at the start of the meeting, (d) provide the members with a voting tool, (e) enable easy logging of the minutes, and (f) at the end and after the meeting, provide the members with an overview of the decisions made, actions assigned and due dates.

5 REQUIREMENTS AND IMPLEMENTATION

The requirements are based on the issues, challenges and best practices identified in the previous chapters. The information from the literature will be enriched by adding experiences and other known challenges identified by Thales. Based on the requirements a prototype implementation will be created. First the goals of the different stakeholders will be mentioned in section 5.1. The following section contains all the requirements, functional and non-functional. Section 5.3 will describe the overall solution design and is followed by the prototype design in section 5.4.

5.1 GOALS

The research is conducted on behalf of Thales, which makes Thales the main stakeholder. Besides Thales the different types of users will be the other stakeholders. The goals for this research are grouped by the corresponding stakeholder below.

5.1.1 THALES

Within Thales Second Life and OpenSim have both been used by Thales' units for experiments (Rulof, 2013). The latter has the advantage of being able to setup a private server, without having to worry about other people, from outside Thales, interfering (Konstantinidis et al., 2010). The OpenSim environment used by Thales is called the Thales Grid, and is located in Paris, France.

For managing the Thales Grid the management system supplied with OpenSim is used, the WIFI (Web Interface For... I) front-end. However, the functions and flexibility offered by the system are limited, especially when using the virtual environment for cooperative work. Thales would like to see if it is possible to create a CMS to increase the usability of their virtual environment. Because the time for this research is limited, the scope is narrowed to a CMS to support meetings in the OpenSim environment.

5.1.2 USER ROLES

The CMS will have different type of users. For example team leaders will probably need more access rights than normal team members to prepare the meeting. In addition, to offer support to all users there need to be a number of system administrators. Depending on the user's role he or she will have different permissions. The following main roles are identified.

5.1.2.1 ADMINISTRATORS

These users can make changes to everything for maintenance and/or assistance purposes. Because of the high access level of administrators, they can not only access their own data but also data owned by other users. Which can be helpful for debugging purposes. In addition they can make changes to user accounts and manage permissions of the users. It is highly recommended to limit the number of administrators to a minimum and only assign experienced users with in-depth technical knowledge.

5.1.2.2 TEAM LEADERS

Team leaders are the users that prepare the meeting and need to be able to manage their teams. Therefore they require some basic management permissions. When comparing to the user roles of Guerrero and Pino (2002), team leaders have some similarities with coordinators. Both are responsible for the pre-meeting success. Since team leaders need to ensure all documents are in place, the team members have access to the documents and all members are invited to the meetings.

5.1.2.3 TEAM MEMBERS

Team members can take any of the remaining roles of Guerrero and Pino (2002): contributor, facilitator or observer. Depending on the way teams operate team members can only read documents, similar to the observer role, or place comments on the available materials like the contributor does. It could be the case that team members also need to be able to add files to the meeting, therefore some flexibility in roles is required. The exact division of user permissions will depend on personal preferences and the way teams want to work.

5.2 CMS REQUIREMENTS

The most important aspect to take into account is the ease of use. Not only is it one of the main issues identified by multiple of the researches done on virtual environments (Kemp et al., 2009; Konstantinidis et al., 2010; Salt et al., 2008), it is also the main concern of this research. Therefore it is applicable in all areas of requirements that are mentioned above. Because the learning curve of the virtual environment itself is steep (Salt et al., 2008), the supporting CMS should not amplify the curve, but rather weaken it.

This can be done by letting the CMS automate certain tasks when preparing the meeting. For example, Thales mentioned an issue about traveling from the location your avatar appears in the world to the meeting room (Rulof, 2013). This same issue is also mentioned in the wish list of Korolov (2009). Which can be solved by using the Second Life viewer Uniform resource locators (SLURLs) to go directly to a specific location, based on given x, y and z coordinates, or by using the teleport command.

The requirements are split in functional requirements and non-functional requirements. Each requirement is followed by a small summary, based on the previous chapters, why it is listed as a requirement. Functional requirements are prefixed with FR, non-functional requirements are indexed starting with NR.

5.2.1 FUNCTIONAL REQUIREMENTS

Functional requirements define a function of the system or of a component of the system. Verschuren et al. (2010) uses the following definition for functional requirements: “Functional requirements are the functions the intervention, or the artefact that must be produced, should fulfil.”

FR01: The system needs support agendas for meetings.

One of the recognizable metaphor, as mentioned in FR01, to which all members are familiar (Rutkowski et al., 2002; Tate et al., 2010) is the agenda. The agenda is used to create the structure of a meeting. Malhotra et al. (2007) found that having a clear version of the agenda is an important factor to make meetings more productive and ensure the quality of the meeting.

FR02: The system needs to be able to link users to their avatar.

As Kemp et al. (2009) explain, it can be difficult to identify someone by its avatar name. This requirement enables identification and access management of users, for example to allow access to a user’s documents by an avatar of that user or to allow an avatar to access a meeting.

FR03: The system needs to be able to schedule meetings.

To ensure that all participants are notified on time, a room is reserved and all required documents are available, a schedule function is a useful addition. Guerrero and Pino (2002) found that using such as system will increases the number of people actually reading the agenda before the meeting starts. In addition this will enable support for the pre-meeting phase, since there will be a meeting to prepare in the system.

FR04: The system needs to be able to manage users and their permissions.

Based on principle eight (Guerrero & Pino, 2002), the management of access rights is required to support multiple roles. In addition the user management supports principle seven Konstantinidis et al. (2010) by making the system user-centred, and the findings of Guerrero and Pino (2002). Using OpenSim can be difficult and a mistake is easily made, to limit accidental damage different access rights can be used.

FR05: The system needs to be able to manage documents and presentations.
FR06: The system needs to enable users to provide feedback on documents and presentations.

Both FR05 and FR06 improve the efficiency of the meeting. When preparing for a meeting it is important to have all documents available. Besides enabling pre-meeting feedback on the documents will improve the efficiency and understanding of topics by the participants. (Guerrero & Pino, 2002; Malhotra et al., 2007).

FR07: The system needs to save a history of previous meetings and minutes.

Bostrom et al. (1993) identified that post-meeting data serves as input for the next pre-meeting. Besides a summary of all decisions, actions assigned and due dates will create commitment towards forward movement (Malhotra et al., 2007). Storing the meeting minutes will allow users to access virtual world content from outside the virtual world (Livingstone & Kemp, 2008).

FR08: The system needs to support multiple meeting rooms.

Both Bouras et al. (2008) and Konstantinidis et al. (2010) suggest using pre-defined rooms with different facilities that can be adjusted by when necessary. Different meeting rooms provide additional flexibility in facilities and size, and support principle two (Konstantinidis et al., 2010). In addition multiple groups can schedule meetings at the same time in the virtual world by using different rooms.

FR09: The system needs to keep track of avatars entering and leaving the room.

To provide a complete overview of all events during a meeting, keeping track of avatars entering and leaving the room similar to an attendance list of meeting can be used. This is also used in the I-Room (Tate et al., 2010).

FR10: The system needs to support voting.

During meetings voting can be used make decision when multiple options are available or when not all participants share the same view or to see if an issue is resolved to the satisfaction of the members (Malhotra et al., 2007). This also supports principle four (Konstantinidis et al., 2010) by keeping things as easy as possible without extraneous load on the user.

FR11: The system needs to support multimedia tools.

Konstantinidis et al. (2010) fifth principle prescribes designing a media-learning centric virtual space. This can be achieved by using multiple communication media layers, such as text, graphics and sound. In addition the user should be able to share his or her content with the other users, such as documents and presentations.

FR12: The system needs to be used in combination with OpenSim.

This is a requirement provided by Thales (Rulof, 2013). In addition OpenSim is open-source and can run on a private server. In contrast to the Second Life grid, which is under control by Linden Labs and therefore less suitable for non-public corporate activities. Open Wonderland is also open-source. However, the community is smaller and the project does not seem to be under active development ("Changes - Open Wonderland," 2014).

FR13: The system needs to enable communication from the virtual world to the outside and from outside to the virtual world.

By using a sort of web-intercom similar to the solution of Livingstone and Kemp (2008). This enables users that cannot access the virtual environment at a certain moment to communicate with users in the virtual environment. Again, this contributes to principle four of Konstantinidis et al. (2010).

FR14: The system needs to allow quick traveling to the meeting's destination to reduce travel times to a minimum.

An issue identified by Thales is the travel time in the virtual world. Travelling from the location your avatar appears in the virtual environment to the meeting room, can take a lot of time. Especially when the grid spans multiple regions. In addition this was also on the wish list of Korolov (2009).

5.2.2 NON-FUNCTIONAL REQUIREMENTS

The following requirements are non-functional requirements and specify criteria that can be used to judge the operation of a system. This is in contrast to functional requirements that specify specific behaviour.

NR01: The system should be easy to use, with a minimal learning curve.

One of the most often returning issues in research on virtual worlds is the steep learning curve and the effort required to become productive (Kemp et al., 2009; Konstantinidis et al., 2010; Salt et al., 2008).

NR02: Keep virtual world objects simple as possible.

Using simple objects so users familiarize with them from the start. When users feel the need, they can add features or create new objects based on existing ones (Livingstone & Kemp, 2008; Rutkowski et al., 2002). This also supports the fourth and sixth principle by Konstantinidis et al. (2010).

NR03: The meeting rooms should be based on real world spaces and use an ergonomic design.

Recreating real world spaces, such as office buildings and meeting rooms, which are familiar to the user offer advantages (Tate et al., 2010; Tate, Dalton, & Potter, 2009), such spaces are understandable for users with all sorts of backgrounds. This is also mentioned in principle 6 of Konstantinidis et al. (2010).

NR04: There should be a support staff.

Having a support staff present with extended knowledge of virtual worlds makes it more enjoyable and productive (Kemp et al., 2009). Without a support staff to fall back on, technical issues can create high barriers for users.

NR05: The system needs to use recognizable terms such as meeting, agenda and document.

Rutkowski et al. (2002) found that using the meeting metaphor in virtual collaboration helps participants to keep their attention. However, the metaphors should be simple and serve as examples and could be improved by users when desired (Livingstone & Kemp, 2008).

5.3 SOLUTION DESIGN

Salt et al. (2008) recommend to use an agile approach when developing for Second Life. Agile methods are not unplanned and undisciplined, but adaptive. The Agile Manifesto (Fowler & Highsmith, 2001) provides several principles how agile development is guided. The main purpose of the Agile Manifesto is: "We are uncovering better ways of developing software by doing it and helping others do it" (Fowler & Highsmith, 2001). The Agile Manifesto values the following four points:

- Individuals and interactions over processes and tools.
- Working software over comprehensive documentation.
- Customer collaboration over contract negotiation.
- Responding to change over following a plan.

The system will be created with this approach in mind. In addition to the advice given by Salt et al. (2008), an agile approach would be the best fit because not all of the details of the final solution are clear at this point. The identified requirements in the previous section need to be satisfied. Nevertheless, a lot of freedom remains in the solution around these requirements and multiple ways of solving a problem exist. This suites the agile approach, working in small steps and adapting when required. Besides, due to the time constraints for this research it would be quite a challenge to follow traditional development methods.

5.3.1 SYSTEM COMPONENTS

Similar to the Open Wonderland architecture the system, called OpenSim-CMS, will be created in separate components (J. Kaplan & Yankelovich, 2011). For this solution the back-end of the system will be accessible through a JSON (JavaScript Object Notation) API written in PHP (PHP: Hypertext Pre-processor) with a MySQL database. This setup is chosen because of the ease of use. Mainly because the easy to use Sim-on-a-Stick (SoaS)[8] includes a webserver with PHP and MySQL. SoaS is a complete

[8] Sim-on-a-Stick - http://simonastick.com/

working portable OpenSim environment that can be run from an USB stick, without having to install any other applications. In addition OpenSim can be configured to use MySQL which minimizes the number of required software components.

The front-end will be a web-based CMS, which uses the JSON API to communicate with the server. When using a web-based CMS the user does not require to install additional programs, since web browsers are commonly available on almost all computers. It even allows users to access the CMS with multiple devices and thus the solution is not platform dependent. For example the CMS can be used from a desktop, laptop, phone or tablet.

OpenSim has an integrated API which uses Extensible Mark-up Language (XML). However, XML is quite heavy since every tag also requires a similar closing tag. JSON is a light-weight alternative for XML. Both are supported in many programming languages and by many services. Besides, both are human readable, which makes it easier to debug the results and create new implementations with the available data. OpenSim includes support for JSON in versions above 0.7.6. Which allows scripts to retrieve, process and send JSON request from local and remote servers. In Table 2 the differences between JSON and XML are displayed, both examples contain the same user information. However, JSON uses less characters and thus file size, especially when the indents and line-breaks are removed. When all line-breaks and indents are stripped the XML example uses approximately 240 characters while the JSON example uses 140 characters.

```xml
<?xml version="1.0" encoding="ISO-
8859-15"?>
<users>
  <user>
    <firstName>John</firstName>
    <lastName>Doe</lastName>
    <email>john@doe.com</email>
  </user>
  <user>
    <firstName>Jane</firstName>
    <lastName>Doe</lastName>
    <email>jane@doe.com</email>
  </user>
</users>
```

```json
{
  "users": [
    {
      "firstName": "John",
      "lastName": "Doe",
      "email": "john@doe.com"
    },
    {
      "firstName": "Jane",
      "lastName": "Doe",
      "email": "jane@doe.com"
    }
  ]
}
```

TABLE 2: EXAMPLE OF XML ON THE LEFT SIDE AND JSON ON THE RIGHT SIDE.

The web-based CMS and scripts in OpenSim are clients that use the JSON API. This structure makes the solution scalable and extendable by allows links to other programs. Besides it would even be possible to link multiple OpenSim grids to one API, allowing users to access their documents in different virtual worlds. Another possibility is running all the components on separated systems. Using one system for the OpenSim grid, another one for the API, and the CMS can be hosted on a third system. The relation between the components is visualized in Figure 3. More detailed examples on how the system works will be provided in the next section.

The CMS offers asynchronous communication, which allows people to prepare the meeting independent from the other users. Where the OpenSim environment offers synchronous communication for the meeting itself. In addition the OpenSim environment is persistent so, it is possible to 'pause' the meeting at some point and continue at another, which also allows someone to enter the room at any moment in time and find the room in the state the previous users left it. Because OpenSim will be used, requirement FR12 is satisfied.

5.3.2 REST

A popular method for web services is using REpresentational State Transfer (REST) (Fielding & Taylor, 2002). REST defines the architectural style of the World Wide Web (Pautasso, Zimmermann, & Leymann, 2008). Fielding and Taylor (2002) explain that: "the name 'Representational State Transfer' is intended to evoke an image of how a well-designed Web application behaves". Which is a virtual state machine represented by a network of web pages. By selecting links or submitting data the user can progress through the different states. Every time a state transition is triggered by the user, a representation of that state it transferred by the application to the user. The authors refer to the modern Web as an instance of a REST-style architecture (Fielding & Taylor, 2002).

The Web uses the Hypertext Transfer Protocol (HTTP) protocol and REST often uses HTTP methods. However, REST is not limited to the HTTP protocol (Chanda & Foggon, 2013). According to Pautasso et al. (2008) the main principles of REST implemented in the HTTP protocol can explain the success and scalability. One of those principles being the use of Uniform resource identifiers (URI), which are used to make resources identifiable by name on the web. Using the HTTP protocol has another advantage, it does not require any new ports to be opened in the company's firewall. All traffic goes over the same ports used by your browser. So if browsing can connect to the World Wide Web, the CMS and API can connect as well.

Another principle is that each resource uses uniform interfaces. These interfaces are HTTP methods for requesting or submitting data from a server. The most commonly used HTTP methods for Create, read, update and delete (CRUD) operations are POST, GET, PUT and DELETE. The GET method is used to query the state of a resource. Where POST is used to create a new resource and PUT is used to replace a resource or create it if it does not exist. The DELETE method is used to remove a resource (Pautasso et al., 2008). Examples of the different methods will be provided later on in this chapter.

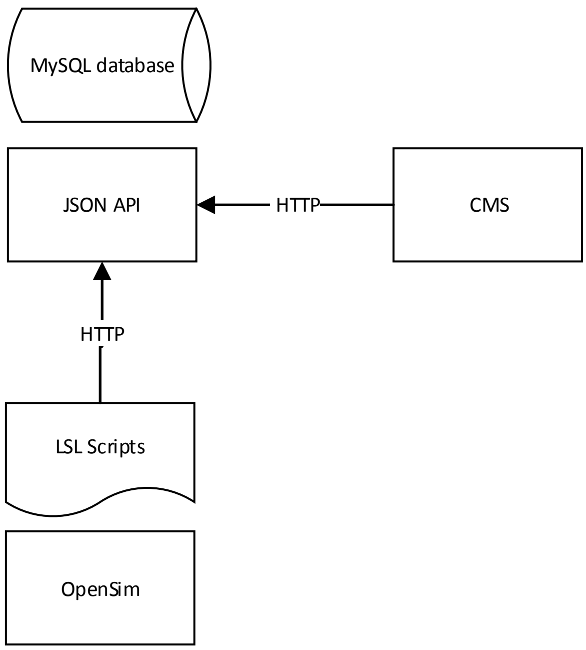

FIGURE 3: OVERVIEW OF THE SYSTEM COMPONENTS

Furthermore REST uses stateless client-server communication. Each message sent from the client to server (request) or from the server to the client (response) needs to be self-descriptive. Which means each message must contain all the required information to complete the task (Fielding & Taylor, 2002; Pautasso et al., 2008).

In contrast to Simple Object Access Protocol (SOAP), which is a protocol, REST is an architectural style. Which means there is no truly official standard when using REST for web APIs. SOAP relies on XML as message body, where REST can use many protocols for its body. The type of body used by REST is specified by an Internet media type, previously known as Multipurpose Internet Mail Extensions (MIME) types.

Summarizing, the architecture will be a JSON REST API written in PHP using a MySQL database. The API will be accessed by to different types of clients, one being the web-based CMS and the other being tool created in OpenSim. The tools in OpenSim will use the included scripting language LSL to access the API. By using this approach the system is accessible from every application that can perform HTTP requests and process JSON, making it quite flexible and scalable. An overview of the components is given in Figure 3.

Since the CMS is web-based it will be created in HTML (HyperText Markup Language) and uses JavaScript to connect to the API. Because of the client-server model, multiple clients can be created. It would even be possible to create a simple client for common usage and a more advanced client for maintenance tasks. However, for this research there will only be a web-based client. Both the CMS and the API have a configuration file containing the most important settings and will be using open-source libraries where available to save development time. An overview of the used libraries for the CMS and API are in Appendix E.

5.4 PROTOTYPE

With the architecture in place the requirements can be implemented to create a prototype. The OpenSim-CMS prototype will be created in small steps, one at a time. The first step was creating the foundation of the API. The first part to create was the authentication system, since authentication is required throughout the whole API. The API needs to support user authentication, but also making modifications to a user, creating users and removing users. These features support requirement FR04.

For authentication to the API several methods are available. However, since an API based on REST is stateless, every request requires some sort of identification to validate the permissions of the user. This will prevent unauthorized access to the functions the API offers.

5.4.1 AUTHORIZATION

The authentication can be achieved in several ways. The first way is using HTTP basic authentication. Which requires the user to attach a header to every request. However, the username and password combination are only encoded with base64, which can be decoded and thus is not very secure. A more secure method is using HTTP digest authorization. This does use encryption when sending the username and password. However implementing HTTP digest authorization in OpenSim could become quite a challenge, since LSL requires the user to set all additional headers manually.

Another method often used for APIs is using an access token. The user needs to authenticate himself and receives an access token which is valid during that session. The access token is linked to the user's user account on the server side. For ease of use and compatibility with OpenSim, the username and password are submitted in a POST request and will return an access token. The access token is returned by the server and only valid for a limited time. On default the token will expire after not being used for 30 minutes and is bound to the user's Internet Protocol (IP) address. Because both HTTP basic authentication and HTTP POST requests are not encrypted it is recommended to use HyperText Transfer Protocol Secure (HTTPS) for additional security. The password is salted[9] and encrypted before being stored in the database.

Users can form groups, allowing them to share files with the other group members. A user can be part of multiple groups simultaneous, making this an advanced extension to the user management. A group can for example represent a team or task force. Another way of using groups is making a 'public' group where all users are part of, to share information with all members. For example sharing a manual for OpenSim.

[9] From Wikipedia (2014): "In cryptography, a salt is random data that is used as an additional input to a one-way function that hashes a password or passphrase. The primary function of salts is to defend against dictionary attacks versus a list of password hashes and against pre-computed rainbow table attacks."

Because of limitations in the way users can provide input to scripts, there is no simple way of authenticating the user with their CMS username and password. However, every object in OpenSim has a Universally Unique Identifier (UUID), to be more specific OpenSim uses version 4 of UUID. An UUID is a 128-bit number, in the form of 8-4-4-4-12 hexadecimal lowercase characters (0 to 9 and the letters A, B, C, D, E and F), for example: 1dd9b4ee-a3eb-4c00-a654-cdf3515de340. Each version of UUID has different characteristics and contains the version number, where version 4 relies on random numbers. The first digit from the third block is the version number, in this case 4. With this number it is possible to identify an avatar. Therefore the API can link an avatar to a user account. The user needs to confirm this link by logging in into the CMS to prevent unauthorized avatars accessing the user's files. Similar to the registration booth of Kemp et al. (2009) an avatar link script has been created to satisfy requirement FR02. The avatar's UUID is retrieved and the user only needs to enter his or her username. Once the avatar is linked and the user has confirmed the avatar, the avatar cannot be linked to other user accounts and the avatar now has access to the user's files.

5.4.2 Documents and presentations

With the authentication in place the other functions can be created. For all aspects of the API there are multiple solutions available. However, every solution needs to be compatible with OpenSim and easy to use. OpenSim can at least use the following HTTP or HTTPS methods: GET, POST, PUT and DELETE. For sending and requesting data this is sufficient. However, documents and presentations need to be converted to images before OpenSim can visualize them.

To ensure FR05, support for documents and presentations needs to be implemented. Documents are often in DOC or DOCX format from Microsoft Office or Open Document Format (ODF) when using other application. Presentations are commonly saved as Microsoft's PowerPoint presentation (PPT or PPTX). Thankfully, both types of media can be stored as PDF by most applications or exported as PDF by using a PDF-printer. Such a PDF-printer converts the data, which would normally be printed on paper by a regular printer, as a file.

PDF files can be converted to separate images per slide or page. OpenSim does not support PDF or other document files, however it does support images. The suggested image type to use as texture in OpenSim is Joint Photographic Experts Group (JPEG) which is commonly known as JPG. Another advantage of PDF is that it does not convert text to pixels. So when the system converts the PDF to a JPG per page or slide, it has access to a high quality source and this will benefit the quality of the final result. OpenSim has options to load dynamic textures from an URL. Textures in OpenSim are often square. Even though it is possible to use other aspect ratios, this sometimes resulted in unpredictable behaviour during the early stages of development, where the texture became only one by one pixel in size. Besides, pages of a document are often in portrait orientation and presentation slides in landscape. Therefore the images are resized to fit within a square of 1024 pixels width and height after being uploaded to the API.

Since JPEG does not have transparency, the empty spaces are filled with black or white. Depending on the average red, green, and blue (RGB) value of the corners of the image. RGB values for JPG images use an 8 bit range, 0 to 255, for red, green and blue. For example when all values are 0, the colour will be black. For the other limit, all values being 255, the colour will be white. So after a PDF has been converted to separate images, the average of all those values for all four corners of the slide or page will be calculated and when it is 128 or above the background will be white, otherwise the background will be black. Besides documents and presentations, the user can also upload single images. For example a screenshot or photo of a prototype design.

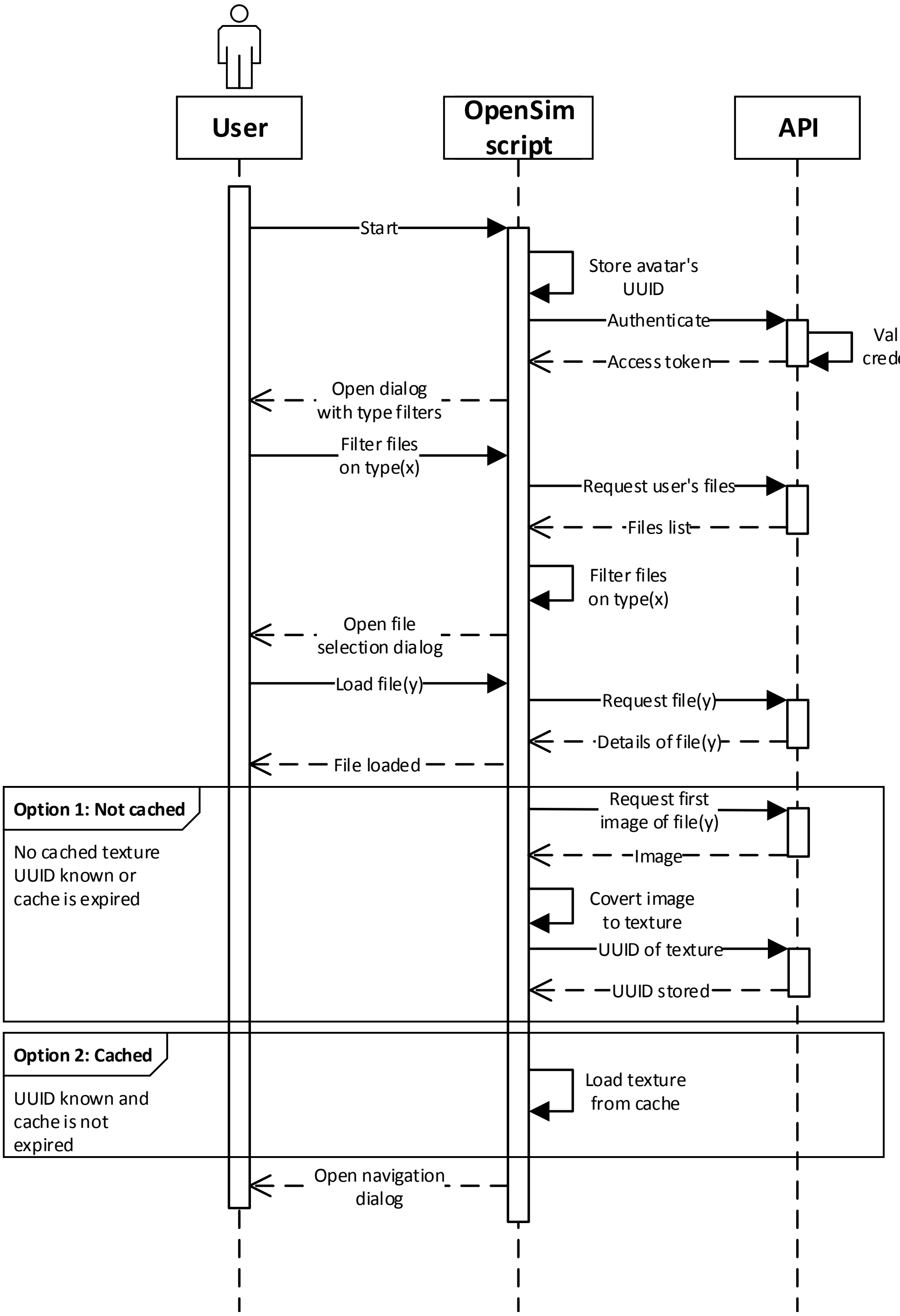

FIGURE 4: SIMPLIFIED SEQUENCE DIAGRAM SHOWING THE PROCESS OF LOADING AN IMAGE, FIRST PAGE OR SLIDE FROM THE API IN OPENSIM.

To satisfy requirement FR06, users need to be able to leave a comment at documents and presentations. The API uses Markdown[10] to format comments. According to the author's website: "Markdown is a text-to-HTML conversion tool for web writers. Markdown allows you to write using an easy-to-read, easy-to-write plain text format, then convert it to structurally valid XHTML (or HTML)." Because of this, the comments remain readable even when not being converted to (X)HTML. HTML

[10] Daring Fireball: Markdown - http://daringfireball.net/projects/markdown/

comments are not a problem in the CMS, since the CMS is web-based. However, in OpenSim the comments are retrieved as plain text and displayed as a chat message.

Users can leave comments at scheduled meetings, uploaded files and even at each page or slide. The comments are threaded, meaning a user can reply to a specific comment and the comments are visually grouped. This adds structure to the discussion and allows users to start a discussion even before the meeting started. In OpenSim only comments for pages, slides and documents can be retrieved. However, comments are retrieved through the API and users could create own implementations to retrieve comments from other elements or display them different than plain text chat messages in OpenSim.

In OpenSim the documents, presentations and images are retrieved by a script placed in a large virtual screen. In Figure 5 the screen on the left is an example of this, showing the Agile Manifesto. The overview of the process of loading an image, the first page or first slide is displayed as a simplified sequence diagram in Figure 4. The user can access all his or her files, and with just three clicks show the file in the virtual world. When the avatar clicks on the screen, the UUID of the avatar is stored. This will be used in requests to identify the user by matching the UUID to a list with known avatar – user combinations. After the script has authenticated itself at the API and received an access token, the user will be prompted to select a file type. Because dialog buttons in OpenSim have a maximum text length of 24 bytes and there is a maximum of 12 buttons, files are identified by their unique ID and filtered on type: image, presentation or document. When the user made a selection, the script will request all the files accessible by the user, identified by his or her avatar's UUID, from the API. The returned file list is filtered on the selected file type. For example, the user would like to show a presentation, so only files with the type 'presentation' are displayed in the dialog. Because of the limited number available buttons, an option is added to load a specific file by entering the ID manually.

When the user made a request to load a file there are two options. Before OpenSim can display an image on a surface, the image is converted to a texture. This texture is temporary stored in the database of OpenSim. For improved performance, a simple cache mechanism is implemented in the API. The UUID of the temporary texture is sent to the API and attached to the corresponding image, page or slide. A reference to the grid is also included, since every grid uses its own database. This enables future requests to use the already available texture instead of reloading the image and converting it to a new texture. The first option in the diagram shows the process of requesting the image from the API, converting it to a texture and sending the texture's UUID to the API. The alternative situation when a cached version is available on the current grid, the image is not retrieved from the API, but the already known texture is used directly. After this the user will be prompted with the navigation dialog, allowing the user to go the next page or slide, load a new file or close the script and ´turn off´ the virtual presentation screen.

5.4.3 Meetings

To satisfy requirements FR01, FR03 and FR08 the user needs to be able to schedule meetings, add an agenda to the meeting and select an available room. The system allows users to pick a date and time for the start and expected ending of the meeting. Based on the selected grid, a list with available regions will be presented and after selecting a region the available meeting rooms are listed. The description of the room contains an overview of the facilities the room offers. The system checks whether or not the room is available in the selected period. This will prevent double-booked rooms.

When scheduling the meeting, the agenda can be included, the relevant images, documents and presentations for the meeting are included, and the users who are invited will be added to the list with participants. Every invited participant will receive an e-mail containing the agenda, an overview of the files and participants, including an iCalendar (ICS) file. The ICS file enables the user to quickly add the meeting to his or her electronic agenda. The e-mail also contains a quick link using the hop protocol, to quickly go to the meeting location in the virtual world.

A hop URL has the following format: hop://hostname:port/regionname/x/y/z/. Where x, y and z are the coordinates in the region: longitude, latitude and altitude. The hop protocol is supported by a growing number of viewers (Tate, 2013). Popular viewers like Kokua and FireStorm have an address bar which uses these URLs. By pasting the URL in the address bar the user can instantly travel to the location of the URL. Which reduces travel times significantly. However, it still requires the user to perform the copy pasting operation. It would be ideal to register the protocol and just having to click the link. Despite that this is technically possible, many e-mail providers block unknown protocols. For example, Google's Gmail strips the hop:// part of the URL and converts it to a normal website URL, which obviously does not work anymore. Besides, your browser needs to know how to handle URLs using the hop protocol. This makes it only a partial solution for FR14.

In the meeting room, see Figure 5 for an example, the information added in the CMS can be accessed. A recorder is created to assist during the meeting. When turned off the recorder is red, the user can turn it on it by clicking the object. The recorder will now turn yellow to indicate that it is almost ready to go. The user will be prompted with an overview of the meetings that are scheduled for today. After selecting one, the recorder will turn green and the agenda will be loaded. In the example below the agenda is also displayed on the flip board in the back of the room. The current agenda topic is highlighted and all textual chat is recorded. The recorder also keeps track of the presence of avatars, which satisfies FR09. The recorder notifies the other avatars when someone enters the meeting.

The recorder does not record any voice chatter. Therefore important decisions or other notes that need to be in the minutes need to be typed in the chat. All chat messages are related to the active topic, therefore in the CMS the minutes already have the structure of the meeting. In addition the recorder also has an option to start an anonymous voting process. All the present avatars will be prompted with a dialog to vote one out of four options: approve, deny, blank or none. After all avatars have voted or when the voting process is manually ended, the results will be displayed. The results are also logged into the minutes. Thereby requirements FR07 and FR10 have been satisfied.

Besides the agenda overview and the ability to show documents, images and presentations, OpenSim also has a built-in web browser. In the example of Figure 5 the web browser shows the Google search page. The browser supports flash and JavaScript, which enables many online solutions. For example interactive web based whiteboards, schedulers and movies. However, there are some limitations to the current in-game browser. Because the viewer processes the browser's URL, sessions are locally and not shared. So almost every web page that requires a user to login will only be visible for that user, the others will see the login screen. Another downside of the browser is that it has limited HTML5 support. However, this could be solved in future releases of the OpenSim viewers. Even though the support for voice and text chat, and the ability to show uploaded files, videos, gestures and web pages satisfy requirement FR11.

Only FR13 needs to be satisfied and FR14 is already partially satisfied. For the communication between the virtual world of OpenSim and the outside world a chat function is added to the API, a solution similar to the web-intercom of Livingstone and Kemp (2008). This allows avatars that are close to the script, default setting for chat distance is 20 meters, to talk to any other user or avatar using the chat API. In OpenSim several 'phones' are created, that once turned on record all public chat within range and sent it to the API. The script at the same time retrieves all chat messages from the API. So even avatars that are regions apart from each other can use the intercom to communicate. To prevent avatars from seeing double messages, the messages sent by avatars that are within range of the script are filtered out, since their messages are already visible in the default OpenSim chat. In the CMS a chat box can be opened, that will do the same thing. To ensure that the CMS user knows who he is talking to, the API attempts to resolve an avatar´s name to the user´s real name by matching the UUID of the avatar to the list with known user – avatar links.

FIGURE 5: THE PROTOTYPE ROOM WITH THE MEETING RECORDER ON THE TABLE AND FROM LEFT TO RIGHT ON THE WALL: PRESENTATION SCREEN, WEB BROWSER AND AGENDA.

In the API database meeting rooms have an x, y and z coordinate. These coordinates are used to generate the hop URLs. However with remote administration enabled in OpenSim, avatars can also be teleported by using these coordinates. An API function is added which allows the user to teleport an avatar on the selected grid to the given x, y and z coordinates with the press of one button. The downside of this solution is that the avatar needs to be linked to the user's account, to prevent abuse of randomly teleporting other user's avatars, and that the avatar needs to be online when the API function is called. However, this solution and the previously mentioned hop protocol decrease the travel time significantly. Therefore FR14 is almost completely satisfied.

5.4.4 ADDITIONAL

The API offers support for autocompleting usernames, group names and file titles. These functions are used to invite users to a meeting or to add users to a group. The same applies for files, and the group names are used to share a file with a specific group. It is also possible to browse the complete list with users, groups or files. However, over time these list can contain many items and it will be like searching for a needle in a haystack. The current search function is, even in its current simple form, an essential for usability on the long run.

Whether or not the non-functional requirements are all met will require user input. NR01, keeping the system easy and with a minimal learning curve, is the most difficult challenge of all. Getting started with OpenSim requires quite some effort. Even with the CMS and API automating many tasks, the user still needs to learn the controls in OpenSim and configure the viewer. However, once this is done the user can access all his or her files with just three clicks. The first click is turning the script on, second select the content type and the third is for selecting the right file. Even for non-experienced users this should be doable, since the dialogs contain instructions on what the buttons represent.

The objects in the virtual world are pretty basic. Using recognizable colours such as red, yellow and green to indicate that an object is respectfully: stopped, starting or running. In addition the presenter screens are black when turned off. Because of the use of an API, users have the possibility to create their own implementations. This is in line with the recommendations of Rutkowski et al. (2002) and Livingstone and Kemp (2008), and thus satisfying requirement NR02.

Meeting rooms are equipped with chairs, tables, presentation screens, flip boards and a tape recorder (meeting recorder). The functions these objects offer are similar to the functions these objects would offer in the real world. In addition meetings have access to agendas, documents, presentations, web browser and voting, which are all examples of terms that many users can relate to. Especially those who have been in meetings before. By using identifiable terms and objects NR05 is satisfied. Even though the possibility exists in OpenSim to create any shape of building, all rooms created for this research resemble real world spaces. Even though the virtual meeting rooms are not exact clones of real-world rooms, they do look realistic enough to be authentic and thus satisfying requirement NR03.

Now only NR04 remains unsatisfied. Since this is just a prototype, the support staff will be limited, and will consist of those who are already experienced users and those who helped during the development and testing of the API and CMS. The complete API is documented to allow advanced users to create their own new implementations or improved implementations of the already offered facilities. In addition the CMS will provide the user from feedback where possible and is created to require as little effort as possible. For new users a short manual is created containing the instructions to get started and a more extended manual containing instructions for every aspect of the CMS and the created tools in OpenSim.

6 DESIGN VALIDATION

The prototype, which is designed in the previous chapter, is validated based on Wieringa (2009) internal and external validation, and trade-offs (sensitivity analysis). This is done to ensure a minimal quality level of the design and increase the significance of the empirical part of this research.

6.1 INTERNAL VALIDATION

Using internal validation should provide evidence that the solution will actually work. One of the general issues with business meetings is that they are costly, both in terms of money and time (Romano Jr & Nunamaker Jr, 2001). To resolve this virtual collaboration techniques are developed. This research focusses on using a 3D virtual environment for the purpose of meetings and increasing the usability by developing a content management system. For evaluating the internal validity of the solution, the following question of Wieringa (2009) is used:

> V1 **Internal validity:** Would the design, implemented in this problem context, satisfy the criteria identified in the problem investigation?

When translated to this research, the question will be whether or not the system as described in the previous chapter would satisfy all the identified requirements and if the requirements would satisfy the problem identified by Thales, which is the usability of a 3D virtual environments. The following two questions are used to evaluate every solution and confirm if the stakeholder criteria are satisfied.

> E1 **Causal question:** In problem domain D, would solution S have effects E?
>
> E2 **Value question:** Do E satisfy stakeholder criteria C?

The requirements are derived from literature about (virtual) meetings and virtual environments, and from the experience Thales has with virtual environments. These requirements are enriched with experiences from other users on the web, individuals that posted blogs about virtual environments in business context, for example Korolov (2009) with her wish list, or companies that supported virtual environments or used them in their products, such as IBM (2011) and Sun (Wonderland, 2012).

In Table 3 an overview is given of the functional requirements and the corresponding solution as implemented in the API/CMS and in OpenSim. The table shows a short summary on how the requirement is satisfied. Because the API and CMS are developed to support each other, they are grouped together. The detailed description of each solution is available in the previous chapter.

Due to time constraints, the solution is not optimal yet. Ease of use can be increased even more, for example enabling search for real names, avatar names or e-mail address when adding users to groups or meetings. However, decisions had to be made in order to find the right balance between the quality of the solution and the effort required to realize it. The biggest time saver was limiting the scope of this research to virtual meetings and letting the CMS focus on the preparations. In the OpenSim environment only the essential tools are implemented, being as simple as possible. However, this is not necessarily a bad thing, since the non-functional requirement NR02 favours this approach. In addition the approach of using a client-server model makes the solution flexible and easily extendible.

Req.	API/CMS	OpenSim
FR01	Created when scheduling the meeting. Can be edited when required.	The meeting recorder can access the agenda and keep progress of the meeting.
FR02	Avatars can be associated with a user account. The API has a list of avatar – user links.	Avatar can request the API to link its UUID to a given username.
FR03	The user can schedule meetings when logged in, in the CMS.	-
FR04	Each API function requires a specific minimal access level. This level can be set per user account in the CMS.	OpenSim already has its own built-in authentication mechanism, where the user can login with the avatar´s name and password. Each avatar can have specific permissions in OpenSim.
FR05	The user needs to convert documents and presentations to PDF. The API accepts PDF files and processes them to separate images.	The processed images can be retrieved by a script in the presenter screen to allow an avatar to show a presentation, document or separate image.
FR06	In the CMS users can add comments to documents, presentations, images, separate pages and slides, and meetings. The comments are threaded and can be used to start a discussion.	The presentation screen script can retrieve the comments for the currently loaded page, slide or image.
FR07	In the CMS users can view all their previous meetings and access the minutes, including voting results and avatar presence, logged by the meeting recorder.	When enabled, the meeting recorder sends all text chat messages (including voting results) to the API to form some basic minutes.
FR08	In the CMS when scheduling a meeting, the user can select one of the meetings that is available during the given period.	Multiple meeting rooms are constructed in the virtual environment.
FR09	-	The meeting recorder scans for presence of avatars and also submits updates to the chat and thus the minutes.
FR10	-	Avatars can vote during a meeting by starting an anonymous voting process through the meeting recorder
FR11	-	OpenSim and the created tools offers support for web pages (including Flash), presentations, documents, images, voice and text chat and gestures.
FR12	The API can perform remote admin calls to the OpenSim grid.	The API is created to be accessible from OpenSim.
FR13	The CMS offers a chat function which allows users to chat with other CMS users, but also with avatars near the intercom in the virtual environment.	Avatars can use an intercom to chat with the users in the CMS and even with other avatars on the same grid at a distant location also near an intercom.
FR14	Users can press the teleport button to instantly move their avatar to a specific location.	URLs using the hop protocol can be inserted into the address bar of the viewer.

TABLE 3: OVERVIEW OF THE FUNCTIONAL REQUIREMENTS MATCHED TO THE SOLUTIONS USED IN THE API/CMS AND IN OPENSIM.

All identified functional requirements are satisfied and explained in Table 3. The non-functional requirements are harder to validate, since no direct system functionality can be linked as a solution. Especially NR01 and NR04 are difficult to satisfy. NR01 states that system should be easy to use with a minimal learning curve. This will highly depend on the perception by the user. One user can find the system really useful, while the other would find it too difficult. The answer on whether or not this requirement is satisfied can be given after the user feedback has been processed.

Another non-functional requirement NR04 prescribes that there should be a support staff. During this research there is no support staff present. For the time being users need to help each other and can consult experienced users. However, based on the challenges and issues from the literature, virtual environments require a lot of effort and have a steep learning curve (Kemp et al., 2009; Konstantinidis et al., 2010; Salt et al., 2008). This research attempts to weaken that curve, but it will most likely always be present to some extent. Therefore it is highly recommended that any company using virtual environments has a support staff present and satisfy NR04.

6.2 TRADE-OFFS

Most of the identified issues have multiple solutions. These choices made for the design influence the result. Wieringa (2009) uses the following question to validate the trade-offs by comparing different designs:

> V2 **Trade-offs:** How would slightly different designs, implemented in this context, satisfy the criteria?

This chapter will compare the current solution to the alternatives. For every option the advantages and disadvantages are compared, providing the reason behind every decision.

6.2.1 VIRTUAL ENVIRONMENT

Even though using OpenSim as the virtual environment is a requirement (Rulof, 2013), it is also the most obvious choice. The platform has to be highly customizable, allowing users to create all kind of tools and use it for a wide range of purposes. In addition the ability to run a private server, using a client-server model with a platform independent client, and having access to the source code of the application will probably be highly valued by any company. This allows companies to ensure that their information is directly accessible by third-parties, which for example is the case with Second Life.

Based on the results of the previous chapters two solutions remain that meet these requirements: Open Wonderland and OpenSim. Both have advantages and disadvantages over the other. Open Wonderland can access X11 applications, allowing avatars to access Linux desktop applications from within the virtual world. However, these features make the server incompatible with Windows. OpenSim does not have access to native X11 applications and the server can be run on multiple platforms. For similar functionality as offered by Open Wonderland, one can create a module for OpenSim or create a web-based application. Since more and more cloud based solutions become available, creating a custom module is probably necessary. In addition web-based applications can be also be used outside the virtual environment, and even outside the company office.

The amount of customizability offered by Open Wonderland is higher than OpenSim. Open Wonderland uses Java combined with a custom toolkit, which offers APIs to allow interaction within the virtual environment (Wonderland, 2012). OpenSim uses LSL, which is the scripting language used by OpenSim and Second Life. New functions are added to LSL with every release of OpenSim, for example JSON support. However, Java is more comprehensive and known by a wider audience. Both environments have access to user created content, Open Wonderland even has a central Module Warehouse, a kind of app store.

When looking at the two environments at a different angle, OpenSim has some advantages over Open Wonderland. From the usability and maintainability point of view, the community (Korolov, 2014a) and development of OpenSim are more active. OpenSim has 2053 commits since January 2013 ("Commits - opensim/opensim," 2014), compared to only 6 for Open Wonderland in the same period ("Changes - Open Wonderland," 2014). This is probably due to the compatibility of OpenSim with Second Life offering instant familiarity and allowing users to create their assets in OpenSim and use them in Second Life, or the other way around, use assets from Second Life in OpenSim.

Even though Open Wonderland offers some advantages to OpenSim, OpenSim has some large advantages that are not in the specifications. Especially the active development and larger community make OpenSim the most obvious choice. Besides, Thales already has experience with OpenSim and Second Life, and for the development the server of OpenSim can be run on Linux, Mac or Windows.

6.2.2 CLIENT-SERVER MODEL

In the solution a client-server model is used, with a JSON API as server. An alternative to this would require to create a different interface for OpenSim to communicate with. This could be done by implementing a module for OpenSim that performs the data retrieval and storage tasks. Without the API the client, which currently only performs API calls, needs to be extended and merged with the functionalities the server has. Creating a large module for OpenSim with a web-based front-end.

Even though this is possible and would probably work fine, it is less flexible than the current client-server model. It would become impossible to separate the CMS from OpenSim, making it difficult to connect multiple grids to the same CMS, and dividing the system components over multiple machines. Which could become an issue when a lot of users are using the system, it does enable users to login into the CMS with their avatar. Besides it creates a single point of failure, when the OpenSim server stops running, the CMS will also be unavailable. Upgrading OpenSim will require updates to the module.

Another advantage of the current separated structure is that the API could also be used by other applications or even be used when migrating to a different virtual environment. It would also be possible to merge the CMS with the server and attach an API to it. In this case the client would have direct access to all the models and controllers used in the API and OpenSim would still be separated. There is no real advantage over separating the CMS and server, except for keeping things clear and organized.

6.2.3 EXISTING CMS

The possibility to use an existing CMS as a basis and extend it with the required functionalities was also a possibility. However, this would reduce the amount of freedom and introduce a high amount of additional features that are would be obsolete for this project. Besides, with the large number of tailored functionalities the amount of effort and number of workarounds could become quite high. By creating a custom system, all requirements are taken into account during the design. In addition, the CMS is less dependent of third parties. In the current design only specific open-source libraries are used, most work independent of the others.

However, since OpenSim only requires access to an API to make all tools work, it would make little difference if an existing CMS was used or the custom CMS is created. The main difference is the ease of development. By creating a custom CMS all requirements can be taken into account from the start, making the system dedicated for meetings. For this research this would most likely be beneficial, since the end-user is not distracted by unused features and the developer has a high degree of freedom in finding the optimal solution.

6.2.4 JSON VS XML

Another decision has been made when choosing the data structure. In this solution JSON was chosen over XML. Both are quite common, with XML being slightly more popular than JSON, and both would work great in this solution. However, JSON is far more popular in new APIs (DuVander, 2013). JSON and XML are supported by OpenSim and many other applications. Nurseitov, Paulson, Reynolds, and Izurieta (2009) found in a case study that JSON is faster and uses fewer resources compared to XML. When the application grows and usage of the API increases, performance and resource usage becomes more and more important. In addition JSON uses a simple human-readable syntax, which eases the development of new features and makes it the better choice for this solution.

6.2.5 FILE SUPPORT

For showing presentations and documents in OpenSim multiple options are available. The first being the current implementation, converting the every slide or page to separate images. After converting again two options are available: (a) loading the image as texture or (b) serving the images as a web application and loading the presentation as a web page. The down side of converting a document or presentation to images is that it removes all the interactive elements and effects. However, it does make the usage a lot simpler and when using images as textures the content is persistent in OpenSim.

The second option is to convert the document or presentation to the Flash format and serve it to an OpenSim media object. While textures are retrieved from the OpenSim server and all users will see the same content once the texture is loaded, web pages are loaded locally by every user's viewer. The latter can cause users to become out of sync on the presentation, especially when joining later.

The optimal solution would be to create a module that can open all regular office file types and directly show them in OpenSim, similar to the X11 implementation of Open Wonderland. However, this makes it a lot more complex, especially when attempting to retrain multi-platform support and having time constraints. In the current solution a PDF file is required as input for documents and presentations, this could be extended with support for other file types. However, with the use of PDF printers all files that can be printed can be converted to a PDF.

The PDF file is converted to separate images of 1024 by 1024 pixels. OpenSim prefers square images, and supports files with a resolution up to 2048 by 2048. However, using the maximum resolution will make files four times larger and the load on the API, the OpenSim server and viewers will be higher, both in terms of computing power and bandwidth. After a number of testing rounds, resolutions of 512 by 512 pixels seem to be too low. It was quite difficult to read normal sized text in documents, with a width and height of 1024 the text was readable, even footnotes became readable. Therefore in most cases a resolution of 1024 by 1024 would be sufficient to read all text. However, if users do require higher resolutions, it is possible to change the dimensions in the configuration of the API.

6.2.6 AUTHENTICATION

In the current solution authentication happens by logging in once, receiving an access token and using that token for future requests. Alternatively HTTP authentication could be used including the credentials as a header. Instead of sending a token or credentials every request, the server could also store a session. However, the last option is inconsistent with the REST principle. Since REST ought to be stateless and every request needs to include all the necessary data to perform the request.

According to the LSL documentation, the HTTP_AUTHORIZATION parameter is not available and basic authentication requires proper URL formatting ("LSL Portal," 2013). The URL will then have the following format: http://username:password@host.com/api/request, exposing both the username and password. Sending the username and password as request body makes the username and password less obvious. When performing the request over HTTPS the body is secured.

A final small change could be encrypting the password locally before submitting. However, the current encryption mechanism uses a salt to increase the password strength. This would require the client to know the salt, or perform additional steps when authenticating. In addition, LSL does not have all the available encryption methods, only supporting MD5 and SHA1 according to the LSL documentation ("LSL Portal," 2013). Additional methods will require customization to OpenSim. This makes using an access token and HTTPS the most simple and secure option.

6.2.7 Teleportation

For moving users to a specific location multiple options are available. Beside the earlier discussed hop protocol and the API teleport function, the avatar's location can be changed by updating the database. However, this will only work when the avatar is currently offline and the grid uses an accessible MySQL database. The last known position of the avatar will be updated and when logging in into the virtual environment, the user needs to select last known location as starting point.

Compared to the previous solutions, this is the least clear. The user can only see if the location change was successful after logging in. It is also easy to forget to switch from the 'home' starting location to 'last known' in the viewer. When the something fails, the user will first need to log out before a new attempt can be made. The advantage of this solution is that the user can set its starting location in advance, even days before the meeting. However, this can become confusing when the user has multiple avatars. Since the starting locations are related to the avatar, the user needs to select the right avatar. In addition, this is in conflict with the actual meaning of the last known location field.

When using the hop protocol or the teleport API, the user already selected his or her avatar and the result of the teleport is instantly visible. In addition it will also work on grids that do not use the MySQL database or where database access from the API is not configured. Besides, the API functions can also be used from scripts in OpenSim, allowing specific user to be teleported by the press of a button from within the virtual environment.

6.2.8 Voice support

OpenSim has three built-in options to enable voice: Mumble, Vivox and FreeSwitch. Currently the Mumble implementation of OpenSim has fallen behind and does not work with the latest versions of OpenSim (Korolov, 2014b). In addition, to use Mumble some modifications need to be made to the viewer.

This leaves only two options. FreeSwitch requires an own server, is open-source and fully customizable. However, the configuration is quite difficult and takes a fair amount of time to set up. In addition, the current version has a bug that the speak indicator does not work, so you can hear others speak, but their lips will not move and no voice icon will be visible.

Vivox works by registering a free account and placing a few lines in the OpenSim configuration. However, all voice will be transmitted over their servers, which can be an issue for corporate usage. When comparing the remaining two options, Vivox offers the greatest ease of use, works great and has the best audio quality. Because FreeSwitch is open-source, the currently present bug can be fixed. Especially companies that want to keep their conversations private and keep all services under their own control should look extensively at this alternative. Even though the setup requires some effort.

Vivox is free for individuals, schools and non-profits, for other users the free plans are limited to five avatars at once (Korolov, 2014b). Because of the bug present in FreeSwitch and the development of Mumble being behind, the options are limited. For this research Vivox will be used, since it does not cause any limitations. However, in a business setting it is recommended to think carefully about which voice service to use.

6.2.9 TIME ZONES

Working over distance has the issue of people living in different time zones. To ensure that all people are present at a scheduled meeting at the same time, a time zone needs to be used as standard to store the data in. OpenSim uses the Second Life Time zone (SLT) which is equal to Pacific Standard Time (PST). However, SLT does not use daylight saving time, and makes conversions more difficult.

Most programming languages, including LSL, support UNIX timestamps. A UNIX timestamp is the time in second since January 1, 1970 in UTC. Having a common factor for storing dates and times, makes the API less complicated. An alternative would have been using SLT, however this would require the API to determine if daylight saving time is being used and correct the time accordingly.

Another advantage of using UNIX timestamps is that it can easily be converted to a time zone of choice. The CMS is configured to display times in a specific time zone and this does not require any changes to the API or the scripts in OpenSim.

6.3 EXTERNAL VALIDATION

It is highly unlikely that the API and CMS will stop functioning. However, the possibility that OpenSim will stop development or start a new project may be more present. Because of the modular setup of the project, separating client en server, most of the functions can easily be converted to another virtual environment. The main requirement for that environment is the support for HTTP or HTTPS connections and some form of scripting. Native support for JSON is highly appreciated, but one could also create a simple JSON parser. It would even be possible to convert the output of the API to a supported form. Even though it requires some customization, switching to another virtual environment is possible with little effort required for changing the API. However, all scripts and tools within the virtual environment need to be recreated.

Switching to Second Life is also a possibility, which would require minimal adjustments to the scripts of OpenSim. Second Life and OpenSim user different functions to process the JSON received from the API. However, one of the requirements is to use OpenSim, so switching virtual environment will not satisfy FR12.

Because of the use HTTP and other standards, many clients can be created for the API and the already created CMS is accessible on every device with an Internet connection and a web browser. Since HTTP is a well-known protocol, load balancing and scalability should not be a big issue. Multiple grids can be linked to the API and OpenSim grids can even be divided over multiple servers and linked to each other at the same time, making it a HyperGrid. The used protocols and solutions offered by OpenSim should ensure that with sufficient hardware available the number of users can be scaled up quite high. The biggest bottle neck would most likely be the required bandwidth of the Internet connection of the server.

6.4 CONCLUSION

The identified issues and the corresponding solutions are derived from multiple sources, which provide a good impression of the issues, challenges and best practices. All functional requirements are covered and even with the limited amount of time available, there are no direct indications that the current solutions do not sufficiently satisfy the requirements. For non-functional requirements, it will depend on how users will perceive the system.

Many choices are made during the design of the system. The client-server model is the most flexible and scalable solution, with a clear structure. As object notation JSON beats XML on resource usage and performance, making it the most obvious choice (Nurseitov et al., 2009). Especially since both are almost equally popular in existing APIs and JSON being the most commonly used in new APIs (Nurseitov et al., 2009). As virtual environment two options remained: OpenSim and Open Wonderland, both have advantages and disadvantages over the other. However, OpenSim has the upper hand since the community and development are more active ("Changes - Open Wonderland," 2014; "Commits - opensim/opensim," 2014; Korolov, 2014a).

OpenSim does not support HTTP authentication, basic authentication can be achieved by using the username and password in the URL. However, sending the username and password as plaintext is not recommended. The recommended method would be the current implemented solution over HTTPS.

For shortening travelling times, multiple solutions are available. The hop protocol is the nicest solution, with support of the API. An alternative, setting the last known position in the database, will cause inconsistent usage and the success or failure of this request is only visible after the avatar logs in.

Another aspect is the voice support of OpenSim. For this research Vivox will be used, since it is free to use for this research. FreeSwitch is the only working alternative for the latest OpenSim version, however a bug causes the speak indicator to fail. Besides, the configuration is quite difficult and can take some time. The third alternative Mumble does not support the latest OpenSim version.

7 TECHNOLOGY ACCEPTANCE

Usability and effort are important factors in whether or not a technology will be successful. There are a lot of theories to predict and explain the acceptance of technology. Some of the most popular theories which can help in explaining and predicting technology acceptance are listed in this section.

7.1 TECHNOLOGY ACCEPTANCE MODEL

Davis Jr (1986) created the Technology Acceptance Model (TAM) based on Theory of Reasoned Action (TRA) of Ajzen and Fishbein (1969). In TAM many of the attitude measures of TRA are replaced by perceived usefulness and perceived ease of use. According to this model the attitude of the user towards using a given system is a determinant of whether or not the user will actually use it. The attitude towards using the system is a function of perceived usefulness and perceived ease of use (Figure 6). Perceived usefulness is defined by Davis as “the degree to which an individual believes that using a particular system would enhance his or her job performance.” He defined perceived ease of use as “the degree to which an individual believes that using a particular system would be free of physical and mental effort.”

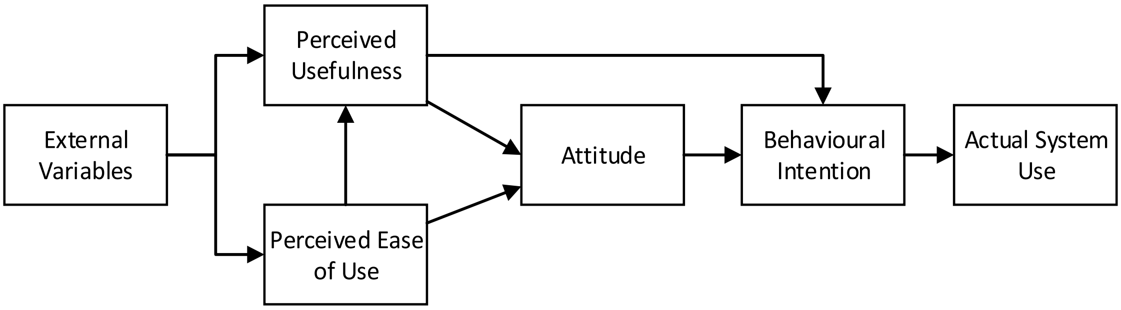

FIGURE 6: TECHNOLOGY ACCEPTANCE MODEL OF DAVIS.

External variables, which are design features, are mediated by perceived usefulness and perceived ease of use. In addition, perceived usefulness is influenced by perceived ease of use. When all being equal, an easier to use system will increase job performance, hence perceived usefulness, for the user (Davis Jr, 1986).

Davis, Bagozzi, and Warshaw (1989) compared TRA to TAM to see how simple models perform. TAM explained between 47 and 51 percent of the variance in behavioural intention, compared to 26 and 32 percent for TRA (Davis et al., 1989).

7.2 TECHNOLOGY ACCEPTANCE MODEL 2

However, TAM only supports voluntary use. Which is sufficient in some cases, but especially in a corporate setting the use of a technology can be mandatory. An extended version of TAM, called TAM2, was developed by Venkatesh and Davis (2000). TAM2 adds support for mandatory use and it extends TAM by showing that subjective norm has a significant direct effect on usage intentions in mandatory setting and when experience is in the early stages (Figure 7). The subjective norm (Venkatesh & Davis, 2000) is adapted from TRA (Fishbein & Ajzen, 1975) and Theory of Planned Behaviour (TPB) (Ajzen, 1991).

The goal of the research of Venkatesh and Davis was to extend TAM by including key determinants for perceived usefulness and usage intention constructs. In addition they wanted to understand how increasing experience with the system changes the effects of these determinants over time (Venkatesh & Davis, 2000).

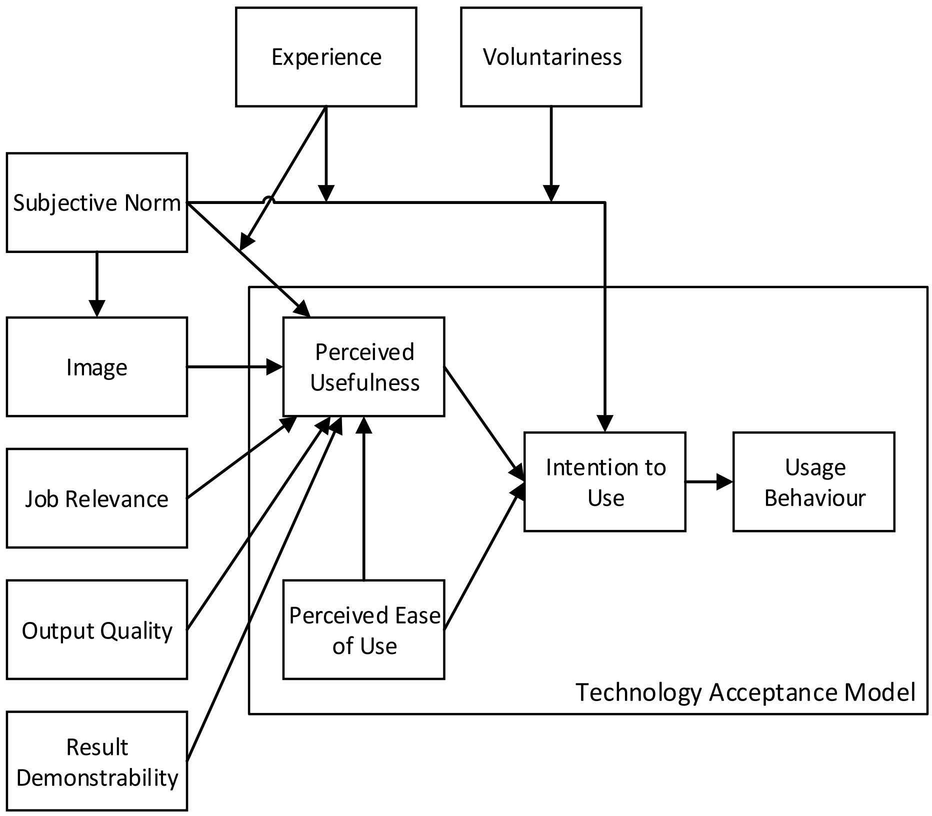

FIGURE 7: TECHNOLOGY ACCEPTANCE MODEL 2.

Subjective norm, from TRA, is defined as a "person's perception that most people who are important to him think he should or should not perform the behaviour in question" (Fishbein & Ajzen, 1975). This was left out of the original TAM because of the lack of having a significant effect on intentions (Davis et al., 1989). Subjective norm can influence intention indirectly through perceived usefulness. A person may come to believe that a particular system actually is useful when it is suggested by a co-worker or superior, and form the intention to use it. This applies for both voluntary as mandatory usage. In TAM2 voluntariness is defined as "the extent to which potential adopters perceive the adoption decision to be non-mandatory" (Venkatesh & Davis, 2000). Venkatesh and Davis (2000) theorise that when the use of a system is organizationally mandated, the perception of a user about the system's usefulness may still increase due to persuasive social information.

In addition subjective norm will positively influence image. When important members of a person's social group at work believe that he or she should use a system, then carrying out this believe will tend to improve his or her standing within the group. Image, in turn, has an effect on perceived usefulness, resulting from the perceived improved job performance due to the elevated status within the group an individual gets from using a system (Venkatesh & Davis, 2000).

Job Relevance is defined by Venkatesh and Davis (2000) as "an individual's perception regarding the degree to which the target system is applicable to his or her job." When a system support tasks that the user needs to perform his or her job it will be perceived more useful. However, the quality the system can perform these tasks also influences perceived usefulness. Therefore, Output Quality is the perceived degree how well the system performs tasks that are relevant for the user's job (Venkatesh & Davis, 2000).

The way the system achieves the results also influences the perceived usefulness. In TAM2 the results demonstrability uses the definition of Moore and Benbasat (1991): "the tangibility of the results of using the innovation.” When a user can understand how the system produces its results, this will have a positive effect on perceived usefulness. On the other hand, if a system produces effective job relevant results which are desired by the user, but does this in an obscure fashion, the user will not understand how the system achieved these results. This will most likely make the user doubt about the usefulness of the system (Venkatesh & Davis, 2000).

TAM2 managed to explain between 37 and 52 percent of the variance in usage intentions and between 50 and 60 percent of the variance in perceived usefulness (Venkatesh & Davis, 2000).

7.3 UNIFIED THEORY OF ACCEPTANCE AND USE OF TECHNOLOGY

Based on the previously mentioned TAM and seven other theories the Unified Theory of Acceptance and Use of Technology (UTAUT) was created (Venkatesh et al., 2003). This theory aims in explaining behavioural intention to use an information system and from there the use behaviour. UTAUT uses four key constructs: (1) performance expectancy, (2) effort expectancy, (3) social influence and (4) facilitating conditions. The first three are direct determinants of behavioural intention and the fourth is a determinant for use behaviour. The four constructs are moderated by gender, age, experience and voluntariness of use (Figure 8) (Venkatesh et al., 2003).

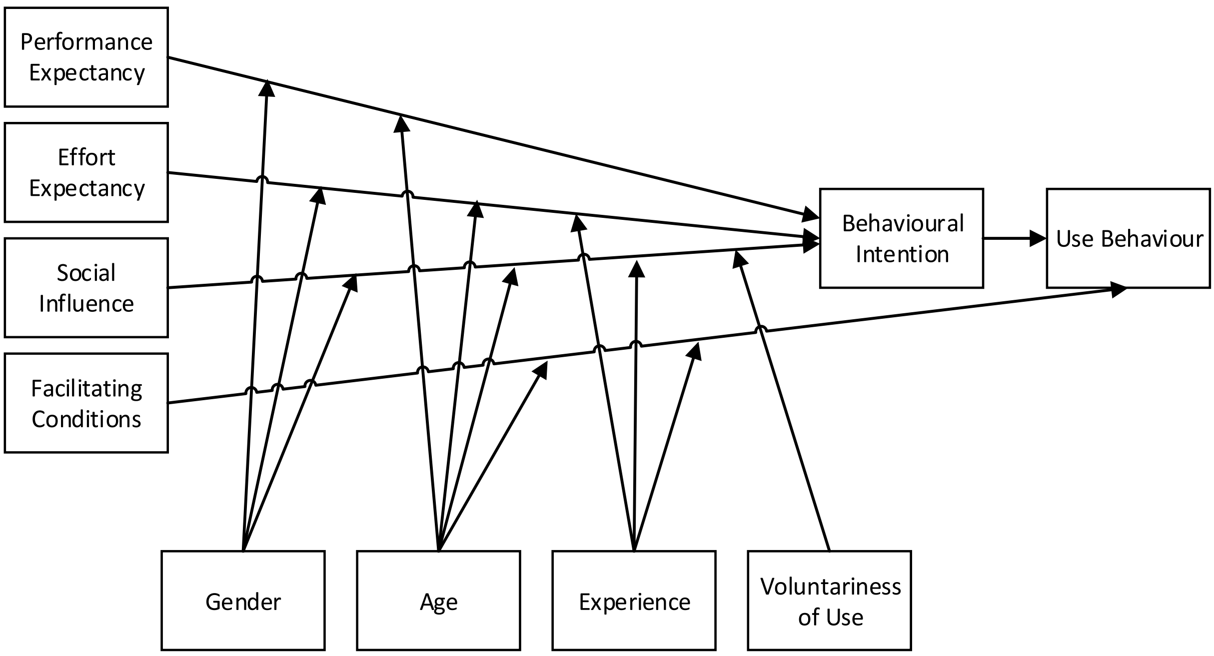

FIGURE 8: UNIFIED THEORY OF ACCEPTANCE AND USE OF TECHNOLOGY.

The eight theories used in the Unified Theory of Acceptance and Use of Technology are:

1. Theory of Reasoned Action (TRA) (Fishbein & Ajzen, 1975)
2. Technology Acceptance Model (TAM) (Davis Jr, 1986)
3. Motivational Model (MM) (Davis, Bagozzi, & Warshaw, 1992)
4. Theory of Planned Behaviour (TPB) (Ajzen, 1991)
5. Combined TAM and TPB (C-TAM-TPB) (Taylor & Todd, 1995)
6. Model of Personal Computer Utilization (MPCU) (Thompson, Higgins, & Howell, 1991)
7. Innovation Diffusion Theory (IDT) (Rogers, 1962)
8. Social Cognitive Theory (SCT) (Compeau & Higgins, 1995).

These models are empirically compared with longitudinal field studies in four organizations at three points in time, post-training, one month after implementation and three months after implementation. At two organizations the use of the system was voluntary and at the other two the usage was mandatory. From the constructs, that appeared to be significant direct determinants of intention or usage in the evaluated models, a selection was made. From the seven constructs, Venkatesh et al. (2003) theorized that four would play a significant role as direct determinants of user acceptance and usage behaviour. Performance expectancy, effort expectancy, social influence and facilitating conditions were selected, and attitude towards using technology, self-efficacy and anxiety were theorized not to be direct determinants (Venkatesh et al., 2003).

Performance expectance is defined by Venkatesh et al. (2003) as the “degree to which an individual believes that using the system will help him or her to attain gains in job performance.” This construct is the strongest predictor within each of the evaluated models for intention, for both voluntary and mandatory settings. It is moderated by gender and age, particularly for younger men the effect will be stronger (Venkatesh et al., 2003).

Venkatesh et al. (2003) defined effort expectancy as the “degree of ease associated with the use of the system.” Which is similar to perceived ease of use from TAM. This is also a significant construct in each of the evaluated models for both voluntary and mandatory use. However, the effect seems to become non-significant over time as the user gains experience with the system. Effort expectancy will be influenced by gender, age and experience. The effects are expected to be stronger for women, in particular younger women and during the early stages of experience (Venkatesh et al., 2003).

The third construct which is derived from the examined theories is social influence. Social influence is defined as the “degree to which an individual perceives that important others believe he or she should use the new system” (Venkatesh et al., 2003). Based on the results, the social influence constructs are not significant in voluntary settings. However, when the system becomes mandatory, social influence is significant. In addition, only during the early stages of experience social influence appears to be important. When the user gets more experienced with the system the effects becomes non-significant over time (Venkatesh et al., 2003).

Besides voluntariness and experience, social influence is also moderated by age and gender. Women tend to be more sensitive to opinions from others than men. Older workers have an increased affiliation need compared to younger workers. Therefore social influence will have the most effect on older women in mandatory settings during the early stages of experience (Venkatesh et al., 2003).

Finally, facilitating conditions are used as a construct in UTAUT. However, facilitating conditions only influence use behaviour, not the behavioural intention. Venkatesh et al. (2003) defined facilitating conditions as the “degree to which an individual believes that an organization and technical infrastructure exists to support use of the system.” Over time the user of the technology will find more and more sources for help and support throughout the organization which remove obstacles for continued usage. In particular older workers value assistance and help on the job. Therefore facilitating conditions will have a stronger effect on older workers with increasing experience (Venkatesh et al., 2003).

However, three important constructs from SCT are left out of UTAUT. The first, self-efficacy is defined as “judgement of one’s ability to use a technology (e.g. computer) to accomplish a particular job or task” (Compeau & Higgins, 1995). Second, anxiety is defined as an “individual’s liking for a particular behaviour” (e.g. computer use) (Compeau & Higgins, 1995). Both are also left out of UTAUT, based on previous work of Venkatesh (2000). Self-efficacy and anxiety seem to be conceptually and empirically distinct from effort expectancy, both have been modelled as indirect determinants of intention and are fully mediated by perceived ease of use (Venkatesh, 2000). Venkatesh et al. (2003) therefore expected that self-efficacy and anxiety behave similarly to effort expectancy and have no additional direct effect on intention. The results confirmed that self-efficacy and anxiety have no significant influence on behavioural intention (Venkatesh et al., 2003).

The third construct not included in UTAUT is attitude towards using technology. Which is defined as "an individual's overall affective reaction to using a system" (Venkatesh et al., 2003). Each construct from the tested models related to attitude towards using technology tap into an individual's feelings (e.g. liking, enjoyment, joy and pleasure) associated with technology use (Venkatesh et al., 2003). Previous work of Venkatesh (2000) shows empirical evidence which suggests that affective reactions may operate through effort expectancy. Therefore Venkatesh et al. (2003) consider that observed relations between attitude and intention are spurious and a result from the absence of other predictors, in particular performance and effort expectancies.

UTAUT explains as much as 70 percent of the variance in behavioural intention and 48 percent in usage behaviour. The authors conclude that this is probably approaching the practical limits of the ability to explain individual acceptance and usage decisions in organizations (Venkatesh et al., 2003).

7.4 OTHER MODELS

There are even newer versions created after UTAUT. An updated technology acceptance model, TAM3, has been proposed by Venkatesh and Bala (2008). Even an updated version of UTAUT, UTAUT2, has been created by Venkatesh, Thong, and Xu (2012). However, these models contain an increased number of constructs and complexity compared to the three models above.

TAM3 is developed by combining the previous TAM2 model with determinants of perceived ease of use from Venkatesh (2000) (Venkatesh & Bala, 2008). The determinants of perceived ease of use are: computer self-efficacy, perception of external control, computer anxiety, computer playfulness, perceived enjoyment and objective usability. TAM3 was able to explain between 52 and 67 percent of the variance in perceived usefulness. For the variance in behavioural intention, TAM3 managed to explain between 40 and 53 percent of the variance. Between 31 and 36 percent of the variance in use was explained (Venkatesh & Bala, 2008).

Compared to TAM2 this is an increase of 2 to 7 percent (TAM2: 50% - 60%) for explaining variance in perceived usefulness and an increase of about 3 percent (TAM2: 37% - 52%) for behavioural intentions (Venkatesh & Bala, 2008; Venkatesh & Davis, 2000). Adding six constructs caused a small improvement in the model's explanatory power. The authors call TAM a parsimonious model and TAM3 a comprehensiveness and potential for actionable guidance (Venkatesh & Bala, 2008). However, it makes it more complex and difficult to use, compared to the previous TAM versions.

UTAUT2 adds hedonic motivation, price value and habit and removes voluntariness compared to UTAUT. It managed to achieve the same results as UTAUT for explaining the variance in intention and usage behaviour, respectively 70 and 48 percent (Venkatesh et al., 2012). However, UTAUT2 focusses on consumers instead of organizations. Hence, the addition of price value and the removal of voluntariness in the model. Therefore UTAUT2's predecessor is the more likely choice of the two.

7.5 COMPARING THE MODELS

Many authors have used, reviewed and tried to improve the previous models. Bagozzi (2007) reviewed TAM and criticizes it because of a number of shortcomings and beliefs it diverted the attention of researchers away from other important issues. TAM focusses, like many technology acceptance research, on the individual user and does not consider group, cultural or social aspects of decision making and usage very much. It ignores the social process which is essential for development and implementation of information systems (Bagozzi, 2007).

In addition Bagozzi (2007) criticizes TAM for being completely deterministic. Every arrow from an independent variable to a dependent variable is a cause/effect relation. When the independent variable increases (or decreases) the dependent variable is expected to increase (or decrease) to some extent. Therefore user's behaviour in TAM is explained as a law-like response to an outside stimuli, without activation of the will (Bagozzi, 2007).

King and He (2006) also looked at TAM. By using 88 published studies a statistical meta-analysis was conducted. They conclude that TAM provides highly reliable measures for perceived usefulness and behavioural intention. However, the direct effect of perceived ease of use on behavioural intention was not significant for all studies, it was only important in the context of internet applications. Even though TAM's correlations are strong, they have considerable variability. The authors suggest that moderator variables can help explain the effects. For example the user's experience was used as a moderator in some of examined studies (King & He, 2006).

Another important finding was the significant overlap between student and professional groups. This gives some evidence to justify usage of students as surrogates for professionals. However, students may not be used as surrogates for "general" users. General users are defined as non-students who do not use the system for work purpose (King & He, 2006). Since students are often used for convenience reasons in studies, the validity is rarely tested. The results of King and He (2006) confirms that using students as surrogates in the examined TAM studies is valid.

TAM may be the most parsimonious model of the three and therefore the easiest to use, it only focusses on voluntary use and leaves out possible mandated corporate settings (Venkatesh & Davis, 2000). TAM2 and UTAUT use moderating variables to help explain certain outcomes (Venkatesh & Davis, 2000; Venkatesh et al., 2003).

Williams, Rana, Dwivedi, and Lal (2011) looked at a total of 870 citations of UTAUT original article (Venkatesh et al., 2003), only 470 full articles were available for download. These were systematically reviewed and categorized. Their main four findings were that from all articles that cited UTAUT, the majority (407) only used it as a basis for supporting an argument or criticizing the theory. Second, many of the studies that claimed to be using UTAUT only used it partially. Third, a number of articles only used the main constructs, without the moderating factors. Fourth, it seems to be a trend to use UTAUT together with external variables and theories. However, the authors do suggest that UTAUT provides an useful tool for evaluating potential success of new technology and for identifying factors that could influence the adoption (Williams et al., 2011).

Theory	Explanatory power on variance in BI
TAM (Davis Jr, 1986)	47 – 51%
TAM2 (Venkatesh & Davis, 2000)	37 – 52%
UTAUT (Venkatesh et al., 2003)	70%
TAM3 (Venkatesh & Bala, 2008)	40 – 53%
UTAUT2 (Venkatesh et al., 2012)	70%

TABLE 4: COMPARING THEORIES ON EXPLANATORY POWER OF THE VARIANCE IN BEHAVIOURAL INTENTION.

When looking at the explanatory power on variance in behavioural intentions of the models UTAUT (70%) out performs TAM (47-51%) and TAM2 (37-52%) (Davis et al., 1989; Venkatesh & Bala, 2008; Venkatesh et al., 2003). Table 4 contains an overview of the discussed theories and their explanatory power on the variance in behavioural intention. In addition King and He (2006) found that probably the most comprehensive narrative review of the TAM literature is provided by Venkatesh et al. (2003) for the development and testing of UTAUT.

Just like TAM2, UTAUT is an extension based on TAM. Although most references in the literature to UTAUT only cite the theory, it can still be used as a useful tool for evaluating new technology's potential success (Williams et al., 2011). The difference in explanatory power also benefit UTAUT.

7.6 CONCLUSION

This chapter provides the answer to SQ3: "Which technology acceptance model can be used best to measure the perceived usability when using a CMS to set up a virtual meeting in a 3D virtual environment?" By looking at existing theories in the literature, their results, reviews and the scope of this research, a selection has been made. The theory that seems to fit best with this research is the Unified Theory of Acceptance and Use of Technology. Because it can be used in both voluntary and mandatory settings, it has a high explanatory power and is a useful tool to evaluate potential success of new technologies, including identifying factors that could influence the adoption of the technology.

8 EXPERIMENT

This research started with looking at (virtual) cooperation, meetings and virtual environments, identifying their best practises, issues and challenges (chapter 3 and 4). This resulted in a list with requirements in chapter 5. These requirements were used to create a design, which was validated in chapter 6 and implemented using an agile approach.

Now that all parts of the system are created and a technology acceptance model has been selected in the previous chapter, the solution can be evaluated by performing an experiment. The experiment will be used to validate the prototype. The results will be gathered by using a questionnaire and talking with the participants. This chapter first describes the test environment, hypotheses, questionnaire and target groups. Section 8.2 describes the execution of the experiment. Which is followed by the results in section 8.3.

8.1 THE TEST ENVIRONMENT

Two separate virtual worlds are created. One grid within Thales for testing with people of Thales and one private grid for the remaining test subjects. Both grids will offer the same functionalities and use the API and CMS. Even though the API has the ability to manage multiple grids, these services will also be separated. Therefore there are two separate fully functioning systems, with no shared data. By doing so, the data of Thales will be kept within Thales and separated from the outside users.

Within both grids, two fully equipped meeting rooms are created. These rooms contain all the created tools which offer access to the services offered by the API. Subjects do not have the permission to remove existing content from the world. Which can easily happen by mistake, as pointed out earlier. However, subjects are allowed to create new content in the world. Allowing them to experience all the possibilities of OpenSim.

All subjects will receive a short manual containing instructions to get started and a user account to login into the CMS. Everyone was instructed to follow the instructions in the manual, with as first part a checklist containing the essentials. For example on the list were: microphone for voice support, computer mouse for easier navigation in OpenSim, OpenSim viewer and up-to-date Internet browser. While there are many viewers available, the manual recommended the use of the Kokua viewer. Since Kokua supports Windows, Mac and Linux, all participants of the experiment will have the same viewer, making it easier to solve issues.

The Second part of the manual is about managing the user account and creating an avatar in the CMS. The third part consists of configuring the viewer and connecting to OpenSim. After the user managed to access OpenSim, the controls and facilities were explained in part four. During the whole process one or more ‘experts’ were available to offer support to users. Support was offered through e-mail, the chat function in the CMS or through voice or text chat in OpenSim.

For every group of subjects, a meeting was created by one of the participants. All subjects had access to all normal functions offered by the API, allowing them to upload files and schedule meetings. However, the administrator functions were limited to only a few users that had prior experience with OpenSim and were closely involved with this research.

8.1.1 HYPOTHESES AND EXPECTATIONS

Before the actual testing begins, there are a number of expectations based on the previously used literature on virtual environments and technology acceptance. For example it can be expected that elderly users will have more difficulties with OpenSim and the CMS compared to the younger users. Which is probably due to the experience younger users have with 3D gaming virtual environments, like

World of Warcraft, and their computer skills in general. This is also represented in UTAUT model since age and experience are moderators of effort expectancy. To validate this expectation the following hypothesis is drafted:

> **H1**: Older users will have lower effort expectancies than younger users.

In addition, people with more experience will have less difficulties with the system and therefore perceive using the system with little effort. Which is expressed in the following hypothesis:

> **H2**: Experienced users will have a higher effort expectancy than less experienced users.

Salt et al. (2008) indicate that using a virtual environment can be fun and meaningful. Since meetings are often costly in terms of time and money, and unproductive (Romano Jr & Nunamaker Jr, 2001). At the same time meetings are part of everyday business and necessary to complete tasks individuals cannot complete on their own (Martins et al., 2004; Romano Jr & Nunamaker Jr, 2001). According to research performed by Kelliher and Anderson (2010), remote workers have higher job satisfaction. Therefore is hypothesized that a meeting in a 3D virtual environment will be perceived as a good idea, which is fun and interesting.

> **H3:** Users will have a positive attitude towards meetings in a 3D virtual environment.

While using the system, people having good computer skills will probably be less anxious about the system. Since the solution is based on already existing technologies which should be familiar to most users. OpenSim-CMS is basically an interactive website and navigating around in the virtual environment is similar to playing a game. Therefore it is expected that users with high computer skills will be able to use the system without any serious issues. Which leads to the following two hypotheses:

> **H4**: Users with high computer skills are less anxious about using the system compared to users with low computer skills.

> **H5**: Users that are not anxious about the system have higher self-efficiency than users that are anxious about the system.

8.1.2 QUESTIONNAIRE

The questions used in the UTAUT experiment (Venkatesh et al., 2003) are modified to fit this experiment and included in Appendix A. Before being used, the questions were reviewed and converted to an online survey. Participants used the survey after their participation in the experiment. For most questions a 7-point scale was used: 1 = completely disagree, 2 = moderately disagree, 3 = somewhat disagree, 4 = neutral (neither disagree nor agree), 5 = somewhat agree, 6 = moderately agree, and 7 = completely agree.

However, for some questions the same scale was used with some adjustments. For example to indicate the level of experience, 1 was used as low and 7 as high and for intentions the scale reached from 1 as highly unlikely to 7 being most likely.

Beside the questions used by Venkatesh et al. (2003), additional questions were added for measuring the computer skills of the user, and their future expectations about virtual meetings in a 3D virtual environment. Both questions used the same 1 to 7 scale as described above. Since the experiment will be conducted by users having different backgrounds, the groups of King and He (2006) are included as a question.

The questionnaire ends with a number of open questions to gather additional feedback of the users. Questions asking what they liked and disliked about the system, and if they have any recommendations. In addition their opinion is asked what would be the greatest barrier in adopting new information technology.

8.1.3 TARGET GROUPS

There are two main target groups for this research, employees at Thales and students. For this research students have to imagine themselves being in a business setting, since the system has a focus on business meetings. As shown by previous research of King and He (2006), students can be used as surrogates for professionals. If enough people participate, the groups can be divided based on their background using similar categories as King and He (2006): Students, Professionals and the remaining 'others' (non-students and non-professionals). With this division the results between the groups can be compared.

However, since it most likely will be difficult to get a large enough sample, everyone that is interested can participate. Because of the division in groups, the results can be filtered when needed. Using all available participants will lead to more feedback on the solution.

8.2 EXECUTION

Multiple user groups used the OpenSim-CMS and the OpenSim virtual environment. One of them was the Thales YES (Young Expert Society) group. Eventually seven people from YES created an avatar in the CMS and signed in and another three or four people watched over their shoulders. One of them even managed to get everything working on a six year old laptop. All participants were distributed over different rooms.

The demonstration started with a presentation in the virtual environment on the possibilities and afterwards a guided tour in the virtual environment demonstrating all the facilities. Figure 9 shows a screen capture made during the demonstration to Thales YES. Some users were fooling around during the presentation, for example by letting their avatar sit on the presentation screen. However, after a while everyone got serious again.

Other participants were gathered by placing messages on social media and let people subscribe to a timeslot. Approximately 20 people responded and participated. For all participants an user account was created in the CMS and they received a document containing instructions on how to use the CMS to create an avatar and upload documents. In addition the instructions explained how to configure the viewer and test the audio settings.

Since people subscribed to an available timeslot, the size of the groups varied from two to six. All groups received a demonstration of all the available tools in the virtual environment and were asked to try the available functionalities themselves. Afterwards, still in OpenSim, the demonstration was evaluated and participants could ask questions and discuss the possibilities and limitations. Overall everyone was quite enthusiastic and positive. The whole process took about two hours per group, to let them experience the virtual environment themselves and give them a good idea about the concept. For the majority of the users the whole idea of virtual meetings in a virtual environment was new and some even were quite sceptic at first.

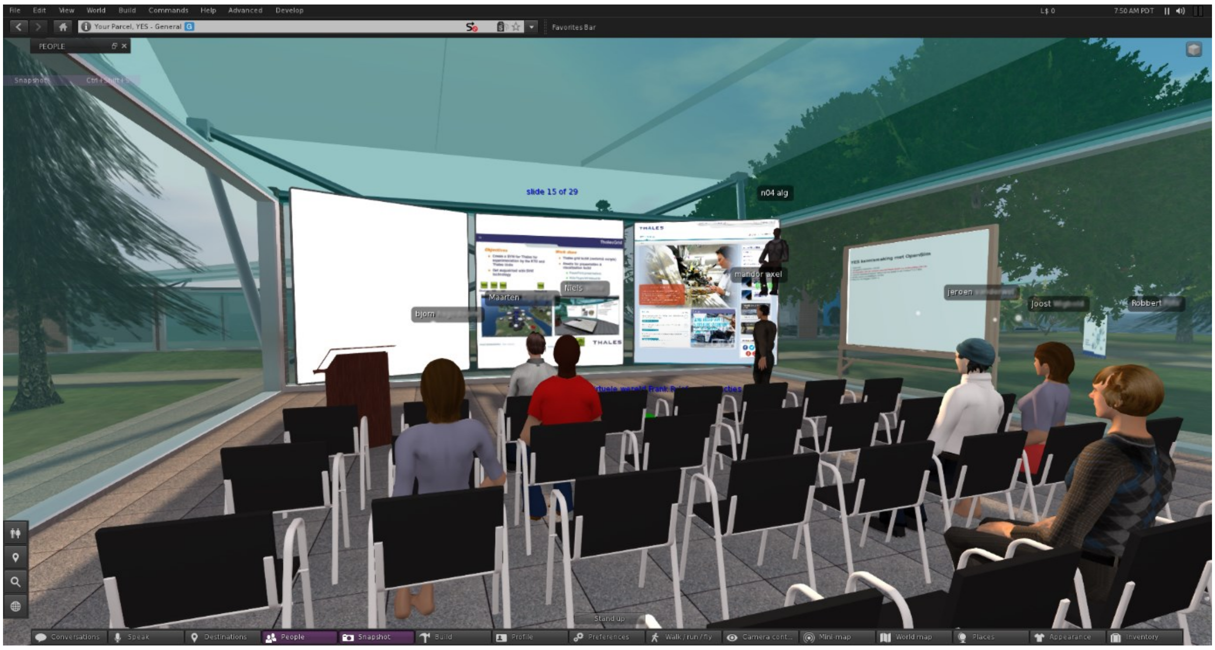

FIGURE 9: GIVING A PRESENTATION IN THE OPENSIM VIRTUAL MEETING ROOM

Most users were located in the Netherlands, however even someone from Australia participated, which showed that geographical distance is no barrier. All users participated voluntarily. In one of the groups, two older persons participated and as expected they had the most trouble getting started. Configuring the viewer and connecting to the OpenSim environment was perceived as difficult for them. However, after some time and using the built-in chat function as support platform both managed to connect and participate in the demonstration.

The activities committee of study association I.C.T.S.V. Inter-*Actief,* which is the study association for computer science, telematics and business information technology students at the University of Twente, wanted to participate in this research by performing one of their meetings in the virtual environment. They received the same demonstration and instructions as the other participants. After the demonstration they performed their meeting, followed by an evaluation. Again everyone was positive over the possibilities and the ease of use. One of them said “With this system I can attend a meeting without getting out of my bed.”

Almost all groups started fooling around with the possibilities of the virtual environment by creating boxes, editing the appearance of their avatar and let their avatar sit on every possible object. This resulted in avatars running or flying around top-less or without pants, people sitting on the ceiling. However, after a while all groups got serious again and the demonstration proceeded without any real issues. This did have a positive effect on the mood of the participants. Which contributed to the positive overall attitude towards the system and compensated the configuration of the viewer, which was often perceived as difficult and for some even frustrating.

People with gaming experience seemed to learn the controls faster than the users without gaming experience. Especially getting changing the point of view, moving the camera, under control takes quite some time. Eventually everyone got the basic functionalities under control. During every demonstration there was a positive atmosphere and even the sceptics enjoyed the demonstration and their stay in the virtual environment.

8.3 RESULTS

Of the approximately 35 people that participated in the experiment, only 22 people completed the questionnaire. From all the participants 50.0 percent was a student, 36.4 percent professional and the remaining 13.6 percent was not a student and did not participated work related. The results are summarized in Table 5, and the complete overview of results is included in Appendix B.

	Frequency	Percent
Other	3	13.6
Professional	8	36.4
Student	11	50.0
N	**22**	**100**

TABLE 5: DIVISION OF PARTICIPANTS' BACKGROUND.

	Gender	Percentage
Male	20	90.9
Female	2	9.1
N	**22**	**100.0**

TABLE 6: GENDER STATISTICS.

Of those subjects, 90.9 percent was male and 9.1 percent female, see Table 6. Which can be explained due to the environment this research was performed in. It is a fact that there are fewer females at technical studies and occupations than males (Merens, Hartgers, van den Brakel, & Ross, 2012).

Almost all participants self-assessed their computer skills quite high. All except one rated their skills above average. With the majority even rating their own skills as high. This can be explained due to the highly technical character of Thales and the fact the group used within Thales consists of Young Professionals and the students all have a technical background. Besides the average age of the participant is 29.23 years, see Table 33 in Appendix C.

The future for virtual meetings in a 3D virtual environment looks bright, according to the predictions done by the participants. None of the participants thinks that there is no future for virtual meetings in 3D worlds while 59.1 percent is almost completely certain of it. Table 8 summarizes the predictions about the future of using 3D virtual environments for virtual meetings.

	Frequency	Percent
1	1	4.5
5	4	18.2
6	10	45.5
7	7	31.8
N	**22**	**100**

TABLE 7: COMPUTER SKILL STATISTICS.

	Frequency	Percent
4	1	4.5
5	6	27.3
6	2	9.1
7	13	59.1
N	**22**	**100**

TABLE 8: FUTURE STATISTICS.

8.3.1 VALIDATION OF RESULTS

Reliability analysis was performed by calculating Cronbach's Alpha using SPSS software version 22 for the results of the questionnaire. The results of this calculation are summarized in Table 9 and the results of the questionnaire are placed in Appendix B. The overall Cronbach's Alpha value for all 36 scales is 0.789. Cronbach's Alpha measures the internal consistency between the items in a test. For example to measure the internal consistency of performance expectancy (PE) all four PE items need to be combined. The reliability estimates show the amount of measurement error in a test. Taking the squared value of Cronbach's Alpha and subtracting it from 1.00 will return the index of measurement error (Tavakol & Dennick, 2011). For example, a test reliability of 0.70 has an error variance of 0.51 in the scores (0.70 * 0.70 = 0.49; 1.00 – 0.49 = 0.51). Alphas of 0.70 or above have a decent degree of reliability, sometimes 0.6 or higher is used as acceptable (Cortina, 1993; Tavakol & Dennick, 2011). Cronbach's Alpha is not resistant to missing data, however all questionnaires are filled in completely so no data is missing and this should not be an issue.

Construct	Cronbach's Alpha	Number of items
Performance Expectancy (PE)	0.789	4
Effort Expectancy (EE)	0.779	4
Social Influence (SI)	0.607	4
Facilitating Conditions (FC)	0.520	4
Behavioural Intentions (BI)	0.781	3
Attitude Towards Using Technology (AT)	0.566	4
Anxiety (AX)	0.635	4
Self-Efficiency (SE)	0.660	4
Experience (EX)	0.493	4
Voluntariness of use (VU)	-	1
Total	**0.794**	**36**

TABLE 9: RELIABILITY BY CALCULATING CRONBACH'S ALPHA

The groups of four questions about performance expectancy and effort expectancy have a decent Cronbach's Alpha, which also applies for the three questions about behavioural intention. Self-efficiency, anxiety and social influence almost reach decent Cronbach's Alpha value. This can be explained by looking at the answers of some of the participants, which were quite inconsistent at times. For example, some users were able to complete the tasks when there is no one around, but could not complete the task when they have someone to call for help.

Social Influence is probably low because not all questions apply to all the participants. For example, almost all students participated on a voluntary basis because they were interested or because they were asked nicely. However, they are not part of an organization which makes SI4 difficult to answer, SI1 and SI2 about people who influence their behaviour or are important to the participants also have highly varying answers. For example some students could say he or she participated because the author of this thesis is important to them at some level, since they wanted to help or were interested in the topic. For the remaining constructs none has a decent Cronbach's Alpha value.

Construct	Average score per item	Scale	Mean	Standard deviation
Performance Expectancy (PE)	4.68	4 – 28	18.73	4.474
Effort Expectancy (EE)	5.60	4 – 28	22.41	4.067
Social Influence (SI)	6.15	4 – 28	24.59	2.538
Facilitating Conditions (FC)	4.88	4 – 28	19.50	3.502
Behavioural Intentions (BI)	5.39	3 – 21	21.55	3.203
Attitude Towards Using Technology (AT)	5.48	4 – 28	21.91	4.566
Anxiety (AX)	2.80	4 – 28	11.18	4.574
Self-Efficiency (SE)	4.83	4 – 28	14.50	4.009
Experience (EX)	5.09	4 – 28	20.36	4.249
Voluntariness of use (VU)	5.50	1 – 7	5.50	1.566
Age (in years)	29.23	-	29.23	9.985
Age (in groups)	3.14	1 – 7	3.14	1.552

TABLE 10: THE COMBINED MEANS AND STANDARD DEVIATIONS OF THE MEASURED CONSTRUCTS

Since the questions use a 1 to 7 scale, combining the results of each group of questions results in a scale from 4 to 28 for the items with four questions and from 3 to 21 for items with three questions. The facilitating conditions fail to achieve a Cronbach's Alpha of 0.7 or higher. However, the mean is quite high and the standard deviation is one of the lowest, see Table 10. Apparently people do believe the organizational and technical infrastructures to support the system exist, however the internal consistency of the questions FC1 to FC4 is not reliable. Which basically means that, according to the Cronbach's Alpha coefficient, questions do not measure the same thing. A possible explanation can be that the way of working with the system follows the pattern of pre-meeting, meeting and post-meeting. Because of only having one iteration, a person that is not used to this pattern does not get the chance to get used to it. However, when leaving out FC3 the coefficient for remaining questions three questions decreases even more.

Appendix C contains the mean, median, standard deviation, range, minimum and maximum values for all the measured constructs for the UTAUT model. The means and standard deviations of the combined scores are summarized in Table 10. After combining the results, the scale reaches from 4 to 28 for the constructs which consist of four questions and from 3 to 21 for behavioural intention. A high score for performance expectancy indicates that people expect the system to increase their performance. For effort expectancy a high score means that the system does not require a lot of effort to work with. Social influence and facilitating conditions are high when the entities around a user support the system. A high behavioural intention indicates that the person is willing to use the system and a high score for attitude towards using technology show that the person has a positive attitude towards using the system. For anxiety the results are the other way around, since a high score indicates that the person does not feel comfortable with the system. Self-efficiency has a high score when the user feels confident he or she can complete tasks using the system. The higher the score for experience, the more experience the user has with all the aspects around using a 3D virtual environment with a CMS for virtual meetings. Mandatory usage is indicated by a low score on voluntariness of use. Finally, age is expressed twice, once in years and second divided in groups. The groups will be explained later on and the distribution of participants in age groups is shown in Table 12.

		PE	**BI**	**EE**	**SI**	**FC**
PE	Pearson's correlation coefficient (r)	1.000	0.635**	0.237	0.377	0.313
	Sig. (2-tailed)	-	0.002	0.289	0.084	0.156
	Coefficient of determination (R^2)	1.000	0.403	0.056	0.142	0.098
BI	Pearson Correlation coefficient (r)	0.635**	1.000	0.334	0.375	0.638**
	Sig. (2-tailed)	0.002	-	0.128	0.086	0.001
	Coefficient of determination (R^2)	0.403	1.000	0.112	0.141	0.407
EE	Pearson's correlation coefficient (r)	0.237	0.334	1.000	0.172	0.505*
	Sig. (2-tailed)	0.289	0.128	-	0.443	0.017
	Coefficient of determination (R^2)	0.056	0.112	1.000	0.030	0.255
SI	Pearson's correlation coefficient (r)	0.377	0.375	0.172	1.000	0.259
	Sig. (2-tailed)	0.084	0.086	0.443	-	0.245
	Coefficient of determination (R^2)	0.142	0.141	0.030	1.000	0.067
FC	Pearson's correlation coefficient (r)	0.313	0.638**	0.505*	0.259	1.000
	Sig. (2-tailed)	0.156	0.001	0.017	0.245	-
	Coefficient of determination (R^2)	0.098	0.407	0.255	0.067	1.000

TABLE 11: PEARSON CORRELATIONS BETWEEN MAIN CONSTRUCTS OF UTAUT, WITHOUT MODERATING VARIABLES.
*** CORRELATION IS SIGNIFICANT AT THE 0.05 LEVEL (2-TAILED)**
**** CORRELATION IS SIGNIFICANT AT THE 0.01 LEVEL (2-TAILED)**

All results support the usage of the virtual environment and CMS. Every measured construct except anxiety, has a 95% confidence interval which is above neutral. For example, behavioural intention consists of three questions with an overall scale of 3 to 21, where 12 equals neutral. The confidence interval for behavioural intention on 95% stretches from 12.72 to 16.28. Meaning that 95 percent of the responses will be within those values. Since 12.72 is above 12, the average intention is in favour of using the system. Similar results are present for the other constructs, except for anxiety. Anxiety has a 95% confidence interval of 9.15 to 13.21, which is below the neutral value of 16 for four question constructs. This means that 95 percent of the scores will be between these values and showing that the average user disagrees being anxious about using the system. The overview of all values is placed in Table 40 of Appendix F.

Appendix D hold the complete inter-item correlation matrix. The off-diagonal values near zero represent strong independence of each other's constructs. The closer the value gets to one or negative one the stronger the dependence between the constructs. Where negative one means that there is a total negative correlation and positive one means there is strong positive correlation. Zero means there is totally no correlation. A negative correlation means that for a relationship between x and y, when x increases, y decreases. For a positive correlation, when x increases, y will also increase.

When looking at the Pearson Correlations of the main constructs of UTAUT without the moderating variables or any other adjustments; the correlation between Performance expectancy, effort expectancy, social influence, facilitating conditions and behavioural intention. There is a strong significant correlation between performance expectancy and behavioural intention, and for facilitating conditions and behavioural intention. Both with a significance at 0.01 ($p < 0.01$), meaning probability that the observed correlation is due to chance is less than 1%. Effort expectancy and social influence do not have a significant correlation with behavioural intention. Besides, the coefficient of determination (R^2) or R-square is still really low, see Table 11. The coefficient of determination is interpreted as the proportion of the variance in the dependent variable that is predictable from the independent variable. Simply put, R-square is used as a guideline for measuring the accuracy of the model. The independent variables in the model are: perceived ease of use, behavioural intention, effort expectancy, social influence and facilitating conditions; which can be used to predict behavioural intention which is the dependent variable.

8.3.2 UTAUT AND MODERATING VARIABLES

For utilizing the full UTAUT model, the moderating variables need to be included. Age, gender, experience and voluntariness will be used to moderate the effects of perceived ease of use, effort expectancy, social influence and facilitating conditions as prescribed by Venkatesh et al. (2003).

8.3.2.1 AGE

The age of the participants was divided into groups, making the results consistent with the other results by using a 1 to 7 scale. The first group contains the age of people under 20 years, group two contains people of 20 to 24, group three are people between 25 and 29 years of age. The fourth group consists of participants between 30 and 34. Group five is for the age of 35 to 39, followed by group six for the age of 40 to 44 and the last group with the age of 45 and above. See Table 12 for the results.

Age	Frequency	Percent
1. <= 19	1	4.5
2. 20 – 24	8	36.4
3. 25 – 29	7	31.8
4. 30 – 34	3	13.6
5. 35 – 39	1	4.5
6. 40 – 44	0	0.0
7. >= 45	2	9.1

TABLE 12: AGE OF THE PARTICIPANTS DIVIDED INTO 7 GROUPS.

When looking at the responses of the participants based on their age, small differences occur. However, the standard deviations are still quite high. Therefore the results will only serve as an indication since they are not significant at the 0.05 level, with facilitating conditions as the only exception. Participants under the age of 30, group 1 to 3, have on average a higher behavioural intention than the participants in group 4 to 7. A similar difference is present for self-efficiency and facilitating conditions. These results are displayed in Table 13.

The higher mean for behavioural intention indicates that younger people are more likely to use the system than older people. When looking at the average scores, participants with an age of 30 or higher find it more difficult to work with the system and require additional facilities to accomplish their tasks. This can partially be explained by looking at the facilitating conditions and self-efficiency scores, which are higher for participants under the age of 30. The available facilitating conditions were assessed lower by the older group than by the younger group, suggesting that elder people require additional facilities. This is supported by the lower score on self-efficiency by the older group.

For the remaining variables the means for both age groups are quite close. Social influence, attitude towards using technology, voluntariness, effort expectancy and anxiety have almost identical scores for younger and elder people. The difference in the remaining variables, performance expectancy and experience, is less than one with a standard deviation of two or more. Which indicates that the results are highly unreliable. However, for this sample it does show that the average person below 30 has less experience than the elder participants. In addition, elder people expect more from the system for their performance.

Variable	Age	N	Mean	Std. Deviation	Significance
Performance Expectancy (PE)	>= 30	6	20.50	3.391	0.265
	< 30	16	18.06	4.739	
Effort Expectancy (EE)	>= 30	6	22.33	3.386	0.959
	< 30	16	22.44	4.396	
Attitude Towards Using Technology (AT)	>= 30	6	24.83	1.835	0.791
	< 30	16	24.50	2.805	
Social Influence (SI)	>= 30	6	20.00	3.688	0.791
	< 30	16	19.31	3.535	
Facilitating Conditions (FC)	>= 30	6	19.83	4.167	0.127
	< 30	16	22.19	2.639	
Self-Efficiency (SE)	>= 30	6	19.00	5.621	0.066
	< 30	16	23.00	3.742	
Anxiety (AX)	>= 30	6	11.00	5.441	0.912
	< 30	16	11.25	4.405	
Behavioural Intentions (BI)	>= 30	6	14.00	5.477	0.729
	< 30	16	14.69	3.516	
Experience (EX)	>= 30	6	21.83	3.869	0.336
	< 30	16	19.88	4.241	
Voluntariness of use (VU)	>= 30	6	5.83	1.329	0.554
	< 30	16	5.38	1.668	

TABLE 13: RESULTS GROUPED BY AGE.

The hypothesis H1, Elder people will find working with the system more difficult than younger people, is rejected. The null hypothesis, that the groups have equal effort expectancies, cannot be rejected since there is no significant difference. The significance is 0.959 when performing a t-test, which is far greater than 0.05. Therefore there is no significant evidence that older people have more difficulties with using the system than younger people, thus rejecting H1.

8.3.2.2 VOLUNTARINESS OF USE

The moderating variable voluntariness of use was included in UTAUT since it influenced the effect of social influence (Venkatesh et al., 2003). However, since the experiment only consisted of one round and many of the participants being students, the effect of social influence will probably be limited. In addition everyone volunteered to the experiment. In addition the effect is the strongest on for older workers, especially women when system usage is mandatory and the users have limited experience (Venkatesh et al., 2003). This situation will be difficult to evaluate in this experiment since most users are men below the age of 30 with a technical background.

Even though participation to the experiment was voluntary, the results do indicate that some users felt some form of pressure to cooperate. Two participants even indicated that the usage was mandatory, see Table 14. One being a student and one being a professional user. If both were professional users, it could have been that they felt obligated to cooperate with the experiment. However, since one is a student and all students participated completely voluntarily this result is most likely a mistake.

	Frequency	Percent
1	0	0
2	1	4.5
3	1	4.5
4	5	22.7
5	3	13.6
6	3	13.6
7	9	40.9
Total	**22**	**100**

TABLE 14: VOLUNTARINESS OF USE AS PERCEIVED BY THE PARTICIPANTS.

8.3.2.3 EXPERIENCE

Another moderator in the UTAUT model is experience. Table 15 shows the results grouped by the experience of the participant. The first group consists of the participants with high experience (21 or higher), the second group are the participants with some experience (12 to 20), and the last group consists of participants with little to none experience (4 to 11). The groups will be called respectively high, medium and low.

None of the participants rated their experience as being low. When looking at individual results, only four persons rated their experience just below the average score of 16, with the lowest being 12. The results show that on average highly experienced participants expect less effort for operating the system than subjects with less experience. This is also emphasized by the results for self-efficiency, since highly experienced users have a higher average self-efficiency score. In addition, highly experienced users feel more confident while using the system, which is expressed by a lower average score on anxiety.

The results seem to support hypothesis H2 which states that experienced users will have a higher effort expectancy compared to less experienced users. When performing a t-test with one group being highly experienced and the second group the remaining users, the null hypothesis reaches a significance of 0.032 which is on below the p-level of 0.05 for the 95% confidence interval. Therefore the null hypothesis can be rejected and H2 accepted.

	Experience	N	Mean	Std. Deviation	Significance
Performance Expectancy (PE)	High	13	19.54	4.427	0.318
	Medium	9	17.56	4.531	
	Low	0	-	-	
Effort Expectancy (EE)	High	13	23.92	3.201	0.032*
	Medium	9	20.22	4.353	
	Low	0	-	-	
Attitude Towards Using Technology (AT)	High	13	25.00	2.309	0.376
	Medium	9	24.00	2.872	
	Low	0	-	-	
Social Influence (SI)	High	13	19.62	4.073	0.858
	Medium	9	19.33	2.693	
	Low	0	-	-	
Facilitating Conditions (FC)	High	13	21.77	3.444	0.704
	Medium	9	21.22	2.991	
	Low	0	-	-	
Self-Efficiency (SE)	High	13	23.15	3.625	0.127
	Medium	9	20.11	5.372	
	Low	0	-	-	
Anxiety (AX)	High	13	9.62	4.253	0.051
	Medium	9	13.44	4.246	
	Low	0	-	-	
Behavioural Intentions (BI)	High	13	14.92	4.051	0.565
	Medium	9	13.89	4.106	
	Low	0	-	-	
Age	High	13	29.31	9.277	0.965
	Medium	9	29.11	11.516	
	Low	0	-	-	
Voluntariness of use (VU)	High	13	5.46	1.713	0.894
	Medium	9	5.56	1.424	
	Low	0	-	-	

TABLE 15: CONSTRUCT VALUES BASED ON USER'S EXPERIENCE.
* SIGNIFICANT AT $p < 0.05$.

The remaining average results are quite similar for both highly experienced users and those that have average experience. Even though the average age is lower for the group with high experience, all except one of the professional users are in the highly experienced user's group, which consists of seven professionals and four students. While the group with medium experienced users consists of one professional, three students and three users that are non-professional and non-student. The complete division based on the user's background will be performed later on in this chapter, in Table 17.

8.3.2.4 GENDER

As displayed earlier in Table 6, only two participants were female, which makes the following comparison highly unreliable. However, for completeness it is included. The summary of this division is included as Table 16. When looking at the average results, the female participants seem to support the system more than their male counterparts. Especially effort expectancy, attitude, facilitating conditions and behavioural intention are rated a lot higher by the female subjects. In addition the female users appear to be more confident (anxiety) and self-efficient with the system compared to the average male. However, males are on average more experienced.

When looking at the standard deviations, both female users scored exactly the same on facilitating conditions and effort expectancy even though they participated in separate groups. Their scores on behavioural intention and attitude also show only small variations. As stated before, since there are only two female participants no reliable conclusion can be derived from the average results. None of the female subjects were professional users, one is a student and the other non-student and non-professional.

	Gender	N	Mean	Std. Deviation	Significance
Performance Expectancy (PE)	Male	20	18.45	4.466	0.371
	Female	2	21.50	4.950	
Effort Expectancy (EE)	Male	20	22.05	4.097	0.197
	Female	2	26.00	0.000	
Attitude Towards Using Technology (AT)	Male	20	24.30	2.473	0.089
	Female	2	27.50	0.707	
Social Influence (SI)	Male	20	19.55	3.546	0.885
	Female	2	19.00	4.243	
Facilitating Conditions (FC)	Male	20	21.10	3.007	0.036*
	Female	2	26.00	0.000	
Self-Efficiency (SE)	Male	20	21.80	4.503	0.732
	Female	2	23.00	7.071	
Anxiety (AX)	Male	20	11.40	4.650	0.493
	Female	2	9.00	4.243	
Behavioural Intentions (BI)	Male	20	14.10	3.986	0.143
	Female	2	18.50	0.707	
Experience (EX)	Male	20	20.60	4.160	0.508
	Female	2	18.50	4.950	
Voluntariness of use (VU)	Male	20	5.50	1.573	1.000
	Female	2	5.50	2.121	
Age	Male	20	29.60	10.410	0.592
	Female	2	25.50	2.121	

TABLE 16: AVERAGES GROUPED BY GENDER.
*** SIGNIFICANT AT P < 0.05.**

8.3.2.5 BEHAVIOURAL INTENTION

For modelling UTAUT, the program SPSS Amos was used, which is a structural equation modelling (SEM) tool. The explanatory power of variance in behavioural intention can be explained for 78.8% for this study. However, UTAUT is known for reaching 70% explanatory power for the variance in BI (Venkatesh et al., 2003), the low result is probably due to the small sample size and a number of variables not having a high reliability. This research ends at behavioural intention to use the system, since no actual usage information is available. The participants were the first group to actually use the system and with only one iteration, there is no data available for actual system usage.

Effort expectancy and social influence both reach significance at levels of 99.9%, and performance expectancy has a significant effect on behavioural intention of 95% after entering the results into Amos. The influence of facilitating conditions and behavioural intention on actual usage remain unknown. See Figure 10 for the results of the model. The dashed arrow lines indicate that the effect is unknown.

The relations between the constructs show that when performance expectancy increases by 1, the behavioural intention will decrease with 0.274. This effect is significant on a p-level of 0.05. When effort expectancy increases by 1, the behavioural intention increases by 0.55 with a significance up to 99.9%. Social influence has a negative influence on behavioural intention, when social influence increases by one, behavioural intention decreases by 0.64. The results show that ease of use is an important aspect in increasing the intention to use the system. On the other side, social influence only decrease the behavioural intention. However, this is most likely the result of social influence not really applying to the participants of this research. In addition, social influence is moderated by age, gender, experience and voluntariness. Since all users participated voluntarily and only social influence is moderated by voluntariness of use, this could explain the negative effect. The research of UTAUT by Venkatesh et al. (2003) show that social influence has a stronger effect for women, older workers under conditions of mandatory use and with limited experience. This situation does not present itself in this research, since all users rated their experience as average or high, most of them were men and the average age is quite low.

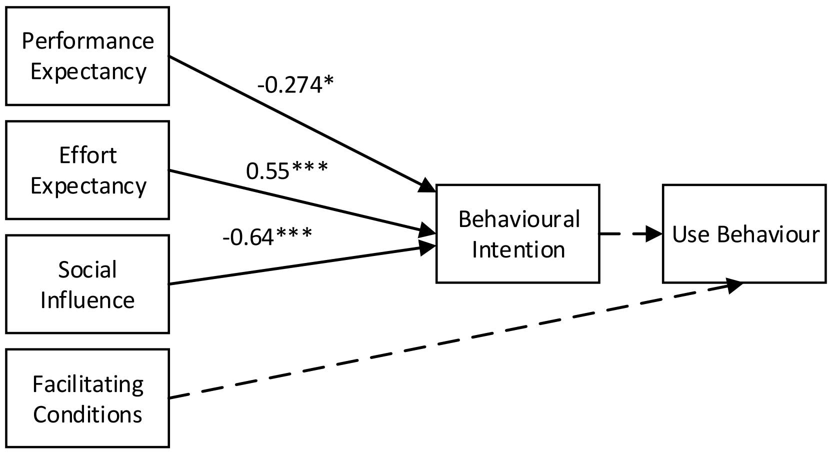

FIGURE 10: UTAUT MODEL AFTER ENTERING THE RESULTS OF THIS RESEARCH.
* SIGNIFICANT AT P < 0.05
*** SIGNIFICANT AT P < 0.001

UTAUT has often been criticized as being a quite complex and difficult to use model (Bagozzi, 2007). Since UTAUT is partly based on TAM and the questionnaire contains the constructs of TAM, the results can be mapped to TAM as well. By doing so the explanatory power decreases to 57.2% on the variance of behavioural intention. The regression weights for TAM and their significance are displayed in Figure 11. UTAUT managed to explain 78.2% of the variance in behavioural intention, which shows that the behavioural intention is only slightly influenced by other aspects that are not measured by the model. Participants have a really positive attitude towards using the system, it could be that people are really excited about the new system and want to know more about it, and since only one iteration was performed, it remains unclear if this effect will wear off over time.

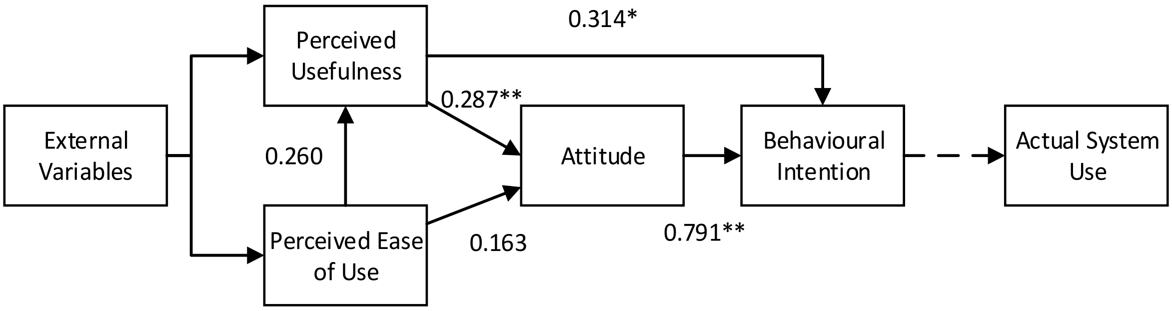

FIGURE 11: RESULTS WHEN USING TAM.
* SIGNIFICANT AT P < 0.05
** SIGNIFICANT AT P < 0.01

8.3.3 REMAINING VARIABLES

According to the UTAUT model, attitude towards using technology, self-efficiency and anxiety are theorized not to be direct determinants of behavioural intention (Venkatesh et al., 2003). The authors found evidence that those variables have no significant effect on behavioural intention since the effect is captured by effort expectancy. The variables are included in the questionnaire to gather more information about the perception of the system by the user. Which can assist in explaining certain phenomena.

All three have low Cronbach's Alpha scores which shows that there is little inter-correlation amongst the questions for each item. However, the results from the survey do provide some indications that the average participant is not really scared of losing data or other aspects of using the software. The average score on anxiety is 2.80, which indicates that on a scale of 1 to 7 the average subject slightly disagrees being anxious. When looking at the individual anxiety questions, AX1 to AX4 in Table 29 of Appendix C, it becomes clear that most people feel apprehensive about the system (AX1). Only AX1 has a mean that is almost neutral, with a score of 3.59. The remaining three questions have means of 2.32, 2.59 and 2.68 respectively for AX2, AX3 and AX4.

Even though feeling slightly apprehensive on average, with enough time or support, participants responded to be able to work with the system, hence the scores for self-efficiency are on average 4.83. In addition the test subjects have a positive attitude towards using the software, with a score of 5.39. Both the total values for self-efficiency and attitude towards using technology have a 99% probability ($p < 0.01$) of being above neutral, while the same applies for anxiety for being below neutral. The positive attitude confirms H3, with the 95% confidence interval being between 23.47 and 25.72, were neutral is represented by a value of 16. H3 even passes for $p < 0.01$ with confidence interval being between 23.09 and 26.12.

Besides the technology acceptance related constructs, the following three aspects were also measured: computer skills, expected future for virtual meetings in a 3D virtual environment and the participant's background. The average participant self-assessed his or her computer skills with a value of 5.91 which is quite high on a scale of 1 to 7. The division of computer skills is displayed in Table 7, which shows that all, except one, rate their computer skills above average. Which makes proving H4 difficult. However, when looking at the overall experience of the user, as discussed earlier and summarized in Table 15, the users with high experience are less anxious about the system. Therefore an alternative hypothesis will be used:

H4a: Users with high experience are less anxious about using the system compared to users with low computer skills.

When performing a t-test to see if the null hypothesis, which suggests that there is no difference between the groups, can be rejected. The significance is 0.051 which is just above the 0.05 p-value. The significance should be below this value to pass the 95% confidence interval. Therefore with the current sample size the null hypothesis cannot be rejected with $p < 0.05$ and H4a has to be rejected as well.

	Background	N	Mean	Std. Deviation
Performance Expectancy (PE)	Professional	8	20.38	5.181
	Student	11	16.82	3.544
	Other	3	21.33	3.512
Effort Expectancy (EE)	Professional	8	23.50	3.855
	Student	11	21.64	4.411
	Other	3	22.33	4.041
Attitude Towards Using Technology (AT)	Professional	8	24.63	1.847
	Student	11	24.18	3.093
	Other	3	26.00	2.000
Social Influence (SI)	Professional	8	19.13	4.518
	Student	11	19.64	2.976
	Other	3	20.00	3.464
Facilitating Conditions (FC)	Professional	8	21.13	4.051
	Student	11	21.91	2.166
	Other	3	21.33	5.033
Self-Efficiency (SE)	Professional	8	22.13	4.016
	Student	11	22.45	3.417
	Other	3	19.33	9.609
Anxiety (AX)	Professional	8	9.50	4.504
	Student	11	11.82	3.417
	Other	3	13.33	2.309
Behavioural Intentions (BI)	Professional	8	15.13	4.486
	Student	11	14.27	3.809
	Other	3	13.67	6.110
Experience (EX)	Professional	8	23.25	2.964
	Student	11	19.27	4.149
	Other	3	17.00	2.646
Age	Professional	8	31.75	11.235
	Student	11	24.55	2.806
	Other	3	39.67	16.010
Voluntariness of use (VU)	Professional	8	5.38	1.768
	Student	11	5.64	1.567
	Other	3	5.33	1.528

TABLE 17: CONSTRUCT VALUES BASED ON PARTICIPANT'S BACKGROUND.

The fifth hypothesis that suggests that users that are less anxious about the system have higher self-efficiency compared to anxious users. When dividing the group in two, one group having an anxious score of 16 or higher, being neutral or anxious, and the other group having a score below 16, being below neutral. This results in 5 participants in group one and 17 in group two. By performing a t-test to see if the null hypothesis can be rejected, the significance is 0.624. This means that the probability that both groups are different is relatively low, only 37.6%. Therefore the null hypothesis cannot be rejected and H5 cannot be accepted.

Another interesting result was already summarized in Table 8, showing the likeliness that there is a future for virtual meetings in a 3D virtual environment. The average result is a 6.23 which indicates that, on a scale of 1 to 7, is very likely that there is future for virtual meetings in 3D environments. This confirms the expectations made earlier.

In Table 17 the results are grouped by the participant's background. The participants were grouped in three categories: professional, student or other. Similar to the groups used by King and He (2006). One of the largest differences is visible in experience, the students and professionals that participated seem to have more experience on average with virtual meetings, content management systems and 3D environments. This can partly be explained by the difference in age, since the average age of the student and professional users is much lower than the other groups. The professional participants are the least anxious of the three groups, having the highest self-efficiency and effort expectancy averages. This seems to support the adjusted hypotheses H4 and H5, however both were not significant and thus rejected. Professional users seem to have the highest intention to use the system. Which indicates that the main target group accepts the system.

8.3.4 FEEDBACK RECEIVED

The participants were asked to provide additional feedback by answering the open questions at the end of the questionnaire. When asked what would be the greatest barrier for adopting a new IT system, many participants responded that the eventual users will most likely be the bottle-neck. Convincing people to invest time in learning to use the new system, because they are used to their existing systems. For example, one of the participants said that: "Changing things don't make people very happy. They get used to their old software and I think this is the biggest barrier when moving to new IT systems." Another person responded with: "Convincing people to invest time in learning to use the new system. People are quite suborn and do not like changes." In addition convincing people of the benefits is also seen as a barrier, especially when there are no short-term benefits. Others responded that the system needs to be easy to use. Which is similar to the goal of this research, increasing the usability of virtual meetings in a 3D virtual environment.

When looking at this solution people responded quite positive, which is reflected by the high average score on attitude towards using the technology. People indicated that they liked the interactivity of the virtual environment and that it was fun to do. Some participants responded that using a 3D virtual environment gave them the idea of being in an actual meeting, making it more personal compared to sitting in front of a camera. One of the participants said: "The system makes long-distance meetings seem more personal. It is fun and it has the potential to show a lot of different things to a lot of different people simultaneously." Which summarizes the overall opinion quite well.

However, there are also things disliked about the system. The main concern of the participants was that the start-up effort is quite high. Getting used to the controls and all the features takes some time. In addition the configuration of the viewer was perceived as difficult by some users. This indicates that the initial start-up costs cause users to be reluctant to get started. A completely different response was that the solution would require powerful hardware to take advantage of all the possibilities and that company networks could be too slow. This is contradicted by one of the users that participated during the experiment, he managed to attend the virtual meeting with a six year old laptop through a slow wireless Internet connection.

Recommendations for improving the system received from the participants contained many suggestions on extending the system. For example by connecting the CMS to file sharing services like Dropbox or to scheduling solutions like Doodle. This was supported by others that suggested easy file upload or even drag-and-drop support. The whiteboard and screen sharing facilities which are used by Thales are also seen as valuable addition. For usage within Thales or other technical companies, one responded that uploading 3D objects would be an important addition.

Others responded that the number of options offered by the viewer for the virtual world is too large. This should be limited to serve only the purpose of holding meetings. It was seen as too easy to fool around or click the wrong button. This probably explains the high anxiety average mentioned previously. Working without addition software like the viewer and being able to join a virtual meeting without installing any software would make the system perfect, according to one of the participants. An overview of all the responses received by the participants is included in Appendix G.

9 DISCUSSION AND CONCLUSION

The goal of this research is to determine if a 3D virtual environment supported by a content management system (CMS) is suitable for virtual meetings. First, the current problems, challenges and solutions were identified for using a 3D virtual environment for cooperative work in section 3. Based on these findings and addition research performed on (virtual) meetings in general (section 4), a list with requirements for the CMS was created in section 5. In addition, section 5 describes the design of the CMS. This design is validated in section 6 based on the internal and external validation methods of Wieringa (2009). In section 7, a technology acceptance model was selected with the best fit for this research, after comparing a number of popular theories. The implemented prototype of the CMS and an OpenSim based virtual environment were evaluated empirically and the results are listed in section 8. The findings of this study provide support for the technology acceptance of virtual meetings in a 3D virtual environment.

The results provide empirical evidence on the technology acceptance of using 3D virtual environments for business meetings. All constructs of UTAUT had a positive results, and managed to explain 78.2% of the variance in behavioural intention. In addition, the high scores on attitude towards using the technology and the future expectations on meetings in a 3D virtual environment. This chapter will start with the conclusion of this research in section 9.1, followed by the limitations of the results in section 9.2. Section 9.3 contains the contributions of this research to theory and practise. Section 9.4 discusses the results mentioned in the previous sections and is followed by directions for future work.

9.1 CONCLUSION

At the beginning of the research a research question and three sub questions were mentioned which need to be answered. The first sub question was answered based on a literature review, interviews with existing users and experiences from the OpenSim community. The question and answers are summarized below:

> **SQ1:** What are the current problems, challenges and solutions when using a 3D virtual environment for cooperative work?

The steep learning curve of using a 3D virtual environment is the main challenge. In addition, meetings are costly in both terms of time and money, and without the right preparations the meeting will become unproductive. A number of new issues arise when working in a virtual environment. For example, finding the right metaphors or offering access to documents and presentations. However, the literature and other sources also offer a number of best practises when using a 3D virtual environment and for preparing meetings in general.

From the available virtual worlds a comparison is made and OpenSimulator, in short OpenSim, is the environment that offers the required amount of flexibility and is still under active development by its community. The identified issues, best practises and experiences are used to answer the next sub question:

> **SQ2:** What are the requirements for the CMS to support group work in a 3D virtual environment?

A list with requirements, both functional and non-functional, are derived from the answer of SQ1. These requirements are used to design a solution, called OpenSim-CMS. The system uses an API which is accessed through a web-based CMS and by the tools created in OpenSim. The design is validated by using the internal and external validation methods, and trade-off analysis of Wieringa (2009). A prototype is created based on this design to validate the solution empirically. However, to measure the technology acceptance one of the many available theories needs to be selected, this is done by answering the following sub question:

> **SQ3:** Which technology acceptance model can be used best to measure the perceived usability when using a CMS to set up a virtual meeting in a 3D virtual environment?

After an extensive literature review of the available models and reviews of the models, UTAUT found to be the best fit for this research. The model has the highest explanatory power and supports both mandatory and voluntary usage. In addition the model was found to be useful in evaluating success of new technologies including identification of factors that could influence the adoption (Williams et al., 2011). With all the pieces in place, only the main research question remained:

> **RQ1:** Will the use of a 3D virtual environment supported by a CMS be accepted for performing a virtual meeting?

After performing an experiment with 35 users divided over multiple groups, 22 of those users completed the questionnaire and provided usable data. Almost half of the users signed up through a request on social media, the other half consisted of a group of young professionals within Thales and the activities committee of a study association at the University of Twente. With the data collected from these users, UTAUT managed to explain 78.8 percent of the variance in behavioural intention. In addition, the average results indicate that users have a positive attitude towards using the system and a high intent to use a 3D virtual environment supported by a CMS for virtual meetings. This research does not provide any actual usage statistics since the system was only used once by the participants. Besides, almost all the participants are highly educated and have a technical background, making it difficult to form a general conclusion.

However, when looking at the average results and the outcome of the UTAUT model, users that are highly educated and have a technical background perceive the system as interesting and fun. Another interesting finding is that age does not seem to influence the user's expected effort to work with the system. All tested hypotheses and their outcomes are listed in Table 18.

Hypothesis	Result	Significance
H1: Older users will have lower effort expectancies than younger users.	Rejected	0.959
H2: Experienced users will have a higher effort expectancy than less experienced users.	Accepted	0.032*
H3: Users will have a positive attitude towards meetings in a 3D virtual environment.	Accepted	**
H4: Users with high computer skills are less anxious about using the system compared to users with low computer skills.	Unknown	
H4a: Users with high experience are less anxious about using the system compared to users with low computer skills.	Rejected	0.051
H5: Users that are not anxious about the system have higher self-efficiency than users that are anxious about the system	Rejected	0.624

TABLE 18: OVERVIEW OF HYPOTHESES AND THEIR RESULTS.
* SIGNIFICANT AT P < 0.05
** SIGNIFICANT AT P < 0.01

Professional users, which are the main focus group, reached the highest average score on behavioural intention. Students and general users also have positive averages. The overall positive attitude towards using the system and the expected future for using virtual environments with the purpose of performing business meetings indicate that the technology is accepted.

9.2 LIMITATIONS

Before discussing the implications of this work for theory and practice, it is necessary to recognize some of its limitations. The limitations of this research will be discussed in this section.

9.2.1 SAMPLE SIZE

The greatest limitation of this study was available time to complete the research. The time was limited to only six months to complete both the theoretical and the practical parts. Therefore, the results are based on a single moment in time, where the studies of TAM2 and UTAUT were longitudinal and used three moments in time to measure their constructs (Venkatesh & Davis, 2000; Venkatesh et al., 2003). This also caused the majority of the participants of the experiment to complain about the start-up costs. When going for a second and maybe even a third round, people would already be familiar with the system; know the controls, have their viewers configured and created their avatar. This would probably benefit the final results, since H2 provides evidence that experienced participants have higher effort expectancy averages. Showing indications that the more experience a user has the less effort is required to work with the system.

In addition, having more time would enable the gathering of actual usage statistics completing the UTAUT model. Currently there are no figures available on actual usage. This would also allow the validation of the facilitating conditions, since facilitating conditions have no influence on behavioural intention and only on actual usage (Venkatesh et al., 2003). However, existing literature on virtual environments emphasizes the importance of having support for the users (Kemp et al., 2009).

The time constraints also caused another issue. Since the whole process of identifying issues, deriving requirements from those issues, creating a design and implementing it takes a lot of time. The available time for gathering results and processing the results was limited. In addition, an often heard excuse from potential test subjects was that the experiment takes too much time. A single round, showing a single group of participants all the available options and let them experience a virtual meeting, took on average two hours.

This resulted in a small sample size, which made comparing the values for the moderators hard. For example, having only two female participants caused the gender comparison to be insignificant. Even when using students as surrogates for professional users (King & He, 2006), the amount of female technical students is still quite low (Merens et al., 2012). In addition not all the questions of the UTAUT questionnaire apply to students. For example, students are not part of an organization that uses the system and do not have managers above them forcing them to use a piece of software. The same could, in this case, be said about all users. Since everyone participated voluntarily and no one was pressured to use the system, for example by their colleagues or organization. Therefore, the aspects of voluntariness and social influence are limited in this study.

9.2.2 SELF-ASSESSING ABILITIES

The gathered results are based on the participant's ability to self-assess him or herself. Even though this is the only real way of collecting user feedback. For example, one could assess his computer skills to be quite high while another participant with similar computer skills could assess his skills as average. To collect reliable average values, the sample size should be as large as possible.

9.2.3 STUDENTS

Besides the small sample size, most of the subjects that participated were students. King and He (2006) showed in their research that students can be used as surrogates for professional users for the technology acceptance model. Because of the small sample size, it is not possible to use the model with only one of the groups and thus the comparison of students, professional and general users cannot be done on the effect level as done by King and He (2006). This will lead to results that are not significant and thus not reliable. However, when looking at the average scores on the individual constructs, as displayed in Table 17, students seem to score similar to professionals. Especially when looking at the main constructs of UTAUT, the student´s scores, their standard deviation and 95% confidence interval are inside of the range of the scores of the professionals.

This does not apply for the general users' results on facilitating conditions and behavioural intention. These results are displayed in Appendix H. Since this is a new technology which has not been fully developed and it will probably take quite some time for meetings in virtual environments to be embraced by companies, the students of today might be the first real users by the time the system becomes widely available. Since the results of students are within the same range as the results of the professionals, both groups have technical and highly educated backgrounds and today's students will be the users of tomorrow, it can be argued that in this case students can be used as surrogates for professionals.

9.2.4 IMPLEMENTATION

During implementation of the CMS the path of least resistance was chosen. The scheduling of meetings can be made a lot easier, the agenda could be more sophisticated and inviting participants made easier. However, for the purpose the CMS was used during this research it did not limit the subjects. This confirms the findings in the literature and the results of the validation. In addition the use of the API enables users to create new or improved functionalities. For example, an overview of scheduled meetings in OpenSim which enabled users to see what is going on in the virtual world without logging in into the CMS. Another implemented feature requested was the ability to upload videos. Since OpenSim supports flash videos by default, a small script was created that enabled users to upload their video which was automatically converted to a flash movie and viewable in OpenSim.

9.2.5 SEPARATE THE PARTS OF THE SOLUTION

The current solution actually consists of two parts, on one side there is the web-based CMS, on the other side there is OpenSim. Both are connected through the API. However, to make the constructs of UTAUT more accurate, the model should be applied to both sides separately. For most of the constructs the combination is not an issue, except for the experience moderator. Users with high experience with CMSs, for example because they maintain an own website, but little experience with 3D virtual environments still have a decent average score. The variation in experience would be larger when looking at the different parts individually.

However, except for experience, this does show that UTAUT and TAM are capable of assessing a complete solution instead of just a single piece of technology. For this research it would not have been possible to measure the aspects separately. Using OpenSim for virtual meetings, especially formal business meetings, requires far too much effort without any support systems. Comparing the situations without and with a decent CMS would be an open door. Only expert users would have been able to work with OpenSim if there are no supporting facilitates available.

9.3 RESEARCH CONTRIBUTION

The initial goal of Thales was to improve the usability of OpenSim for cooperative work. Since cooperative work is a broad field, the scope was narrowed to virtual meetings. A content management system was created and theory on technology acceptance, in this case UTAUT, was used to measure the perceived experiences of the user. Therefore this research contributes to both theory and practise. First the contributions to the literature will be discussed followed by the contributions to practise.

9.3.1 CONTRIBUTIONS TO THE LITERATURE

The current literature available on virtual worlds focusses on educational purposes (Boulos et al., 2007; Kemp et al., 2009; Salt et al., 2008; Schaf et al., 2008; Warburton, 2009), however the usage of virtual environments for corporate usage seems to receive less attention. The existing research on using 3D virtual environment for corporate purposes, does not provide any scientific evidence which can explain why some solutions failed and others succeeded, such as the I-Room of Tate et al. (2009). This research attempts to fill this gap and show that virtual worlds can be used for business meetings.

By using issues and their best practises identified by existing research on virtual worlds, a list with requirements was created. These requirements were used to create a design, which was validated by the internal and external validation methods of Wieringa (2009). A prototype of the design was created, called OpenSim-CMS. The CMS and additional tools were empirically tested by a number of groups, with a total of 35 users and of those users 22 completed the questionnaire. Most of the users have a technical background and are highly educated. Users are divided in three groups: professionals, students and the remaining other users. When looking at the average results, students can be used as surrogates for professional users. UTAUT was selected as the best fit for this research after comparing several technology acceptance models. The model managed to explain 78.8% of the variance in behavioural intention.

This research shows that using virtual environments for meetings are perceived as fun, interesting and a good idea by the users. However, only one iteration was performed, which makes it difficult to tell if people will remain to perceive the system as interesting over time. The participants of this research rated all measured constructs positively. In addition, the results show that age has no significant influence on the expected amount of effort required to use the system when users have a technical and highly educated background. Besides, there seems to be a connection between experience and expected effort. Users with more experience seem to perceive the system as easier to use than the less experienced users.

Other findings of this research are that there is no relation between having a high level of experience and little anxiety, and between having little anxiety and being self-efficient. Users with high experience do not seem to be less anxious about using the system compared to their less experienced colleagues. Those users who are not anxious about the system do not have higher self-efficiency than other users.

The responses of the users also show that they expect that there is a future for 3D virtual environments for the purpose of virtual meetings. Hopefully this opens the door for additional research on virtual environments for cooperation in a business setting.

9.3.2 CONTRIBUTIONS TO PRACTICE

One of the goals of this research was to increase the usability of virtual worlds. Without any support systems, using an environment such as OpenSim would require a lot of time consuming effort by the users to make all information available. This research shows that using an API to offer functionalities to the virtual world enables the automation of many tasks. For example showing a presentation no longer requires the user to upload each slide as a separate image into their avatars inventory before showing it on a screen. By using the API and the OpenSim-CMS front-end, users can upload a complete pdf of their presentation which is processed automatically and can be retrieved by a simple HTTP request in the virtual environment.

The empirical tests show that users can access the virtual environment from all around the world, tested with Australia and the Netherlands. In addition, such an environment is designed to support large groups, is highly customizable and offers many interaction forms, which makes is suitable for cooperative work. From the results, companies will most likely be interested in the positive attitude towards using the technology, the intention to use the technology and the expectations about the future. All three show that people like the concept of using a virtual environment for meetings, and probably other purposes.

The list with requirements can be used as a foundation to create an improved version of the prototype OpenSim-CMS and API. Since this research is limited by only having a small sample of the population, with the majority being highly educated and having a technical background, additional research is required to predict the behavioural of the general population. However, the results show that on average professional users have almost equal or higher scores on the measured constructs then students. This indicates that the professional users will have a higher intention to use the system.

9.4 RECOMMENDATIONS

The results of this research lead to a number of recommendations for a company that wants to use a 3D virtual environment for their business meetings. First, a platform needs to be selected. For companies that want to run their own services and keep all the data in-house, OpenSim is the platform of choice, supported by the FreeSwitch audio service. Getting FreeSwitch to run requires some effort and currently does not work flawless. When good audio is required and the company does not fear using a third-party for their voice services, Vivox is voice services with the best quality and works instantly.

In addition, a tool like OpenSim-CMS connected to an API is highly recommended to manage content and offer access from within the virtual world. Without such a system the amount of effort required to set-up a meeting exceeds all workable levels. By using familiar terms and metaphors lets users relate to things they already know. Besides, using simple objects in the virtual world allows users to familiarize with them from the start. When needed users can add features or create new objects based on the existing ones.

A final recommendation is to let users play and fool around in the environment before using it in a serious setting. This can be done by organizing a workshop were everyone can experience the CMS and the virtual environment with all the functions it offers. During this research many users started with fooling around and after a while they were done and participated seriously with the demonstration. Some other users that did not start ‘playing’ began fooling around during the meeting and afterwards. It is therefore recommended to user the fun factor offered by the virtual environment as beneficial from the start.

9.5 DISCUSSION

The solution, OpenSim-CMS, API and tools in the virtual environment, was created by using an agile approach, as prescribed by Salt et al. (2008). This worked quite well, using small sprints to create one function at a time and continuously improving the system. OpenSim has a lot of features that are not fully documented, for example the new JSON functionalities that can be used in LSL and the API functions offered by OpenSim. A concrete example of functions not being fully documented are the different ways of creating a new avatar. When creating a new avatar in OpenSim through the XML API the avatar will have no body and will display as a cloud, while creating a new avatar through the command line or the WIFI front-end works correctly. Issues like this can discourage people from using virtual environments.

When using OpenSim for virtual meetings the steep learning curve, as identified by Salt et al. (2008), and the effort required to get started (Kemp et al., 2009; Konstantinidis et al., 2010) remains present. However, the OpenSim-CMS minimizes the required effort and limits it to only the first usage. After the first use, the viewer is configured, the avatars are created and the user is familiar with the controls and facilities offered in the virtual environment. It can be argued that many of the experienced difficulties would diminish or even disappear at a second use of the system.

9.5.1 Requirements

The list with requirements derived from the literature and from other experienced users, such as Rulof (2013) and Korolov (2009), resulted in complete solution. Most of the issues and solutions found were related to educational usage or general usage of a virtual world, since there was little to no research found on using a 3D virtual environment in a business settings. Only requirement FR02, linking users to their avatar, as identified by the work of Kemp et al. (2009) solved a different issue in this research. The original issue that needed to be solved was derived from Second Life, were many usernames are already taken. In OpenSim, all usernames are available and all participants created an avatar with their own first and last name. Therefore the issue of identifying a real person by his or her avatar was no issue anymore. However, users still needed to link their avatar to their account, to be able to access their own or shared files and other data. The original issue will most likely return when more users create an avatar in the virtual world and two users have the same name.

It is probable that companies will use a structured format for the avatar naming, similar to how they distribute e-mail addresses for their employees. A. M. Kaplan and Haenlein (2009) also mentions the issue of trust and friendliness. They ask the question: “Do you really want your CEO to negotiate the merger of your company with a potential partner in another country using virtual worlds? (A. M. Kaplan & Haenlein, 2009)". This is probably still a bridge too far, especially when there are no formal usage guidelines and it still seen as a game or playground, instead of a serious opportunity for new collaboration methods.

The chat function which enabled communication from the web to OpenSim and back, was mainly used to assist users that had problems connecting to OpenSim. Instead of a web-intercom, the chat was used as an additional support tool. Since being geographically dispersed made it impossible to just walk by and solve the issues locally, the chat offered a nice solution which did not require any additional programs or tools, such as Skype, telephone or other chat applications.

The teleport functionality allowed users to reach their destination with the press of a button. Especially for new users, who are not familiar with the controls, this saved them a lot of time. The recognizable terms and the use of simple objects and metaphors helped participants keep their attention. At the end of the meeting, during the evaluation phase, some of the participants came with ideas to improve the existing tools. Which support the findings of Livingstone and Kemp (2008).

9.5.2 Questionnaire results

Looking at the overall results of the questionnaire, most of the participants responded positively to meetings in a 3D virtual environment. With the averages on all constructs being significantly above neutral, except for anxiety which is, and should be, below neutral. Indicating that the overall attitude towards the system is positive. People commented that they liked this way of virtual collaboration, since it was fun to do and an interesting experience.

In addition, the average user was highly educated and has a technical background. This combination is probably the reason that many of the barriers found by the research of Venkatesh et al. (2003) and its predecessors did not apply to the participants of this research. For example there was no significant difference between age groups, none of the subjects rated his or her experience as low and even gender only shows a significant difference for facilitating conditions. Since only two females participated the gender results are not reliable. The high experience with 3D virtual environments, CMS and virtual meetings is most likely related to the technical background of the users.

Because the sample size was quite small, a number of hypotheses could not be confirmed. Hypothesis H1 was rejected even though the elder users had the most difficulties in getting started and their self-efficiency average score is lower. However, there was no significant evidence that this was not due to the effect of chance. Another explanation could be the high technical background of the participants, which offered them sufficient skills to work with the system without getting stuck. For H4 the significant value was almost reached, with a 90% confidence interval and also probably with a slightly larger sample size, the hypothesis would have passed. Though, hypothesis H3, which is important in supporting the main goal of this research, is accepted with a 99% confidence interval. An overview of all the hypotheses and their outcomes are displayed in Table 18.

Even though the small sample size made it difficult to prove any of the hypotheses and use the UTAUT model, the average scores on the constructs, and the positive responses do show that technical users like the concept of virtual meetings in a 3D environment. In addition, the three constructs of UTAUT for behavioural intention all reached significant R-squared values which contributed to an explanatory power of 78.8% of behavioural intention.

9.5.3 Technology acceptance theories

UTAUT was selected since it has the highest explanatory power and the model can be used in both mandatory and voluntary settings. Even though most students participated voluntary, some of them could feel being forced at some degree. For example, the activities committee of the study association participated because their chairman liked the idea. However, some other members of the committee could feel forced to cooperate. The same could apply to some of users that are part of the Thales YES group. Therefore the choice for UTAUT still seems to remain the correct one. In addition, the explanatory power of UTAUT in behavioural intention also exceeded TAM for this research.

9.5.4 Virtual meetings

At the beginning of this research the following question of A. M. Kaplan and Haenlein (2009) was mentioned: “when do you think your assistant will be capable of navigating and setting up meetings in Second Life with the same ease as using the phone?” With OpenSim-CMS, scheduling a meeting is just as simple as adding an event to any digital agenda. The biggest challenge before virtual worlds will be used by companies, is the lack of experience with virtual worlds. Companies will run into many new issues, ranging from the previously mentioned avatar naming guidelines to legal issues. For example, who owns a product that is developed in a virtual world by multiple users around the globe? (A. M. Kaplan & Haenlein, 2009). Companies need to think about such issues before using virtual worlds for collaboration, especially when using it with external parties.

The meeting cycle of Bostrom et al. (1993) is used as a foundation for OpenSim-CMS. The system enables users to prepare a meeting, by creating an agenda, sharing documents and discussing the content. During the meeting the available tools in OpenSim can access the available data from the pre-meeting phase. After the meeting, the minutes are saved and accessible for future reference. Since the CMS forces the user to add an agenda to the meeting, automatically logs the chat messages during the meeting and allows users to comment on the available documents, it also forces the user to work according the meeting cycle. Which ensures a minimal amount of structure and preparations which prevents the meeting of being unproductive.

In addition, electronic media often reduce the richness of the information exchange compared to face-to-face communication (Hedlund et al., 1998; Hertel et al., 2005; A. M. Kaplan & Haenlein, 2009). However, virtual worlds offer a unique environment where everything can be adjusted to the needs of the users. Collaborating in a 3D virtual environment creates a single solution which is location independent and can be used by large groups of users simultaneously. In addition, multiple communication methods can be used and combined together, using text and audio chat, supported by videos, documents, presentations, images, 3D models and other content available on the web. Which make it a valuable platform for virtual collaboration.

9.6 FUTURE WORK

Since the sample size of this research is quite limited addition research needs to be performed before a general conclusion can be made. Involving users with a higher variety in background. The positive average attitude of the participants could also be the result of only having voluntary users. Most of the people that participated were excited about the concept even before the demonstration started, and it could be argued that this is the reason that the results are quite positive. On the other hand, these users would most likely have high expectations that need to be met in order to stay enthusiastic about the concept and prevent the user from being disappointed afterwards. Therefore additional research needs to be done, with a focus on non-voluntary users.

Thales could extent the API and CMS even further, since the current implementation only includes the minimal functionalities to operate. For example, the ability of changing the password of an avatar has not been implemented. In addition, the scripts, rooms and options in OpenSim need to be improved based on the feedback received by the users.

When the system is actually being used, the model of UTAUT can be completed with the actual usage statistics. In addition the research can be continued to become a longitudinal study, making the results more reliable and see if the effect of everything being new and interesting decreases over time. This also provides options to measure the productivity of meeting in OpenSim. Does the productivity of a virtual meeting increases when using a 3D environment compared to teleconferencing? Comparing the meetings in a 3D virtual environment to traditional face-to-face meetings to measure the effectivity.

A complete different approach can be looking at more ways of using a virtual environment. For example by mixing it with augmented reality such as Kantonen et al. (2010) and Vega, Cardador, Fuks, and Lucena (2011) have done. Thales already has a similar idea, by using Oculus Rift 3D goggles with OpenSim for training and simulation purposes. The participants of this research indicated that they predict that there is a future for cooperative work in a 3D virtual environment.

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APPENDICES

A. QUESTIONNAIRE

USABILITY OF OPENSIM-CMS

The answers to these questions will be used to evaluate the technology acceptance, with a focus on usability, of the CMS and OpenSim as a tool to perform virtual meetings. The first part contains questions which are related to the UTAUT model (Unified Theory of Acceptance and Use of Technology). These questions use a 1 to 7 scale, with 1 as the lowest value (completely disagree) and 7 as the highest (completely agree).

The second part consists of some general questions.

NOTE: In the questions "the system" refers to the CMS and the OpenSim environment including all its tools.

* Required

PART 1: UNIFIED THEORY OF ACCAPTANCE AND USE OF TECHNOLOGY (UTAUT)

This section will serve as input for the UTAUT model. The model requires a total of 12 variables and moderators.

1) Performance Expectancy (4 questions)
2) Effort Expectancy (4 questions)
3) Attitude Towards Using Technology (4 questions)
4) Social Influence (4 questions)
5) Facilitating Conditions (4 questions)
6) Self-Efficacy (4 questions)
7) Anxiety (4 questions)
8) Behavioural Intention to Use the System (3 questions)
9) Voluntariness of Use (1 question)
10) Experience (4 questions)
11) Age (1 question)
12) Gender (1 question)

PE1: I find the system useful in my job *

Completely disagree 1 2 3 4 5 6 7 Completely agree

EE1: My interaction with the system is clear and understandable *

Completely disagree 1 2 3 4 5 6 7 Completely agree

AT1: Using the system for virtual meetings is a good idea *

Completely disagree 1 2 3 4 5 6 7 Completely agree

SI1: People who influence my behaviour think that I should use the system. *

Completely disagree 1 2 3 4 5 6 7 Completely agree

FC1: I have the resources necessary to use the system. *

Completely disagree 1 2 3 4 5 6 7 Completely agree

SE1: I can complete a job or task using the system, if there is no one around to tell me what to do as I go. *

Completely disagree 1 2 3 4 5 6 7 Completely agree

BI1: I intend to use the system for future meetings. *

Highly unlikely 1 2 3 4 5 6 7 Most likely

AX1: I feel apprehensive about using the system *

Completely disagree 1 2 3 4 5 6 7 Completely agree

EX1: How would you self-assess your experience level with content management systems in general *

Low 1 2 3 4 5 6 7 High

VU1: Is using the system mandatory or voluntary? *

Completely mandatory 1 2 3 4 5 6 7 Completely voluntary

PE2: Using the system enables me to accomplish tasks more quickly *

Completely disagree 1 2 3 4 5 6 7 Completely agree

EE2: It would be easy for me to become skilful at using the system *

Completely disagree 1 2 3 4 5 6 7 Completely agree

AT2: The system makes virtual meetings more interesting *

Completely disagree 1 2 3 4 5 6 7 Completely agree

SI2: People who are important to me think that I should use the system. *

Completely disagree 1 2 3 4 5 6 7 Completely agree

FC2: I have the knowledge necessary to use the system. *

Completely disagree 1 2 3 4 5 6 7 Completely agree

SE2: I can complete a job or task using the system, if I can call someone for help if I get stuck. *

Completely disagree 1 2 3 4 5 6 7 Completely agree

AX2: It scares me to think that I could lose a lot of information using the system by hitting the wrong key. *

Completely disagree 1 2 3 4 5 6 7 Completely agree

BI2: I would use the system to improve my virtual meetings *

Highly unlikely 1 2 3 4 5 6 7 Most likely

EX2: How would you self-assess your experience level with virtual meetings in general *

Think of Skype, Hangouts, teleconference, etc.

Low 1 2 3 4 5 6 7 High

PE3: Using the system increases my productivity *

Completely disagree 1 2 3 4 5 6 7 Completely agree

EE3: I find the system easy to use *

Completely disagree 1 2 3 4 5 6 7 Completely agree

AT3: Virtual meetings with the system are fun *

Completely disagree 1 2 3 4 5 6 7 Completely agree

SI3: The instructor has been helpful in the use of the system. *

Completely disagree 1 2 3 4 5 6 7 Completely agree

FC3: The system does _NOT_ fit with the way I like to work *

Completely disagree 1 2 3 4 5 6 7 Completely agree

SE3: I can complete a job or task using the system, if I have a lot of time to complete the job for which the software is provided. *

Completely disagree 1 2 3 4 5 6 7 Completely agree

AX3: I hesitate to use the system for fear of making mistakes I cannot correct. *

Completely disagree 1 2 3 4 5 6 7 Completely agree

BI3: I would like to use the system again in the next 2 months *

Highly unlikely 1 2 3 4 5 6 7 Most likely

EX3: How would you self-assess your experience level with 3D virtual environment usage *

Low 1 2 3 4 5 6 7 High

PE4: Using the system increases my chances of holding a good virtual meeting. *

Completely disagree 1 2 3 4 5 6 7 Completely agree

EE4: Learning to operate the system is easy for me *

Completely disagree 1 2 3 4 5 6 7 Completely agree

AT4: I like virtual meetings with the system *

Completely disagree 1 2 3 4 5 6 7 Completely agree

SI4: In general, the organization has supported the use of the system. *

Completely disagree 1 2 3 4 5 6 7 Completely agree

FC4: A specific person (or group) is available for assistance with system difficulties *

Completely disagree 1 2 3 4 5 6 7 Completely agree

SE4: I can complete a job or task using the system, if I have just the built-in help facility for assistance. *

Completely disagree 1 2 3 4 5 6 7 Completely agree

AX4: The system is somewhat intimidating to me. *

Completely disagree 1 2 3 4 5 6 7 Completely agree

EX4: The training/instructions I received were sufficient for me *

Completely disagree 1 2 3 4 5 6 7 Totally agree

What is your age? *

You are: *

- Male
- Female

PART 2: GENERAL QUESTIONS

You are: *

- o Student
- o Professional (used this tool work related)
- o Other

How would you self-asses your computer skills *

Low 1 2 3 4 5 6 7 High

Do you think there is a future for virtual meetings in a 3D environment? For example using the Oculus Rift (Virtual Reality Headset for 3D gaming) or other techniques to make the experience more realistic *

Highly unlikely 1 2 3 4 5 6 7 Highly likely

What would, in your opinion, be the greatest barrier when it comes to adopting a new IT system?

FEEDBACK

These questions are optional

What do you like about the system?

What do you dislike about the system?

Do you have any recommendations for improvement?

B. RESULTS QUESTIONARRE

PE1	PE2	PE3	PE4	EE1	EE2	EE3	EE4	AT1	AT2	AT3	AT4
5	2	2	5	5	7	4	5	6	7	7	7
5	2	5	5	6	5	4	3	4	6	5	5
4	5	6	7	5	5	5	7	7	7	7	6
6	7	7	6	4	7	6	7	7	4	7	7
4	3	3	4	3	5	4	5	4	6	6	6
6	3	3	6	7	6	6	7	6	7	7	7
3	6	3	3	6	7	6	7	3	6	7	6
4	3	3	3	7	6	5	6	4	5	7	6
5	6	2	5	6	6	4	2	7	7	6	4
7	6	6	6	6	7	6	7	7	7	7	7
5	6	6	6	2	5	3	2	6	7	6	5
6	5	5	5	7	6	6	4	6	7	7	6
4	2	2	5	5	4	3	5	6	7	7	5
6	6	6	7	7	7	6	7	6	7	7	6
6	4	5	6	7	7	5	7	7	6	6	7
5	4	4	3	4	7	5	6	4	7	6	5
5	5	6	5	5	5	4	5	6	7	6	5
6	6	7	7	7	6	7	6	7	6	7	7
3	2	3	5	5	7	5	6	5	5	5	5
4	2	3	5	5	6	7	6	5	5	7	5
6	4	3	6	6	7	7	7	7	7	7	7
4	5	4	5	6	6	6	6	6	7	7	7

TABLE 19: OVERVIEW OF THE RESPONSES ON THE INDIVIDUAL QUESTIONS.

SI1	SI2	SI3	SI4	FC1	FC2	FC3	FC4	SE1	SE2	SE3	SE4
4	6	7	6	6	7	4	7	3	7	6	7
2	4	5	5	6	6	2	5	2	6	5	4
6	6	7	6	4	6	4	7	5	2	7	6
1	5	7	7	6	7	4	5	4	7	7	7
1	4	7	4	7	7	3	4	4	7	7	5
4	4	7	7	7	7	2	7	5	4	5	4
2	2	6	3	7	6	4	6	6	6	5	6
4	4	7	2	7	7	4	6	7	7	6	7
5	5	6	6	6	3	6	5	3	1	4	1
4	1	7	4	6	6	1	7	7	7	7	7
4	4	7	6	5	6	3	6	3	7	4	7
4	4	7	7	6	5	2	6	5	7	3	6
4	4	6	4	6	6	6	4	5	4	4	4
6	6	7	7	7	7	2	7	7	7	7	7
4	4	6	5	6	7	1	6	7	7	2	7
6	5	7	3	6	5	2	4	6	7	6	6
1	4	4	4	5	5	2	5	4	4	5	5
6	4	7	6	7	7	1	6	6	5	2	5
4	4	6	4	7	7	5	5	6	5	5	5
4	4	6	4	6	7	6	5	6	7	7	4
5	5	7	4	7	7	6	7	7	7	7	6
4	5	6	4	6	6	6	4	6	7	7	6

TABLE 20: OVERVIEW OF THE RESPONSES ON THE INDIVIDUAL QUESTIONS (CONTINUED).

AX1	AX2	AX3	AX4	BI1	BI2	BI3	VU1	EX1	EX2	EX3	EX4
5	6	4	3	6	6	7	7	7	2	5	5
2	1	2	3	5	5	5	7	5	4	3	3
4	1	6	1	2	6	6	3	6	7	5	6
1	1	4	1	7	6	4	2	6	6	5	7
5	1	2	5	3	4	5	6	7	3	6	6
2	1	1	2	6	6	6	7	5	6	4	7
5	1	1	2	2	3	5	6	5	5	5	6
7	6	2	2	4	3	2	7	7	5	4	7
4	4	5	3	3	3	1	5	5	2	5	4
6	3	2	1	7	6	6	4	1	1	7	6
5	5	5	6	6	5	5	4	4	4	2	4
6	2	2	2	4	7	4	7	6	5	5	4
3	4	4	3	5	4	4	5	6	5	1	7
3	1	2	2	6	6	7	7	7	5	6	6
1	1	1	1	7	5	7	7	6	7	7	7
6	1	4	6	4	3	2	4	5	6	5	5
5	3	2	2	3	5	5	5	5	6	7	4
1	1	1	2	7	7	7	7	6	7	6	6
2	3	3	3	3	5	4	4	1	5	6	5
2	1	2	4	3	3	3	7	2	3	2	5
2	2	1	3	4	6	7	6	6	3	7	7
2	2	1	2	5	5	6	4	5	3	7	6

TABLE 21: OVERVIEW OF THE RESPONSES ON THE INDIVIDUAL QUESTIONS.

Age	Gender	Background	Computer skills
25	Male	Student	7
24	Male	Student	6
24	Male	Student	7
24	Male	Professional	6
29	Male	Student	7
27	Female	Student	5
24	Male	Professional	7
25	Male	Student	6
56	Male	Other	1
24	Female	Other	5
28	Male	Student	7
39	Male	Other	5
25	Male	Professional	6
27	Male	Professional	7
34	Male	Professional	6
31	Male	Professional	7
31	Male	Professional	5
58	Male	Professional	6
22	Male	Student	6
19	Male	Student	6
24	Male	Student	6
23	Male	Student	6

TABLE 22: OVERVIEW OF THE RESPONSES ON THE INDIVIDUAL QUESTIONS (CONTINUED).

C. UTAUT STATISTICS

	PE1	PE2	PE3	PE4
N	22	22.00	22.000	22
Mean	4.95	4.27	4.27	5.23
Median	5.0	4.5	4.0	5.0
Std. Deviation	1.090	1.667	1.667	1.193
Range	4	5	5	4
Minimum	3	2	2	3
Maximum	7	7	7	7

TABLE 23: PERFORMANCE EXPECTANCY (PE) STATISTICS.

	EE1	EE2	EE3	EE4
N	22	22	22	22
Mean	5.50	6.09	5.23	5.59
Median	6.0	6.0	5.0	6.0
Std. Deviation	1.371	0.921	1.270	1.593
Range	5	3	4	5
Minimum	2	4	3	2
Maximum	7	7	7	7

TABLE 24: EFFORT EXPECTANCY (EE) STATISTICS.

	AT1	AT2	AT3	AT4
N	22	22	22	22
Mean	5.73	6.36	6.55	5.95
Median	6.0	7.0	7.0	6.0
Std. Deviation	1.241	0.902	0.671	0.950
Range	4	3	2	3
Minimum	3	4	5	4
Maximum	7	7	7	7

TABLE 25: ATTITUDE TOWARDS USING TECHNOLOGY (AT) STATISTICS.

	SI1	SI2	SI3	SI4
N	22	22	22	22
Mean	3.86	4.27	6.45	4.91
Median	4.0	4.0	7.0	4.5
Std. Deviation	1.583	1.162	0.800	1.477
Range	5	5	3	5
Minimum	1	1	4	2
Maximum	6	6	7	7

TABLE 26: SOCIAL INFLUENCE (SI) STATISTICS.

	FC1	FC2	FC3[11]	FC4
N	22	22	22	22
Mean	6.18	6.23	3.86	5.64
Median	6.0	6.5	4.0	6.0
Std. Deviation	0.795	1.020	1.781	1.093
Range	3	4	6	3
Minimum	4	3	1	4
Maximum	7	7	7	7

TABLE 27: FACILITATING CONDITIONS (FC) STATISTICS.

	SE1	SE2	SE3	SE4
N	22	22	22	22
Mean	5.18	5.82	5.36	5.55
Median	5.5	7.0	5.5	6.0
Std. Deviation	1.532	1.790	1.649	1.503
Range	5	6	5	6
Minimum	2	1	2	1
Maximum	7	7	7	7

TABLE 28: SELF-EFFICIENCY (SE) STATISTICS.

	AX1	AX2	AX3	AX4
N	22	22	22	22
Mean	3.59	2.32	2.59	2.68
Median	3.5	1.5	2.0	2.0
Std. Deviation	1.894	1.701	1.532	1.460
Range	6	5	5	5
Minimum	1	1	1	1
Maximum	7	6	6	6

TABLE 29: ANXIETY (AX) STATISTICS.

[11] Used a reversed scale, 1 = 7, 2 = 6, 3 = 5, 4 = 4, 5 = 3, 6 = 2, 7 = 1.

	BI1	BI2	BI3
N	22	22	22
Mean	4.64	4.95	4.91
Median	4.5	5.0	5.0
Std. Deviation	1.677	1.327	1.770
Range	5	4	6
Minimum	2	3	1
Maximum	7	7	7

TABLE 30: BEHAVIOURAL INTENTIONS (BI) STATISTICS.

	VU1
N	22
Mean	5.50
Median	6.0
Std. Deviation	1.566
Range	5
Minimum	2
Maximum	7

TABLE 31: VOLUNTARINESS STATISTICS.

	EX1	EX2	EX3	EX4
N	22	22	22	22
Mean	5.14	4.64	5.05	5.59
Median	5.5	5.0	5.0	6.0
Std. Deviation	1.754	1.814	1.786	1.221
Range	6	6	6	4
Minimum	1	1	1	3
Maximum	7	7	7	7

TABLE 32: EXPERIENCE (EX) STATISTICS.

	Age
N	22
Mean	29.23
Median	25.00
Std. Deviation	9.985
Range	39
Minimum	19
Maximum	58

TABLE 33: AGE STATISTICS.

D. INTER CORRELATION MATRIX

	PE1	PE2	PE3	PE4	EE1	EE2	EE3	EE4
PE1	**1.000**	0.400	.505*	.558**	0.303	0.289	0.317	0.098
PE2	0.400	**1.000**	.640**	0.327	0.021	0.231	0.284	0.062
PE3	.505*	.640**	**1.000**	.566**	-0.021	0.014	0.239	0.134
PE4	.558**	0.327	.566**	**1.000**	0.160	-0.020	0.279	0.152
EE1	0.303	0.021	-0.021	0.160	**1.000**	0.302	.533*	0.338
EE2	0.289	0.231	0.014	-0.020	0.302	**1.000**	.592**	.513*
EE3	0.317	0.284	0.239	0.279	.533*	.592**	**1.000**	.660**
EE4	0.098	0.062	0.134	0.152	0.338	.513*	.660**	**1.000**
AT1	.624**	0.406	0.383	.816**	0.168	0.064	0.162	0.085
AT2	0.260	0.121	-0.069	0.185	0.077	-0.214	-0.200	-0.223
AT3	0.231	0.286	0.031	0.195	0.310	0.147	.518*	.486*
AT4	.458*	0.189	0.249	0.346	0.347	.440*	.522*	.648**
SI1	0.189	0.069	-0.003	0.345	0.318	0.205	0.301	0.128
SI2	-0.027	-0.089	-0.040	0.262	-0.090	-0.024	-0.044	-0.065
SI3	0.298	0.188	0.045	0.186	-0.043	0.329	0.315	0.265
SI4	.530*	0.339	0.397	.715**	0.094	0.006	0.113	-0.158
FC1	0.010	-0.183	-0.363	-0.247	0.393	.432*	.429*	0.287
FC2	0.010	-0.318	0.074	0.229	0.051	0.230	0.363	.587**
FC3	0.119	-0.131	-0.067	0.150	0.068	0.211	0.393	0.130
FC4	.465*	0.214	0.214	.505*	0.413	0.365	0.371	0.321
SE1	0.091	0.092	0.036	0.028	.476*	.494*	.663**	.754**
SE2	0.191	-0.062	0.129	-0.203	-0.097	0.415	0.291	0.223
SE3	-0.149	-0.055	-0.090	-0.092	-0.274	0.165	0.232	0.367
SE4	0.219	0.242	.432*	0.087	-0.069	0.410	0.206	.455*
AX1	-0.125	0.067	-0.144	-.547**	-0.193	-0.087	-0.336	-0.247
AX2	-0.146	-0.183	-0.351	-0.225	-0.153	-0.141	-.542**	-.442*
AX3	-0.183	0.083	0.008	0.079	-.578**	-0.276	-.562**	-0.403
AX4	-0.279	-0.295	-0.315	-0.394	-.678**	-0.225	-0.396	-.509*
BI1	.720**	0.207	.429*	.496*	0.166	0.238	0.130	0.120
BI2	.624**	0.264	.566**	.759**	0.249	0.120	0.317	0.194
BI3	0.368	0.106	0.348	.619**	0.216	0.151	0.285	0.408
VU1	0.126	-0.401	-0.292	-0.089	.565**	0.033	0.204	-0.048
EX1	0.103	0.068	-0.013	-0.016	0.148	-0.155	-0.100	0.004
EX2	0.039	0.176	.460*	0.238	0.211	-0.036	0.162	0.358
EX3	0.319	0.396	0.284	0.196	0.321	.547**	0.415	.442*
EX4	0.093	0.034	-0.083	0.132	0.242	0.246	0.370	.766**

TABLE 34: INTER-CORRELATION MATRIX

	AT1	AT2	AT3	AT4	SI1	SI2	SI3	SI4
PE1	.624**	0.260	0.231	.458*	0.189	-0.027	0.298	.530*
PE2	0.406	0.121	0.286	0.189	0.069	-0.089	0.188	0.339
PE3	0.383	-0.069	0.031	0.249	-0.003	-0.040	0.045	0.397
PE4	.816**	0.185	0.195	0.346	0.345	0.262	0.186	.715**
EE1	0.168	0.077	0.310	0.347	0.318	-0.090	-0.043	0.094
EE2	0.064	-0.214	0.147	.440*	0.205	-0.024	0.329	0.006
EE3	0.162	-0.200	.518*	.522*	0.301	-0.044	0.315	0.113
EE4	0.085	-0.223	.486*	.648**	0.128	-0.065	0.265	-0.158
AT1	**1.000**	0.263	0.301	0.352	0.344	0.252	0.179	.583**
AT2	0.263	**1.000**	0.129	-0.035	0.403	0.128	0.024	0.169
AT3	0.301	0.129	**1.000**	.564**	0.253	0.044	.492*	0.149
AT4	0.352	-0.035	.564**	**1.000**	0.027	-0.031	.467*	0.201
SI1	0.344	0.403	0.253	0.027	**1.000**	0.358	.465*	0.157
SI2	0.252	0.128	0.044	-0.031	0.358	**1.000**	0.168	0.403
SI3	0.179	0.024	.492*	.467*	.465*	0.168	**1.000**	0.278
SI4	.583**	0.169	0.149	0.201	0.157	0.403	0.278	**1.000**
FC1	-0.333	-0.296	0.073	0.264	-0.017	-0.211	0.238	-0.188
FC2	-0.062	-.456*	0.228	.601**	-0.068	0.026	0.334	-0.017
FC3	-0.039	0.092	0.145	0.193	0.010	-0.119	0.179	0.049
FC4	0.380	0.237	0.413	.488*	0.355	0.007	0.416	0.391
SE1	0.052	-0.085	0.409	0.399	.423*	-0.216	0.279	-0.371
SE2	-0.281	-0.252	0.126	0.415	-0.177	-0.158	0.293	-0.205
SE3	-0.159	-0.093	0.243	0.133	-0.108	0.194	0.194	-0.220
SE4	0.032	-0.083	0.305	.585**	0.013	-0.007	0.417	-0.041
AX1	-0.374	0.314	0.072	-0.249	-0.035	-0.228	0.160	-0.337
AX2	0.043	0.138	0.008	-0.197	0.035	0.026	0.029	-0.177
AX3	0.189	0.113	-0.143	-.471*	0.192	0.413	0.159	0.235
AX4	-.444*	0.128	-0.398	-.526*	0.042	0.110	0.089	-0.235
BI1	.476*	-0.003	0.185	.557**	0.106	-0.044	0.306	.428*
BI2	.628**	0.213	0.243	.603**	0.156	0.163	0.289	.678**
BI3	0.378	0.290	0.244	.705**	0.080	0.059	0.131	0.324
VU1	-0.245	0.067	0.091	0.112	0.086	-0.052	-0.038	0.021
EX1	0.018	0.148	0.298	0.261	0.007	.542**	0.225	0.226
EX2	0.038	-0.148	0.014	0.073	0.164	0.253	-0.012	0.236
EX3	0.285	0.137	0.018	.478*	0.053	0.040	0.018	0.002
EX4	0.206	-0.204	.576**	.640**	0.118	-0.018	.443*	-0.127

TABLE 35: INTER-CORRELATION MATRIX CONTINUED.

	FC1	FC2	FC3	FC4	SE1	SE2	SE3	SE4
PE1	0.010	0.010	0.119	.465*	0.091	0.191	-0.149	0.219
PE2	-0.183	-0.318	-0.131	0.214	0.092	-0.062	-0.055	0.242
PE3	-0.363	0.074	-0.067	0.214	0.036	0.129	-0.090	.432*
PE4	-0.247	0.229	0.150	.505*	0.028	-0.203	-0.092	0.087
EE1	0.393	0.051	0.068	0.413	.476*	-0.097	-0.274	-0.069
EE2	.432*	0.230	0.211	0.365	.494*	0.415	0.165	0.410
EE3	.429*	0.363	0.393	0.371	.663**	0.291	0.232	0.206
EE4	0.287	.587**	0.130	0.321	.754**	0.223	0.367	.455*
AT1	-0.333	-0.062	-0.039	0.380	0.052	-0.281	-0.159	0.032
AT2	-0.296	-.456*	0.092	0.237	-0.085	-0.252	-0.093	-0.083
AT3	0.073	0.228	0.145	0.413	0.409	0.126	0.243	0.305
AT4	0.264	.601**	0.193	.488*	0.399	0.415	0.133	.585**
SI1	-0.017	-0.068	0.010	0.355	.423*	-0.177	-0.108	0.013
SI2	-0.211	0.026	-0.119	0.007	-0.216	-0.158	0.194	-0.007
SI3	0.238	0.334	0.179	0.416	0.279	0.293	0.194	0.417
SI4	-0.188	-0.017	0.049	0.391	-0.371	-0.205	-0.220	-0.041
FC1	**1.000**	0.416	0.187	0.025	0.402	0.326	-0.017	-0.047
FC2	0.416	**1.000**	0.254	0.291	0.368	.519*	0.232	.505*
FC3	0.187	0.254	**1.000**	0.267	0.167	0.395	.585**	0.154
FC4	0.025	0.291	0.267	**1.000**	0.240	0.013	0.024	0.387
SE1	0.402	0.368	0.167	0.240	**1.000**	0.308	0.123	0.389
SE2	0.326	.519*	0.395	0.013	0.308	**1.000**	0.233	.693**
SE3	-0.017	0.232	.585**	0.024	0.123	0.233	**1.000**	0.224
SE4	-0.047	.505*	0.154	0.387	0.389	.693**	0.224	**1.000**
AX1	-0.170	-0.393	-0.003	0.063	-0.055	0.089	0.141	0.216
AX2	-0.115	-0.153	-0.064	0.091	-0.224	-0.043	-0.077	0.078
AX3	-.640**	-0.395	-0.266	-0.093	-.494*	-.428*	0.099	-0.105
AX4	0.011	-0.141	0.001	-.434*	-0.314	0.195	0.050	-0.178
BI1	0.123	0.357	0.030	0.262	0.064	0.373	-0.225	0.385
BI2	-0.082	0.289	0.239	.546**	0.004	0.077	-0.123	0.347
BI3	0.046	.539**	0.222	.548**	0.182	0.220	-0.004	.449*
VU1	.497*	0.253	0.060	0.278	0.119	0.204	-0.332	-0.121
EX1	0.084	0.088	-0.405	0.077	-0.134	0.023	-0.084	0.169
EX2	-0.051	0.201	-.503*	0.074	0.231	-0.153	-0.336	0.198
EX3	0.195	0.046	0.092	0.228	0.415	0.122	0.140	0.310
EX4	0.375	.575**	-0.071	0.204	.627**	0.139	0.196	0.335

TABLE 36: INTER-CORRELATION MATRIX CONTINUED.

	AX1	AX2	AX3	AX4	BI1	BI2	BI3	VU1
PE1	-0.125	-0.146	-0.183	-0.279	.720**	.624**	0.368	0.126
PE2	0.067	-0.183	0.083	-0.295	0.207	0.264	0.106	-0.401
PE3	-0.144	-0.351	0.008	-0.315	.429*	.566**	0.348	-0.292
PE4	-.547**	-0.225	0.079	-0.394	.496*	.759**	.619**	-0.089
EE1	-0.193	-0.153	-.578**	-.678**	0.166	0.249	0.216	.565**
EE2	-0.087	-0.141	-0.276	-0.225	0.238	0.120	0.151	0.033
EE3	-0.336	-.542**	-.562**	-0.396	0.130	0.317	0.285	0.204
EE4	-0.247	-.442*	-0.403	-.509*	0.120	0.194	0.408	-0.048
AT1	-0.374	0.043	0.189	-.444*	.476*	.628**	0.378	-0.245
AT2	0.314	0.138	0.113	0.128	-0.003	0.213	0.290	0.067
AT3	0.072	0.008	-0.143	-0.398	0.185	0.243	0.244	0.091
AT4	-0.249	-0.197	-.471*	-.526*	.557**	.603**	.705**	0.112
SI1	-0.035	0.035	0.192	0.042	0.106	0.156	0.080	0.086
SI2	-0.228	0.026	0.413	0.110	-0.044	0.163	0.059	-0.052
SI3	0.160	0.029	0.159	0.089	0.306	0.289	0.131	-0.038
SI4	-0.337	-0.177	0.235	-0.235	.428*	.678**	0.324	0.021
FC1	-0.170	-0.115	-.640**	0.011	0.123	-0.082	0.046	.497*
FC2	-0.393	-0.153	-0.395	-0.141	0.357	0.289	.539**	0.253
FC3	-0.003	-0.064	-0.266	0.001	0.030	0.239	0.222	0.060
FC4	0.063	0.091	-0.093	-.434*	0.262	.546**	.548**	0.278
SE1	-0.055	-0.224	-.494*	-0.314	0.064	0.004	0.182	0.119
SE2	0.089	-0.043	-.428*	0.195	0.373	0.077	0.220	0.204
SE3	0.141	-0.077	0.099	0.050	-0.225	-0.123	-0.004	-0.332
SE4	0.216	0.078	-0.105	-0.178	0.385	0.347	.449*	-0.121
AX1	**1.000**	.486*	0.251	0.261	-0.334	-0.292	-0.367	-0.024
AX2	.486*	**1.000**	0.363	0.158	0.042	-0.162	-0.243	-0.009
AX3	0.251	0.363	**1.000**	0.280	-0.172	-0.127	-0.383	-.585**
AX4	0.261	0.158	0.280	**1.000**	-0.224	-.450*	-0.362	-0.010
BI1	-0.334	0.042	-0.172	-0.224	**1.000**	.527*	.453*	0.073
BI2	-0.292	-0.162	-0.127	-.450*	.527*	**1.000**	.708**	0.011
BI3	-0.367	-0.243	-0.383	-0.362	.453*	.708**	**1.000**	0.206
VU1	-0.024	-0.009	-.585**	-0.010	0.073	0.011	0.206	**1.000**
EX1	0.061	0.017	0.004	-0.094	0.082	0.126	0.188	0.303
EX2	-0.267	-.424*	-0.039	-0.262	0.080	0.210	0.152	0.017
EX3	-0.051	-0.256	-0.393	-0.414	0.085	0.363	.438*	-0.060
EX4	-0.261	-0.141	-0.272	-0.397	0.273	0.076	0.290	-0.037

TABLE 37: INTER-CORRELATION MATRIX CONTINUED.

	EX1	EX2	EX3	EX4
PE1	0.103	0.039	0.319	0.093
PE2	0.068	0.176	0.396	0.034
PE3	-0.013	.460*	0.284	-0.083
PE4	-0.016	0.238	0.196	0.132
EE1	0.148	0.211	0.321	0.242
EE2	-0.155	-0.036	.547**	0.246
EE3	-0.100	0.162	0.415	0.370
EE4	0.004	0.358	.442*	.766**
AT1	0.018	0.038	0.285	0.206
AT2	0.148	-0.148	0.137	-0.204
AT3	0.298	0.014	0.018	.576**
AT4	0.261	0.073	.478*	.640**
SI1	0.007	0.164	0.053	0.118
SI2	.542**	0.253	0.040	-0.018
SI3	0.225	-0.012	0.018	.443*
SI4	0.226	0.236	0.002	-0.127
FC1	0.084	-0.051	0.195	0.375
FC2	0.088	0.201	0.046	.575**
FC3	-0.405	-.503*	0.092	-0.071
FC4	0.077	0.074	0.228	0.204
SE1	-0.134	0.231	0.415	.627**
SE2	0.023	-0.153	0.122	0.139
SE3	-0.084	-0.336	0.140	0.196
SE4	0.169	0.198	0.310	0.335
AX1	0.061	-0.267	-0.051	-0.261
AX2	0.017	-.424*	-0.256	-0.141
AX3	0.004	-0.039	-0.393	-0.272
AX4	-0.094	-0.262	-0.414	-0.397
BI1	0.082	0.080	0.085	0.273
BI2	0.126	0.210	0.363	0.076
BI3	0.188	0.152	.438*	0.290
VU1	0.303	0.017	-0.060	-0.037
EX1	**1.000**	0.346	0.074	0.272
EX2	0.346	**1.000**	0.064	0.252
EX3	0.074	0.064	**1.000**	0.184
EX4	0.272	0.252	0.184	**1.000**

TABLE 38: INTER-CORRELATION MATRIX CONTINUED.

E. LIBRARIES AND SOFTWARE USED IN SOLUTION

Name	Website	Open-Source License
AngularJS	http://www.angularjs.org/	MIT
Angular-motion	http://mgcrea.github.io/angular-motion/	MIT
Angular-Strap	https://github.com/mgcrea/angular-strap	MIT
Apache HTTP Server	http://httpd.apache.org/	Apache 2.0
Boostrap	http://getbootstrap.com/	MIT
Bootstrap-Calendar	https://github.com/Serhioromano/bootstrap-calendar	MIT
Class.Images.php	https://github.com/sprain/class.Images.php	Custom[12]
jQuery	http://jquery.com/	MIT
LessCSS	http://lesscss.org/	Apache 2.0
Markdown-js	https://github.com/evilstreak/markdown-js	MIT
Moment.js	https://github.com/moment/moment	MIT
MySQL	http://www.mysql.net/	-
PHP	http://www.php.net/	-
PHPMailer	https://github.com/PHPMailer/PHPMailer/	GNU Lesser GPL 2.1
PHP-MySQLi-Database-Class	https://github.com/avbdr/PHP-MySQLi-Database-Class/	GNU GPL
Restangular	https://github.com/mgonto/restangular	MIT
SpinKit	https://github.com/tobiasahlin/SpinKit	MIT
Underscore.js	https://github.com/jashkenas/underscore	Custom[13]

TABLE 39: OVERVIEW OF THE USE OF EXISTING LIBRARIES AND COMPONENTS IN THE API AND CMS.

F. SIGNIFICANCE OF THE CONSTRUCTS

	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
AT	19.633	21	0	18.727	16.74	20.71
PE	25.845	21	0	22.409	20.61	24.21
EE	45.438	21	0	24.591	23.47	25.72
SI	26.12	21	0	19.5	17.95	21.05
FC	31.55	21	0	21.545	20.13	22.97
SE	22.506	21	0	21.909	19.88	23.93
AX	11.467	21	0	11.182	9.15	13.21
BI	16.965	21	0	14.5	12.72	16.28
EX	23.078	21	0	20.409	18.57	22.25

TABLE 40: 95% CONFIDENCE INTERVAL OF THE MEASURED CONSTRUCTS.

[12] https://github.com/sprain/class.Images.php#license
[13] https://github.com/jashkenas/underscore/blob/master/LICENSE

G. ANSWERS TO OPEN QUESTIONS

What would, in your opinion, be the greatest barrier when it comes to adopting a new IT system?	What do you like about the system?
Acceptance by people. The 3m post it is very old and a lot of programs try to replace it, but yet it's still used a lot.	The completeness of the solution. There's no need to go around the system so you get less distracted.
To indicate the benefits of using the system to users.	The virtual environment and meeting space look very much like a physical environment, which makes virtual meetings more enjoyable and attractive.
User friendly (or lack off)	The ability to add everything you may need.
Resistance to change from the stakeholders, lack of clarity as to purpose or role of the system within the normal workflow, lack of usability of the software	The high level of immersion, the ability to manipulate a shared 3d space, the ability to transfer objects into the system.
Convincing people that even they it may not make things go more effectively/efficiently from the very start, it can still become quite beneficial	Making long-distance meetings seem more personal. It is fun. It has the potential to show a lot of different things to a lot of different people simultaneously.
- Ease of use - Added value in comparison with other 'traditional' meeting tools	Fun, already quite easy to use
De wil om te veranderen bij medewerkers. Mensen moeten openstaan voor verandering.	Het is leuk om te doen. Veel mogelijkheden.
Dat alle werknemers een cursus moeten volgen, hoe te gebruiken.	Het rondlopen in de wereld.
It's new. Hard instructions. Has to be very easy to use.	The fact that it gives you more the idea of an actual meeting, rather than having to sit before a camera.
Changing things don't make people very happy. They get used to their old software and I think this is the biggest barrier when moving to new IT systems.	The whole concept: Joining a meeting online with al new technologies available and all in the virtual world.
Convincing people to invest time in learning to use the new system. People are quite stubborn and do not like changes.	The high amount of interactivity and it is just more fun to do compared to teleconferencing
The future users will be a problem. Not everyone is ready to shift to new it systems. Especially older users will fear changes. Secondly, it departments of huge companies are slow. It will take time to convince them to provide the right it environment.	It is open and low profile. When people start using it after hesitating, they will live it in the end.
De tijd. Mensen en technologie zijn er nog niet klaar voor.	Je kan je in een omgeving bevinden die er (nog) niet is.
Change. It is necessary to manage the change of behaviour of people. The final result should be that people are going to work with the system instead of using it during a one-time demonstration/gadget.	
security	to easy communicate with ppl on distance
That people are not really likely to change the system they already use.	The fact that it also has a lot of build-in features to make things in the program.

The learning curve to people with lesser computer skills.	- Many features, including preparing a meeting, adding documents and presentaties. - Highly customizable environment.
	Being able to walk around makes virtual meetings more interesting.

What do you dislike about the system?	Do you have any recommendations for improvement?
Although in general the system can suffice in everything during a meeting, it sometimes is easier to go around the system. It will be more helpful if you use it a lot.	Connect it with existing solutions (dropbox, datumprikker) look at meetings in general and what is needed at this meetings to support them.
A start up effort is required to learn the system and its features.	- Making it easier to upload and share documents - Enabling collaboration tools (like whiteboard or document editing)
glitching graphics	
The controls, the lack of a cohesive experience (it's possible, and much easier, within the virtual space, to do things unrelated to the meeting), the need to have two applications open simultaneously (one of which is full screen)	Make the virtual interface more tailored to the task, eliminate distracting control options, make the connections between actions within the CMS and the virtual space more obvious (by for example visual correspondence of elements).
I think there is a reasonable chance that these meetings will on average take more time than meetings through less elaborate systems (especially with participants that are less "IT-savvy".	A whiteboard to create some notes/pointers during the meeting.
Sometimes hard to switch between different modes	- Drag drop items into view? Something like 'screen share'
In het begin wat lastig uit te vogelen hoe het precies werkt. Wanneer mensen een training vooraf krijgen moet het allemaal wel te doen zijn.	Het systeem werkt prima, heb alleen wat twijfels over het virtueel vergaderen. Mijn mening; de vraag is wat levert het virtueel vergaderen op. Ik denk dat het voor bedrijven belangrijk is dat er kosten/tijd bespaard kan worden. Er bestaat software waar je vrijwel dezelfde functies hebt maar dan zonder de virtuele wereld. Bestanden delen, gezamenlijk websites bezoeken/presentaties bekijken, dat kan allemaal. Wat is de toegevoegde waarde van een virtuele wereld? Het is leuk om te doen, maar is het ook een efficiëntere/effectievere manier om te vergaderen? Mensen die een druk schema hebben, hebben denk ik geen tijd om virtueel te vergaderen. Het is misschien wel interessant voor internationale project teams. Zo krijgen ze de mogelijkheid om op een wat informelere manier elkaar te leren kennen en vergaderen.
De camera besturing is lastig.	De camera besturing makkelijker maken.
It was a bit hard to figure out. And you can mess around way too much. There shouldn't be an option to sit on the sealing etc.	Users should not all have the options to change things or mess around (too much). Sometimes it’s also too easy to click the wrong button by accident.

I think it's too difficult to install\configurate the system before you can join a meeting. I think it's really a success if this is easier for people	it would be perfect when you can join a meeting without installing any software
Getting started is quite difficult. It takes a lot of time to perform the initial steps.	Make it even easier to get started. Automatic avatar creation when creating a user account?
You need an up to computer system to fully make advantage of all possibilities. Also companies' computer network speeds can be a problem.	Try to work on an attracting environment. There are almost endless possibilities, but not all are used. Serious gaming and the possibility to upload 3d objects would be an important addition for a technician company like Thales
	Wachtwoorden synchronisatie kan beter.
that I cannot run it on the Thales Intranet	
-	-
- The controls are not always very intuitive.	-
	Maybe an easier way to access the sheets, moving the camera with ALT+click takes a while. Maybe a button like the one to view browser screens.

H. BOXPLOTS OF MAIN CONSTRUCTS OF UTAUT BASED ON USER´S BACKGROUND

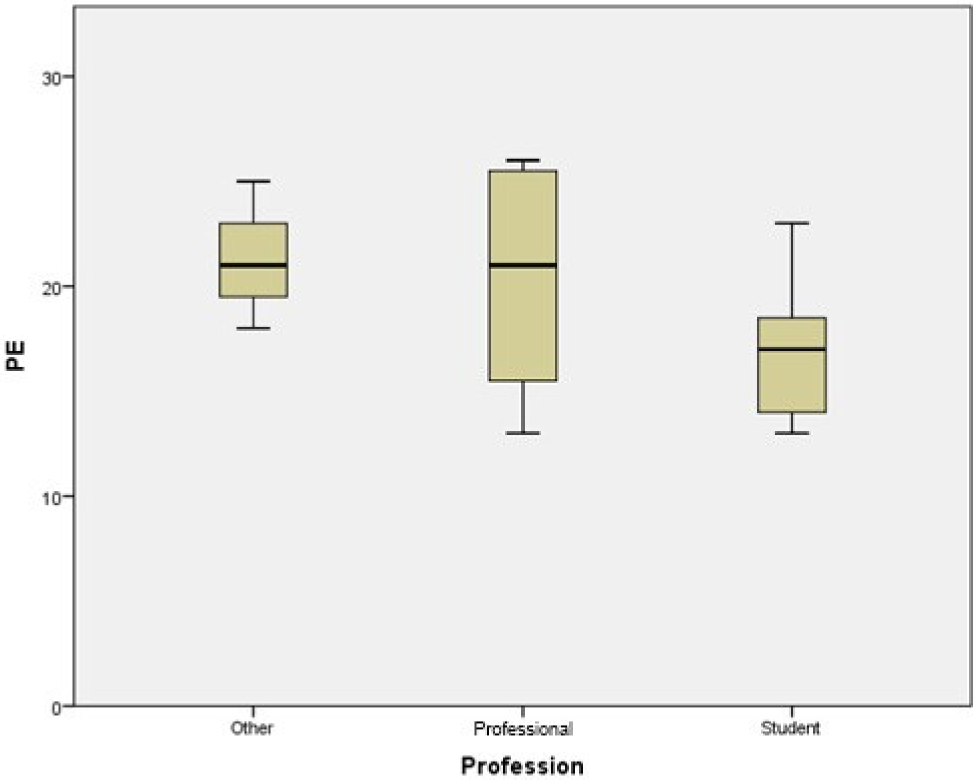

FIGURE 12: BOXPLOT SHOWING THE AVERAGE SCORE FOR EACH USER GROUP, THE 95% CONFIDENCE INTERVAL AND THE RANGE FOR PERFORMANCE EXPECTANCY.

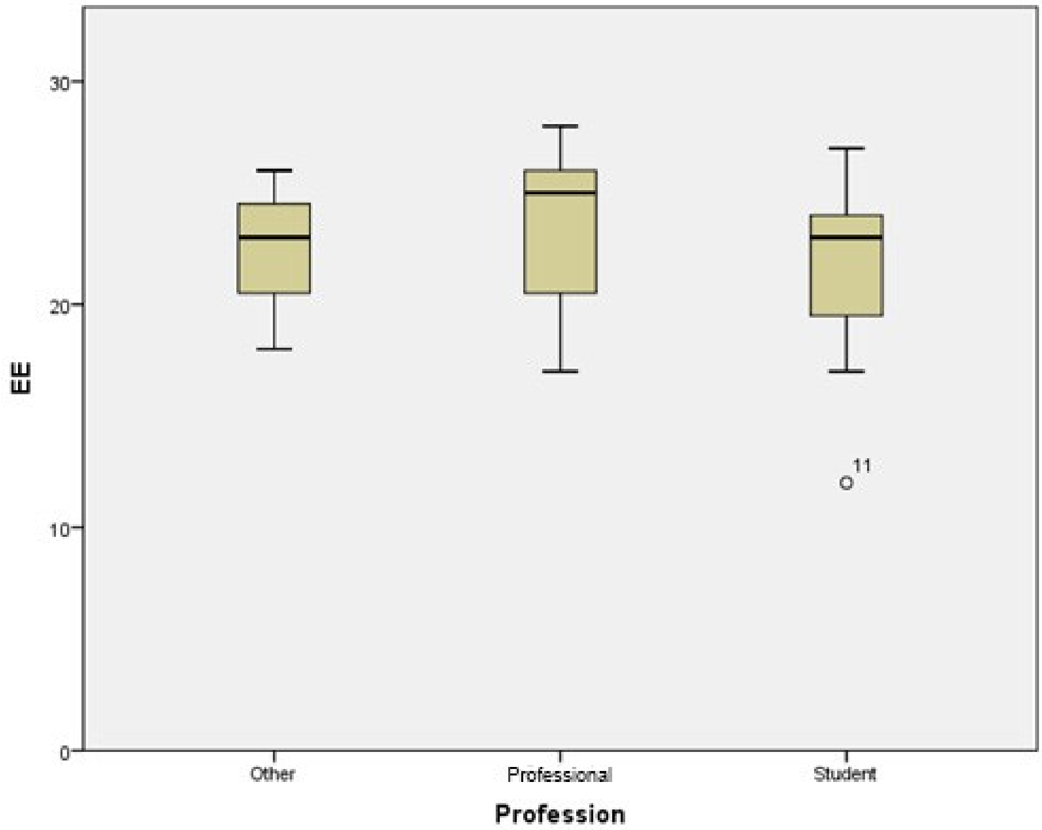

FIGURE 13: BOXPLOT SHOWING THE AVERAGE SCORE FOR EACH USER GROUP, THE 95% CONFIDENCE INTERVAL AND THE RANGE FOR EFFORT EXPECTANCY.

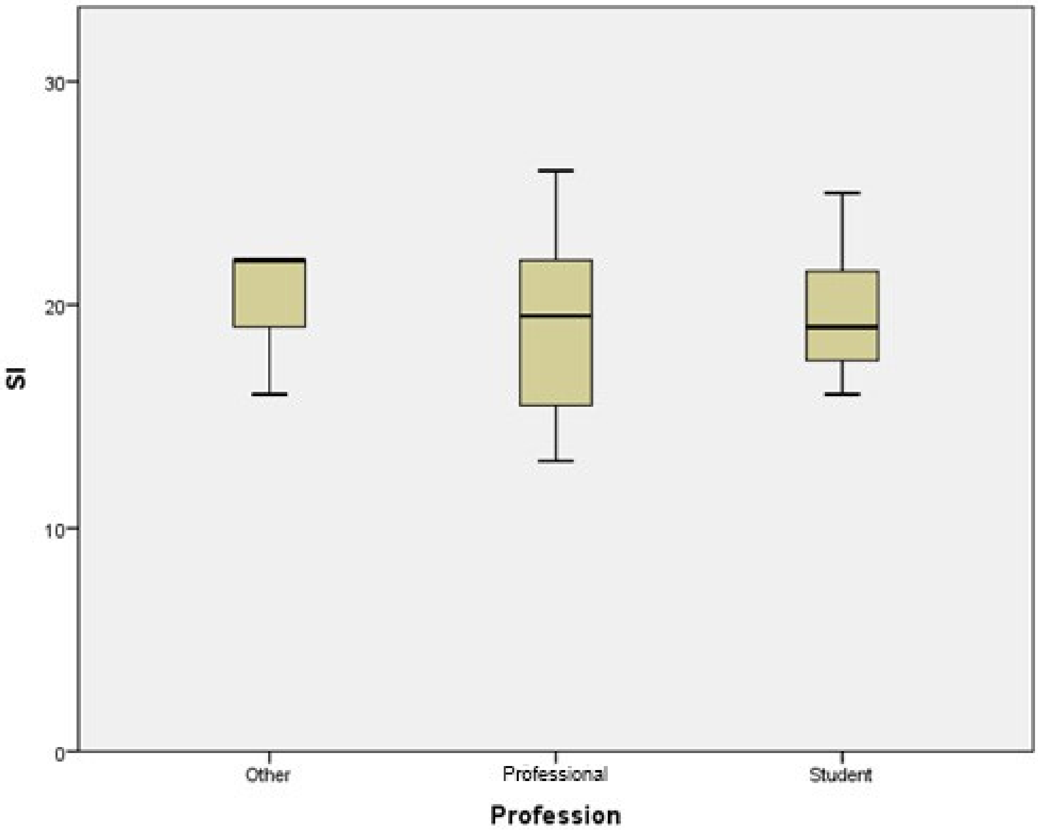

Figure 14: Boxplot showing the average score for each user group, the 95% confidence interval and the range for Social Influence

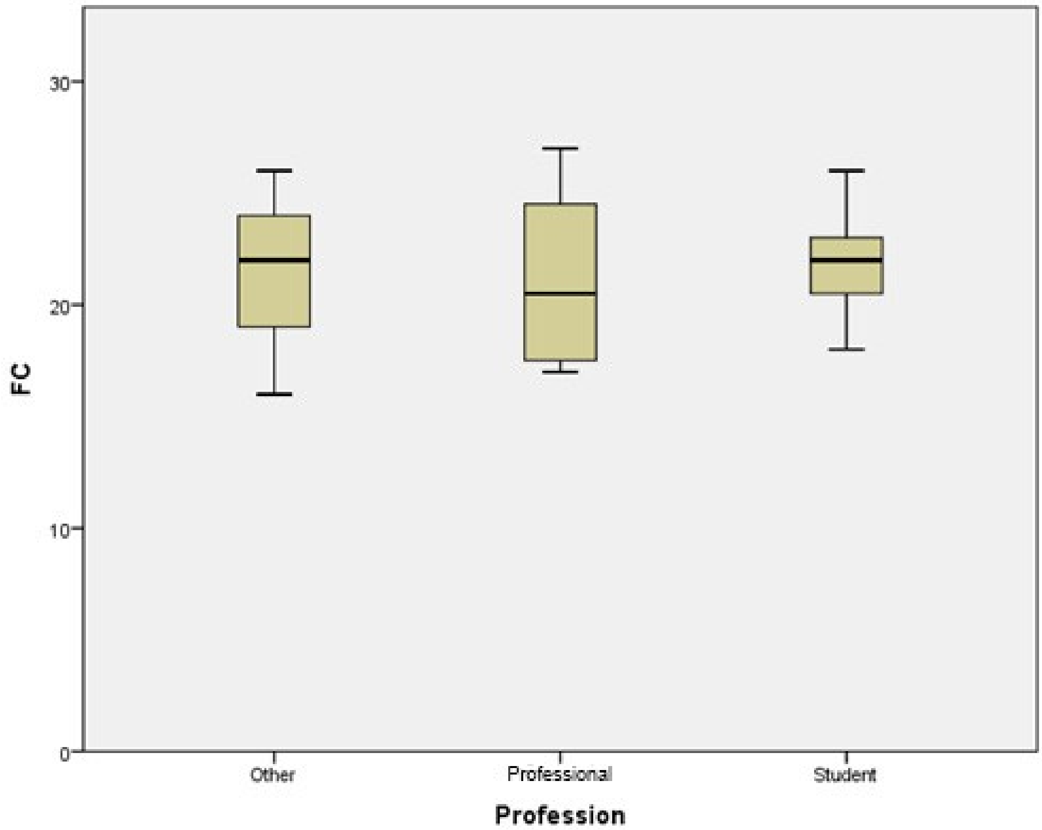

FIGURE 15: BOXPLOT SHOWING THE AVERAGE SCORE FOR EACH USER GROUP, THE 95% CONFIDENCE INTERVAL AND THE RANGE FOR FACILITATING CONDITIONS.

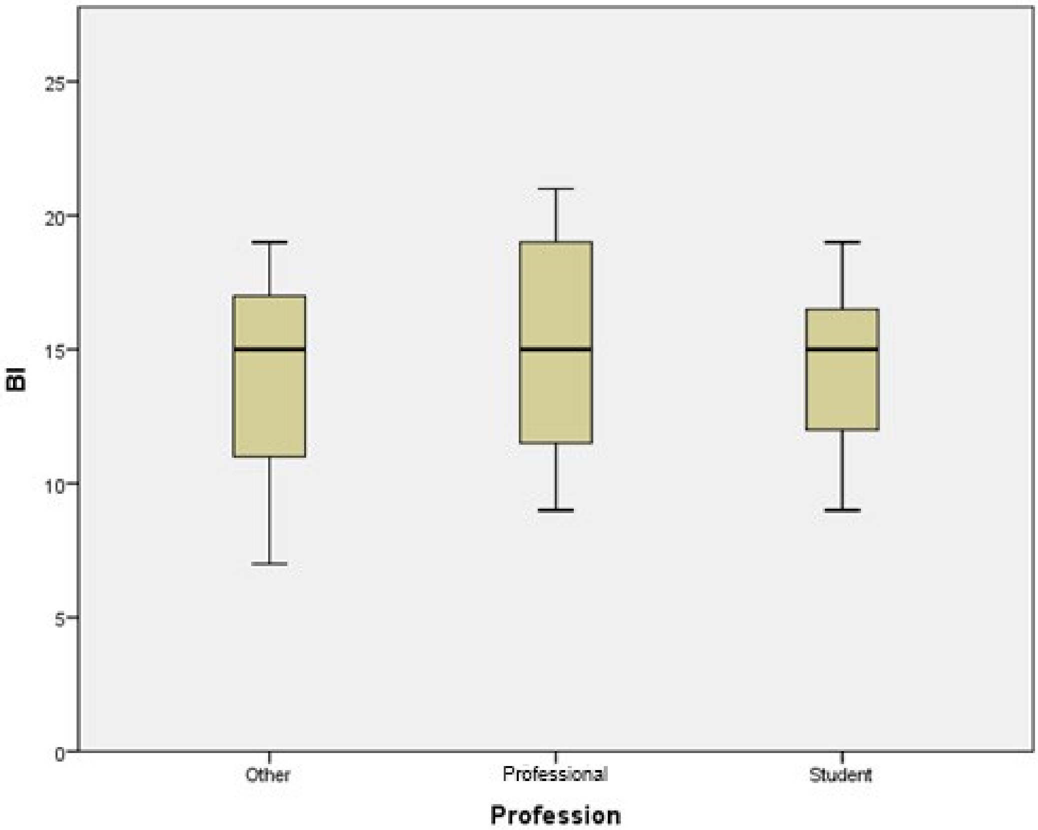

FIGURE 16: BOXPLOT SHOWING THE AVERAGE SCORE FOR EACH USER GROUP, THE 95% CONFIDENCE INTERVAL AND THE RANGE FOR BEHAVIOURAL INTENTION.