TAMPERE UNIVERSITY OF TECHNOLOGY

MASTER'S THESIS

AUTOMATED AUDIBLE COUNTDOWN SYSTEM

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Examiners: Professor Hannu Jaakkola,
Tenure track Professor Sami Hyrynsalmi
Examiner and topic approved by the
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ABSTRACT

TAMPERE UNIVERSITY OF TECHNOLOGY
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When launching scientific sounding rockets into the atmosphere or space, a computer system is used to help monitor and keep track of the launch progress. A manual system is being used for the audio voice where one of the staff speaks out through the loudspeakers the countdown when there is a launch. This thesis focuses finding an automated digital voice through the computer that can be used at the same during a launch.

The significance of this thesis is to create a new application or a computerized system for the sound and voice during launching of scientific rockets. The importance is to increase the quality and accuracy for the timing of the sound. As material for the research part and test version of the new system a home computer was used. A new digital audio voice was tested together with a manual countdown timer. Once the testing was a success the implementation phase could start. The connection to the internal network was tested and the also a test version of the audio voice was tested in the environment where it will be used. The sound was working and the phase was to add and install the user interface and the rest of the applications that were needed.

This thesis is divided into four parts. The first part explains what Esrange is and what work they are doing there. The second part discusses in general what digitalization is and what it means for a company. The third part goes into examining some different research approaches that exists for planning, designing and implementing a new computer software. The fourth part goes into explaining the new digital audio voice and how the voice system is connected with the internal network. Discussion of the results and conclusions are also included at the end of this thesis.

TIIVISTELMÄ

TAMPEREEN TEKNILLINEN YLIOPISTO
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Laukaistessa tieteelliset luotausraketit ilmakehään tai avaruuteen tietokonejärjestelmää käytetään avustamaan ja valvomaan laukaisun etenemistä. Manuaalijärjestelmässä lähtölaskentaa suorittaa kovaäänisten välityksellä tutkimuskeskuksen henkilökuntaan kuuluva henkilö. Tämän tutkielman tavoitteena on kehittää automaattinen, tietokonepohjainen järjestelmä, joka tuottaa lähtölaskennassa tarvgittavan äänisignaalin.

Tämän tutkielmassa kuvataan lähtölaskentaa suorittava sovellutus, joka on toteutettu kohdeorganisaatiossa. Keskeisenä vaatimuksena oli parantaa laskennassa tarvittavan äänituotoksen laatua ja tarkkuutta. Kehitetyn sovelluksen alustana käytettiin tavanomaista henkilökohtaista tietokonetta. Uutta digitaalista laskentaääntä kokeiltiin yhdessä manuaalisen lähtölaskennan ja reaaliaikakellon kanssa. Onnistuneen testauksen jälkeen siirryttiin toteutusvaiheeseen. Tässä yhteydessä kokeiltiin järjestelmän liitäntää paikallisverkkoon sekä sen toimivuutta todellisessa käyttöympäristössä. Järjestelmä osoittautui toimivaksi ja siihen lisättiin lopullinen käyttöliittymä sekä öiitännät muihin tarpeellisiin järjestelmiin.

Tämä tutkielma jakautuu neljään osaan. Alussa kuvataan Esrange Space Centerin toimintaa. Tämän jälkeen tarkastellaan digitalisointia sekä yleisellä tasolla että sen tarjoamia mahdollisuuksia kohdeorganisaatiolle. Tämän jälkeen tarkastellaan tutkimusmenetelmiä; tavoitteena on arvioida niiden sopivuutta suunnittelutyölle ja ohjelmiston kehittämiselle. Tältä pohjalta on valittu työssä käytetty tutkimusote. Työn loppuosa käsittelee tutkimusongelman ratkaisua kuvaten toteutetun järjestelmän yleisperiaatteita ja toteutusta. Tutkielman lopussa tarkastellaan työn tuloksia ja niiden merkittävyyttä.

PREFACE

This thesis began at Esrange where during six months the research and implementation part was made. This thesis was written after the research and implementation part and it took a longer time. At Esrange the staff members were giving information if I needed and were interested in my progress. Significant support from of Mr. Marko Kohberg and Mr. Stig Mämmi were given for the implementation and research part. For writing this thesis, endless support and ideas for the structure and content of this thesis were given by Professor Hannu Jaakkola and Professor Sami Hyrynsalmi.

NADIA TAMMI, 2017-11-01

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LIST OF SYMBOLS AND ABBREVIATIONS

RT1	Launch platform 1
RT2	Launch platform 2
OP	Operations
SA	Safety
SC	Scientific
TM	Telemetry
RA	Radar
FCO	Flight Control
LA	Launching
US1	User channel
UTC	Universal Time coordinated
RT	Relative time
C/H	Count/Hold
PTT	Push to talk
PA	Public address
ET	Elapsed time
POSNET	Position Data Network

1. INTRODUCTION

When launching scientific sounding rockets into the atmosphere or space, a computer system is used to help monitor and keep track of the launch progress. In order to use an audio voice together with the countdown system, the importance weighs heavily on that that the audio voice together with the countdown system, is used in real-time. For the company that uses a launch platform to send scientific sounding rockets for customers, a change from a manual audio voice to a digitized automatic audio voice, will better provide a real-time system that enhances quality, safety and also saves staff work-time.

This thesis examine how to provide a synthetic voice that can automatically be used instead of a staff member, usually working by the microphone when the countdown begins, speaking out the countdown. The first relevant question that needs to be answered is what sort of a synthetic audio voice could be used? Should the new digital voice be a recorded human voice or a computerized digital voice? The Scientific sounding rockets carries different sorts of payloads and are being sent up to the atmosphere or space in different altitudes. This means that the launch progress is being followed both before and after the launch. There might be payloads that are released at a different point or altitude after the launch, or that some equipment in the payload needs to be started before the launch. For the launch progress it would be better and easier with an automatic or digitized audio voice marking out through a sound the different stages of the launch from the launch platform and in the atmosphere. The second question that arises from this is “How to customize the audio voice according to the company needs”?

Two main questions to be answered in this thesis:

1) “What sort of synthetic audio voice could be used, recorded human voice or a computerized digital voice”?
2) “How to customize the audio voice according to the company client’s needs”?

When starting to make a background research on the topic of this thesis, a travel was needed, to the place where the company has its launch platform and to meet the staff who are working with the countdown system. The main objective for the background research is to interview some of the staff members and to collect information. This was the starting point in getting to know more about what the solution should look like according to what the company would prefer. I also needed to know more about the existing timing system used by the control room so that an audio voice could somehow be connected and work together with it. Another important starting point for the thesis was to see the place where staff member would manually be speaking out the countdown through the microphone. This would eventually then be replaced by an automatic digitized audio version.

Some of the background research and questions needed to be answered for thesis are following. What equipment and tools are in use at the launch platform? What programs are in use and how to synchronize the digital audio voice with the existing system, network and server? Does the company have any specifications/regulations that should be implemented in the audio voice?

With the two main questions there are also a few sub questions that are following:

- What software or hardware should be used in the final solution?
- What sort of programming language could be used in the solution?
- Should the code/algorithm include a link to the timing server in the operations center?
- Where the new hardware/software should be installed or used?
- What other systems/parts does the audio voice need, is the countdown recorded for technical documentation?
- Should additional audio sounds be included besides the audio voice?
- What sort of framework or design should there be for the interaction panel between the audio voice and the user?

This thesis will begin by a summary about Esrange Space Center and the work they do there. One section will focus on the launching of scientific rockets into space from Esrange. Another sub chapter will focus on the work they do with research balloons in high altitude. The next section will bring up the mark and satellite station services which is also provided at Esrange. The last section will briefly describe the European Space Agency's REXUS/BEXUS programme for university students doing rocket and balloon experiments at Esrange.

The topic of this thesis is about digitizing an audio voice. Hence the next chapter will summarize the definition of digitization. The first section will discuss the definition of digitization. The following section will take a look at what are the effects of digitization for a company. These two questions, “What is digitization”, and “what are the effects of digitization”, will bring up the theoretical background to the question why a new audio voice for the countdown is needed.

The next chapter will go through some of the main scientific research methods. The first section will describe two research process methods, namely Jenkins model and Wallace’s model. The next sections will go through the different research methods that are Conceptual-analytical, theory testing, qualitative-interpretive and new theories creating research, design science research and the last one mathematical research. The design science research method is the one that could describe and resembles my own thesis research work.

After describing what digitization is and what research method has been used, a new chapter follows where this thesis will go deeper in answering the two main questions. This is the main chapter for this thesis and it is also where the solution for the new audio voice will be described in more detail. First the requirements for the new audio voice will be explained. This is where any standard regulation or specification must be added and described. The next section will go through in more detail the technical environment for the new audio voice, since it will part of a larger system. The next step is to describe the different stages of the background research and how eventually the new digital audio voice, together with a user interface, kept building up. The next section will describe in more detail the solution of the application in its completed form. The user interface is described separately in a section with its primary functions for the user. The final section goes through what testing was done for the new solution and how it was installed in new hardware.

The final chapter will discuss the results of finding a new digital audio voice. What other possibilities were there for a new digital audio voice? Was the new application used later on or just some parts of it, if used? Conclusions can be drawn from these questions.

When looking into previous research that has been done related to the topic of this thesis, it is easy to draw a comparison with other similar technology existing already. Today in our everyday lives we are used to having digital audio voices in our answering machines, busses that have digital voices that tells us the name of the bus stop and a digital clock time tellers, just to name a few.

The digitization of the audio voice for countdown used in thesis, is using existing technology with an adaption of the company needs. The solution is part of a larger countdown system used in the operations center. The purpose for the new solution is that the timing system inside the operations center will be controlling the digital audio voice.

2. ESRANGE SPACE CENTER

This chapter will focus on the target environment and its target organization namely Esrange Space center and the Swedish Space Corporation SSC. The first section will describe in general about the target organization SSC, The second section will describe what sort of scientific rockets are being launched at Esrange. The third section will describe about the research balloons also being launched at Esrange. The fourth section will describe that there are also satellite and mark station services being given at Esrange. The last and final section will describe the European Space Organization's program for research students called REXUS/BEXUS.

2.1 THE TARGET ORGANIZATION

This section will describe in general about Esrange Space Center and what sort of activities are conducted there. Through the website of the company SSC, Swedish Space Corporation, (ELib portal, SSC), a good general description is given. The company SSC has been operating at Esrange Space Center for a long time, about 50 years, and they have offices also in other parts of Sweden and some facilities in other parts of the world. They provide "space services" for customers around the world on global basis. Since the startup of the company back in the early years in 1970's, they conduct "rocket launches" at Esrange. Some of the main activities of the company includes providing "space engineering services, satellite services and launch services" for different customers, both "commercial and institutional", around the world (eLib portal, SSC, About).

Through the company website (eLib portal, SSC, About), a description is given to how the global space market is a "fast growing industry and has exciting changes". Through these changes on the global space market, the company SSC has been a part of the growing industry and "developed new capabilities" at the same time (eLib portal, SSC, About). The space industry makes it of essence to keep a close cooperation with its customers. SSC can "deliver and tailor" space services to customers (eLib portal, SSC, About).

In the company website there is also a description of the three main business activities that are also at Esrange (eLib portal, SSC, About):

- "Rocket and balloon launch services" at Esrange Space Center and to "develop experimental payloads" (eLib portal, SSC, About). There is an ongoing "upgrade of the Space Center", including planned "new launch capabilities" for small satellites that will expand the activities at Esrange and "deliver new services" for the future (eLib portal, SSC, About).
- "Operating" one of the "world's civilian network" of "ground stations" and "providing access to satellites" in orbit (eLib portal, SSC, About). With the ongoing upgrade of the Space station also the satellite services will have new equipment and facilities.

- “Providing space engineering services” to customer’s projects by bringing consulting expertise to all phases of the individual space program or project (eLib portal, SSC, About).

Through the company website it is also explained that SSC “designs” their own “sounding rocket vehicles” and provides to them “launching facilities” (eLib portal, SSC, About). SSC has designed more than “sixty sounding rocket vehicles” since the start of their early 1970’s and has “provided space services” to “scientists and space organizations worldwide” since the beginning (eLib portal, SSC, Science Services).

According to the company website (eLib portal, SSC, Science Services), some of the activities that are ongoing at Esrange includes “analyzing a trajectory”, “calculating the load” on a vehicle and assuring the overall “stability” of it. Some of the structural parts of the “rocket vehicles” are being “designed” by SSC like for example the “nose cone” and “interstage adapters”. For “science experiments” some service modules are prepared that include “telemetry”, “tele command” and “support devices”. For “high altitude balloons” a “high speed data link” is used, that is designed for transferring data over long distances. A “new system” is being used that measures the “wind velocity” before a “rocket launch”. The activities with balloon launches integrated together with balloon systems started much later compared with rocket launches, but the high altitude balloon launch activities are expanding. (eLib portal, SSC, Science Services)

The company website describes describes (eLib portal, SSC, Esrange Space Center) that Esrange is located in latitude 68°N and longitude 21°E above the Arctic circle in northern part of Sweden. The location is based on that it is a scarcely populated area and can be therefore used as an impact area or recovery area for the rocket/balloon launches. The launch facilities at Esrange were used already back in 1966 when it was mainly used by the “scientific community”. The purpose was to do microgravity and atmospheric research with the help of launching sounding rockets. Although the balloon launches started at Esrange once SSC was operating there, the purpose of the balloon launches have been to do astronomy research, atmospheric research and drop tests of space/aerial vehicles. (eLib portal, SSC, Esrange Space Center)

At Esrange, according to the company website (eLib portal, SSC, Esrange Space Center), there is of a satellite ground station in operation. This satellite ground station is part of the internal satellite network at SSC, called the SSC Universal Space Network. Besides the satellite ground station at Esrange, the other main activities and objectives are following (eLib portal, SSC, Esrange Space Center):

- Operating and giving support for the sounding rocket programmes and high altitude balloon programmes belonging to the member states of ESA/EASP. Same service is given at the Esrange facilities to non-member states on second priority basis.
- Operation and management of ground based scientific instrumentation

There is, as mentioned earlier, plans for upgrading and modernizing Esrange according to the company website (eLib portal: SSC, Modernization of Esrange). Inside these plans there are steps for new laboratories with new equipment, upgrading of payload premises and a new type of rocket launchers for launching satellites into the atmosphere. Also mentioned are plans for an upgrade in the technology for research platforms for the benefit of researchers. This means also better communication systems and guidance systems for rocket/balloon launches. (eLib portal, SSC, Modernization of Esrange)

As mentioned earlier, according to the company website (eLib portal, SSC, Modernization of Esrange), the upgrading and modernizing of Esrange will make some large changes. These changes, with the help of new equipment, will bring better measurements coming from the ground based instruments, the sounding rockets, high altitude balloons and satellites. These changes along with new equipment will improve the landing of drop-tests or balloon borne technical tests to return safely to the impact area at Esrange. The plans to increase the number of launch platforms will make launching of rockets simultaneously possible for the purpose of conducting coordinated scientific measurements. (eLib portal, SSC, Modernization of Esrange)

The history of Esrange started back in March 1964, according to the company website (eLib portal, SSC Esrange history), when ESRO (the European Space Research Organisation), was founded. The organisation consisted at that time of ten countries, Belgium, Denmark, France, the Netherlands, Italy, Switzerland, Spain, the United Kingdom, Sweden and Germany. The purpose for the scientific organisation was to coordinate a scientific programme between the member countries for space research. Another aim was to combine the scientific research with technological development and also to support European space industry. ESRO funded and built Esrange space center when it was inaugurated in 1966. Already then there was activities with rocket launch projects, these were launched between November 1966 and June 1972. (eLib portal, SSC, Esrange history)

Esrange switched ownership in July 1972, according to the company website (eLib portal, SSC Esrange history). Since then it has been operated and managed by SSC. The Esrange Andøya Special Project (EASP), gives funds and coordinates the sounding rocket and high altitude balloon activities. Besides Sweden, the other member states of EASP are France, Germany, Switzerland and Norway. (eLib portal, SSC, Esrange history)

SCC completed in 1974, according to the company webpage (eLib portal, SSC, Esrange history), a launching facility for high altitude balloon missions at Esrange Space Center. The facility has continuously been upgraded and it has been used since then for launching high altitude balloons that have size of 1,000,000 m^3 and carry payloads that can weigh several tons. The impact point for landing and recovering the high altitude balloons is chosen about 75 km north of the launching pad. The actual impact area for a balloon launch can cover the northern parts of Sweden, Norway, Finland Russia, Canada and Alaska. (eLib portal, SSC, Esrange history)

With the increasing need for small satellite launch opportunities, according to the company website (eLib portal, SSC, SmallSat Express), SSC has initiated the SmallSat Express at Esrange Space Center. It is an initiative for the capability of launching small satellites into space from Esrange. The geographical locational is advantageous for satellite launching platform. The purpose and aim is to make Esrange a center for a multitude of space services. The customer range includes the scientific community as well as commercial customers. (eLib portal, SSC, SmallSat Express)

2.2 SCIENTIFIC ROCKETS

This section will describe in general what sort of scientific sounding rockets are being launched at Esrange. SSC, according the company website (eLib portal, SSC, Rocket missions), has activities for launching suborbital sounding rockets where a single rocket is launched, microgravity research rocket launches, educational rocket launches, scientific sounding rocket launches and technology test rocket launches. There are opportunities for frequent use of the launch platforms for both industrial and educational communities. (eLib portal, SSC, Rocket missions)

For the rocket vehicles, according to company website (eLib portal, SSC, Rocket missions), the altitude can be reached of about 70 - 800 km. After launching, the payload that has landed on ground, is later on retrieved and recovered 0.5 -1 hour after the actual launch. These rocket vehicles are launched as part of the Swedish national space program. They can also be launched as part of the ESA microgravity research program. Esrange Space Center is benefiting from that the impact lan area is about 5,200 square kilometers which is scarcely populated. There are also external organizations using the launching facilities at Esrange. (eLib portal, SSC, Rocket missions)

In addition, according to company webpage (eLib portal, SSC, Rocket missions), there are also activities for designing and launching customized sounding rocket missions. These are done on demand and according to requirements. Since the start of Esrange back in 1966 there have been about 550 sounding rockets launched from the launching platforms on site. (eLib portal, SSC, Rockets)

The previous mentioned rocket vehicles, according to the webpage (eLib portal, SSC, Rockets), can carry different sort of payloads for different purposes. These missions or experiments can be for astrophysics or astronomy and atmospheric studies. These rocket flights, can in terms of financial comparison, often save expensive missions on board a shuttle flight or the International Space Station. For the rocket launches at Esrange, the time that the experiment spends in weightlessness, can be between 6-12 minutes. This can depend on the type of rockets that is used or the sort of payload being used. (eLib portal, SSC, Rockets)

Rocket programmes

SSC, according to the company webpage (eLib portal, SSC, Rockets), has up until today 2017, developed and designed 60 different rocket vehicles. The company webpage also describes the two main rocket types used at Esrange Space Center namely MASER and MAXUS. The MASER rocket can reach a height of about 250 km and can offer 6 minutes of weightlessness. The MAXUS rocket can reach an altitude of about 800 km and the time used in weightlessness can be about 12 minutes. The payload usually lands while a parachute is being ejected. Then after that normally a helicopter comes and retrieves the remaining payload or experiment module and brings it back to the scientist. (eLib portal, SSC, Rockets) These rocket programmes are mainly used for microgravity experiments according to the company webpage (eLib portal, SSC, Rocket programmes)

The MASER rocket, according to the company webpage (eLib portal, SSC, Rocket programmes), is part of an SSC sounding rocket programme. It has been used and is used by international participants. It can provide for payloads or experiments up to between 6-8 minutes of microgravity and the launching campaign started already in 1987. THe MAXUS programme is a joint programme and cooperation between SSC and an organisation or space company called “EADS Astrium GmbH” in Germany. The MAXUS sounding rockets can be in weightlessness in microgravity up to 14 minutes. The programme of launching MAXUS rockets started in 1991. According to the company webpage (eLib portal, SSC, Rocket programmes), SCC has been since 1975 giving consulting services, space studies, space research and development, space or aviation technology testing, management and operation when performing research in microgravity. Researchers have been using the launching facilities at ESrange through SSC to perform their own experiments with the use sounding rockets. (eLib portal, SSC, Rocket programmes)

Dedicated missions

A dedicated mission is, according to company website (eLib portal, SSC, Dedicated missions), made of user requirements for launching sounding rockets. SSC has subsystems that include payload. During these missions support is given from pre studies to launch and operation at Esrange. (eLib portal, SSC, Dedicated missions)

Until today many of the launching campaigns and missions at Esrange have been, during these last 40 years, to make scientific investigations according to the company webpage (eLib portal, SSC, Dedicated missions). The research area of investigation has been different starting from Astrophysics, Geophysics, atmospheric research to plasma physics and others. Sometimes the launching facilities at Esrange have been used for technical testing of new space systems or aviation systems. (eLib portal, SSC, Dedicated missions)

Subsystems & services

Parallel to the rocket missions, there has been over the years, according to the company webpage (eLib portal, SSC, Subsystems and services), development of different kinds of subsystems for sounding rocket missions at SSC. These subsystems have been available, commercially, on a separate basis for clients when needed. The subsystems can include support services for sounding rocket missions. The subsystems can also be used for missions analysis, project management, different kinds of testing and analysis or verification. Subsystems are also used for launching and and operation of a sounding rocket. (eLib portal, SSC, Subsystems and services)

Just to give a few examples of a subsystem, the company webpage mentions a few (eLib portal, SSC, Subsystems and services):

- A service module used for communication (eLib portal, SSC, Subsystems and services)
- A ground support software (GSE) called RAMSES for the possibility of controlment (eLib portal, SSC, Subsystems and services)

The first one mentioned above is the service module. According to the company webpage (eLib portal, SSC, Subsystems and services), the service module can communicate between the ground station at Esrange withe the actual experiment or payload. Another use for the service module is when the payload needs to be moved or act in a certain way during a flight, it can be done through the service module. There is a parachute in the recovery system which can be released and the payload recovered safely. (eLib portal, SSC, Subsystems and services)

The second one mentioned is the ground support software (GSE) or called RAMSES. The company webpage describes how it is useful in controlling the payload or experiment during a rocket flight or even for testing. It is used not only in rocket systems but also in satellite systems. (eLib portal, SSC, Subsystems and services)

2.3 RESEARCH BALLOONS IN HIGH ALTITUDE

This section will describe in general about the balloon campaign activities at Esrange. The balloon launching facilities at Esrange, according to the company webpage, have been in use mostly by researchers or students coming from national or international scientific programmes. Depending on the research, the balloon campaign can in some cases last for several years. Only when the balloon is to be launched and the payload to be tested, will the researchers or students come and visit the actual launch facilities. Since 1974 there has been balloon campaigns at Esrange Space Center, after the first stratospheric balloon was launched. Over 550 scientific balloon have been launched according to company webpage. The launch programme is operated by SSC but done often in cooperation with CNES launch team (France) or the CSBF launch team working for NASA (USA). (eLib portal, SSC, Balloon missions)

Also the high altitude balloon missions uses subsystems for the purpose of controlling and measuring what happens during a flight. According to the company webpage (eLib portal, SSC, Balloon subsystems), E-Link is a subsystem that uses a high-speed data link for connecting with the high altitude balloons. The subsystem uses a normal IP/Ethernet in its networking. Another subsystem is the EBASS system. It is used a telemetry and telecommand system with the purpose of supporting and operating balloon flights. Many of the basic functions are included like GPS positioning, different command tools for the operations center and also some functions in the ballast machine for balloon piloting. The third and last mentioned subsystem is called a E-TAG system. It is designed for measuring the wind conditions before a launch at Esrange. Normally i is used for rocket launches but it is also used in balloon mission for determining where the impact area will be. (eLib portal, SSC, Balloon subsystems)

Since the start of the high altitude balloon missions in 1974 at Esrange, the balloon activities have been frequent. According to the company webpage (eLib portal, SSC, Balloons), these balloon flights can fly together with the wind in heights from 15 km to 45 km. They carry instruments for research purposes and the main area of research can be atmospheric research, astronomy or meteorology. Just like with rocket launches these balloon missions are used also for drop tests. Another part that is used is for satellite measurement, the high altitude gives the ability to perform control measurements. (eLib portal, SSC, Balloons)

Like mentioned before there are advantages of the Esrange Space Center location, according to the company webpage (eLib portal, SSC, Balloons). Even for high altitude balloons the geographical location can give a balloon flight using sun energy the possibility to recharge under a long period of time. The reason is amount of sunlight that can be used especially during the summers in the arctic latitude. (eLib portal, SSC, Balloons)

There is another advantage of the northern location where Esrange Space Center is located, according to the company webpage (eLib portal, SSC, Balloons). The reason is the polar vortex. It creates an area near the arctic polar circle with strong winds in the stratosphere, mainly during the winter months. For the ozone layer the polar vortex plays an important role in reducing the ozone. Therefore many environmental scientists come to ESrange during winter season to study the ozone. (eLib portal, SSC, Balloons)

The size of the stratospheric balloons can be large, sometimes twice as large as the Globe Arena in Stockholm, according to the company webpage (eLib portal, SSC, Balloons). The payload can be up to two tons. The balloons can travel from Esrange Space Center to Alaska in four days. Once the balloon flight is finished the payload is retrieved back to Esrange by a helicopter. The aim is to be able to use the equipment once more. (eLib portal, SSC, Balloons)

2.4 SATELLITE AND GROUND STATION SERVICES

This section will describe in general about the Satellite & Mark station activities at Esrange. Currently the ESrange satellite station is under enormous expansion. There is a need for satellite services and with the location above the arctic circle the operations and satellite activities have increased. Since the start of ESrange back in 1978, the Space Center has overseen and operated different kinds of satellite missions. They have daily contacts with satellites that are in orbit above the earth's atmosphere. The satellite station at Esrange is part of an internal network at SSC, called SSC Universal Space Network. It is a global network that covers the SSC’s satellite stations in different parts of the world. (eLib portal, SSC, Universal space network)

According to the company webpage (eLib portal, SSC, On orbit services), the Esrange Satellite Station has six independent Telemetry Tracking & Command (TT & C) systems in use. All of them uses the S-Band frequency, and one of the systems can use also the UHF band frequency (eLib portal, SSC, Inuvik satellite station). Six of the systems can use the multi frequency antenna system that can receive in S/X Band (eLib portal, SSC Inuvik satellite station). There is one operational building at Esrange Space Center for Satellite ground control with staff working 24/7. (eLib portal, SSC, On orbit services)

The location of Esrange Space Center makes, according to the company webpage, makes it very practical also for Satellite ground control. For polar orbiting satellites, the location of Esrange is ideal for retrieving data from satellites. For satellite control it makes it practical for the processing of remote sensing in satellites. The satellite ground station is used for scientific missions and also TT & C support. When the satellite station called Inuvik in northern Canada is used simultaneously together with the satellite station at Esrange the coverage is good. (eLib portal, SSC, Inuvik satellite station)

With the increasing demand for ground based satellite services, according to the company webpage (eLib portal, SSC, Infinity), an increased flexibility and availability is required. For this SSC has designed the SSC Infinity. The purpose is meet these needs by using technology for the specific target. Also the SSC Infinity is a network that can provide accessible and automated ground network services. (eLib portal, SSC Infinity)

As mentioned before there are ground stations at SSC that are scattered around the globe, according to the company webpage (eLib portal, SSC, Infinity). The purpose is to give constant availability for reaching the satellites in orbit and to provide coverage for satellite control and satellite monitoring. The frequent satellite contacts has given also the possibility for Telemetry, Tele command and data download from the satellites. The SSC Infinity uses a web-based and API customer interface that is according to the satellite schedule. The SSC Infinity service is based on ground station antennas that are in motion and can have a diameter of about five meter or smaller. (eLib portal, SSC, Infinity)

At SSC, according to the company webpage (eLib portal, SSC, Infinity), because of the many years that some of the staff members have been part of the satellite, rocket and balloon launches, knowledge has and experience has been acquired for these projects. Special training and knowledge is needed for the launch preparations at Esrange. Some expertise is also vital when acquiring first contact with a satellite. (eLib portal, SSC, Infinity)

Another part of the satellite services at Esrange Space Center is the LEOP (Launch and early orbit services), according to the company webpage (eLib portal, SSC, Launch support services). It is used for many different kinds of missions, where the Geostationary Orbit service is also included (GEO-TOS). The LEOP is used in lunar missions, low earth orbits and also in Deep Space escape orbits. The LEOP service can be used simultaneously when launching. (eLib portal, SSC, Launch support services)

2.5 REXUS/BEXUS

This section will describe the student programme REXUS/BEXUS at Esrange. The student programme, according to the company webpage (eLib portal, SSC Student programmes), allows higher education students coming Universities in different parts o f the world, to come to ESrange and to perform their scientific or technological experiments. This happen once a year and is divided into two parts, first there is the REXUS part for rocket launching. The second part is the BEXUS for high altitude balloon launches. In both parts students conducts their own designed and built experiments. The number of experiments can be up to 20. The student programme REXUS/BEXUS is a close cooperation between the german Aerospace Center (DLR) and the Swedish National Space Board (SNSB). The european space organization (ESA) is behind this project and also funding it. (eLib portal, SSC, Student programmes)

The REXUS rocket launch experiments that carries student designed payloads onboard, are launched with rockets that are spin-stabilized and powered by the Orion motor. The motor has a propellant that weighs about 290 Kg, according to the company webpage (eLib portal, SSC Student programmes). The REXUS rocket is capable of carrying a load of up to 40 Kg of student experiments or technological tests. The altitude can be reached up to 100 km. The REXUS rocket is about 5.6 m in length and with a diameter of about 25.6 cm. The BEXUS high altitude balloons are launched, with a payload of between 40-100 Kg, up to the sky with a n altitude of 35 Km. The volume of the BEXUS high altitude balloon is 12 000 m^3. When the BEXUS is launched it can stay up in the sky for about 2-5 hours. (eLib portal, SSC, Student programmes)

Euro Launch, is a cooperation between Esrange Space Center of SSC and Mobile Rocket Base (MORABA) of DLR, the company website explains. It is mainly responsible for the campaign management and operations of the rocket launch vehicles for the REXUS/BEXUS programme. Experts from ESA, SSC and DLR provide technical support to the different student teams throughout the project. Both the REXUS and BEXUS are launched from SSC's launching facility at Esrange Space Center in northern part of Sweden. (eLib portal, SSC, Student programmes)

A part of the REXUS/BEXUS programme is the Euro Launch, according to the company webpage (eLib portal, SSC, Student programmes). It is a cooperation between Esrange SPace Center and Mobile Rocket Base (MORABA) of DLR (german Aerospace center). The Euro Launch is operating and managing the rocket launch vehicles in the REXUS/BEXUS programme. Both the REXUS and BEXUS are launched at the Esrange launching facilities. Experts from ESA, SSC and DLR provide the students with technical support. (eLib portal, SSC, Student programmes) The various student teams build together their experiments and retrieve later on the results when the launching campaign is finished.

3. DIGITIZATION

This chapter will describe in brief the definition of digitization, the effects of it and it's short history. The definition for digitization is, or sometimes called digitalization, according to Collins dictionary (eLib portal, Collins dictionary), it represents an object, image, sound, document or a signal. The representation is made in another format by generating a series of numbers in either 0 or 1. Another dictionary called the TechTarget, names this result of numerical numbers as a digital representation. It is also named a digital form or digital image. Today with the evolving computers we use binary numbers to describe a digital form, mostly used by computer processors and other operators. The meaning of digitizing is converting something in analog form to a digital form. (eLib portal, TechTarget - WhatIs)

The TechTarget dictionary describes that digitization is of a crucial importance in data processing, storage and transmissions, because it allows information of all kind and in all format to be carried with the same efficiency and to be intermingled. Analog data typically suffers some loss of quality and quantity each time it is copied or transmitted through a channel. The digital data can in theory be propagated indefinitely with absolutely no degradation. Usually this is why digital data or digital format is a favored way of preserving information for many organizations around the world. (eLib portal, TechTarget - WhatIs)

Another description for digitization, according to the dictionary TechTarget, is the importance a digital form has become in storing something, processing data or transmitting information over large distances without delay. It allows information to be transferred without losing any of the information or parts of the signal. Usually with analog signal there is some loss of quality and quantity of signal. In theory the digital signal can be transmitted, processed or stored several times without the signal suffering from any loss. This has become an invaluable way of preserving information, data or a signal. (eLib portal, TechTarget - WhatIs)

3.1 DEFINITION OF DIGITIZATION

According to Flew (Flew, 2008), the word digitization is often used when something is being described as being transformed or converted into a digital form or binary form. This can be also be described as a binary code format. The process of converting from analog to digital, according to Flew (Flew, 2008), is when the capturing device and the player device compromise in order for the result to represent as exact as possible the original source or signal. The difference in speed considerable when comparing an analog and a digital signal. (Flew, 2008)

As mentioned previously a digital signal or information is represented as either one of these two digits, either 0 or 1. According to Flew (Flew (2008), these are known or mentioned as bits which is shortening for binary digits. The digital signal is shown in a series of bits, 0 or 1. This one sequence is called bytes. (Flew, 2008)

Flew describes (Flew (2008) how analog signals are changeable and varying continuously regarding to the value of the signal at a given time. Another things that is varying, when looking at analog signals, is the number of points the signal has at a given time, according to Flew (Flew 2008). In general terms, the digital signal can be described as a sequence of digits or integers. The term digitization is in practicality only an approximation the original source. (Flew, 2008)

Flew describes how the process of digitization occurs in two parts, discretization and Quantization (Flew, 2008):

Discretization: According to Flew (Flew, 2008), it is the first stage where the analog signal is being read. While reading through the analog signal, or the original source, the signal is being sampled at regular time intervals or frequencies. This reading is called sampling and each individual reading is called a sample. (Flew, 2008)

Quantization: According to Flew (Flew, 2008) the second step in digitization is when the samples are gathered together in set of numbers or integers. This process is known as quantization. This process of rounding up the samples can occur at the same time for an analog signal or source, though the results for these are very distinct. In the other way around, a digital signal can be transformed back into an analog signal. This transformation is known as a digital to analog conversion, or DA conversion. The frequency or the sampling rate and the numbers of bits, determine how well the digital signal has represented the original source or signal. (Flew, 2008)

Digitization has a brief history but is at the moment one of the main technological changes occurring in our society today. It has already revolutionized many industries and at the same time bringing new technology and new industries. Many parts of our society have already been digitized. It is in the industries today that the main changes are occurring and who are facing an even more revolutionizing digital evolution. More parts of the industry is becoming dependent on digitization with the use of software and apps for many of the tools and equipment that they use for production or their products. The change in how the public uses technology, especially digital equipment, changes also the industry.

Beginnings of digitization

In the latter half of the 19th century much of the underlying technology had been invented. First came the telegraph for communication. After the Second World War came the computers. The transistor inside the computers made it possible to convert analog signals to digital. Therefore the invention of the transistor after the Second World War led to the evolution of computers. The importance with computers came with the ability to pass on digital signals without losing any parts of the signal. It became easy to move the digital information, access it or to distribute it remotely.

The media industry is the one of the first to be influenced by the digital revolution. The military industry however, was first and quick to adapt the newly invented computers. In the music industry the analog recording system was widely used with vinyl and cassette tapes. In the 80's, the music was recorded in digital format with CD's and in the 90's the movies were recorded in DVD's.

With the computers came the World Wide Web, as it was first called. In the 90's it became accessible for public use. Many companies started using for marketing purposes with homepages. This expanded quickly and many started using the World Wide Web. Even computers became more common in households with the development of the World Wide Web. The first web browsers were also introduced with the World Wide Web being widely used. To establish the connection a dial-up was used with a complicated configuration.

TV began also in the latter half of the 19th century with the first mechanical television appearing as box mainly used for measurement and scientific purposes. Then later came the black and white electronic television that started sending broadcasting as analog signals to the households. After that came the color television that changes the viewers experience in media. Then came the digital television that received broadcasting as digital transmissions. There is talk about the possibility of 3D television (three dimensional television), that could be used in the future but this has been put on hold at the moment. Smart television combines both the internet and normal digital broadcasting. Then there is the internet television that is used through the internet for live streaming.

The mobile phones were first used in the early 90's with the possibility of sending text messages and calling. The first mobile phones were large in size and were mostly used inside cars. The mobile phones quickly developed into a more user friendly size and user friendly interface. In the late 90's the mobile phones became more widely used and with the ability of receiving phone calls and playing simple games. Between the years 2000-2010 the smart phones were invented with the first models sold for a high price. After 2010 the smart phone prices have gone down and are in wide public use.

With the smart phones came the development of applications for the smart phones, or later called ”Apps”. These APPs can be used in many different and for different purposes. One example is by using the localization tracking on the smart phone, one can retrieve the current local weather. Another example is using an application for making direct phone calls, most common application is called WhatsApp, by using the network coming from the network service provider. Many more uses and different applications on smart phones have been developed and are still being developed.

With digital format being most commonly used, also literature books, material published in paper format, have been transformed into digital format. Nowadays there is a growing E-library with newly published literature and old literature being available for public use. Also some art have been transformed into digital format. The E-library is a growing phenomenon and it has been discussed about using it as an alternative affordable instrument in education.

Another exciting part of digitization is ”Internet of things”, where startup companies or existing companies turn into making their products completely digital and connected to the internet. These products have the ability to make a change in society by being connected.

One example is a medical equipment that needs to be attached to a patient for medical observation, there is a sensor that sends and receives data to the digital device.

Cloud computing is also a part of digitization where companies or organization uses a shared pool to distribute, send and retrieve information. The cloud can be used also in ”Internet of Things” as a sort of database. The usages are many for a company using the cloud, for example data processing. The cloud can be reached through servers, or through a third party. The data, information shared on the cloud can be reached with minimal effort.

Digitization today and the future

The digitization is evolving rapidly and for this many companies struggle with keeping up with the rapid technological advances. For some companies it has come to the point that if they don’t change their products into more digitized version or applications, they lose some customers depending on the product. For some companies it means making a complete turn over to more digitized products, for which the company has no previous experience. What the future looks for digitization is difficult to say. With the widespread use of the internet in the society, even at home in a refrigerator, the need for more internet security will grow. This will perhaps be another step in the digitization process. The digitization has made it possible to make fast analytical calculations based on a shared storage space, the cloud. Perhaps these tools will evolve into more advanced analytical tools, making decisions based on the information and material retrieved.

3.2 EFFECTS OF DIGITIZATION

This section will discuss and describe in general what the effects of digitization has been. According to McQuail (McQuail, 2000) the shift towards digitizing content has been most noticeable up until today in how broadcast, distribute material and also in publishing. The main effect of digitization has been the use of mass broadcasting. For single individual the rapid change in digitization in society has been significant. There are many people who still might have VHS cassettes shen already the same material might be in Blu Ray just to mention an example.

The point that McQuail tries to make is that the more technology evolves the more the storage limits becomes a gray area. To put it in another way the traditional way of storing material will disappear. The internet is an example of mass communication tool that has changed the way many people communicate and businesses communicate. It has for sure made communication easier and faster, perhaps more efficient, according to McQuail (McQuail, 2000). That is perhaps one positive side of digitization. While some media are disappearing or have disappeared, there are new digital media that have taken over the same tasks but with new technology. It has been debated for example inside the music industry, how digitization has changed the music industry with the availability of listening to music for free through youtube, just to mention an example. The fast pace of changes in technology makes it even more important that new solutions are made that makes them more reliable when it comes to information sharing.

4. SCIENTIFIC RESEARCH METHODS

For this thesis a description of different kinds of research methods will be given. It should be expressed and with underlining how important the research part was for this thesis. In this chapter some of the important research methods will be summarized for the reader. There are two models of a research process, the Jenkins model from 1985 and Wallace's model from 1969.

The first section will discuss Jenkin's model and then Wallace's model. It is important to emphasize that these two are process models for the research method. The next section will discuss conceptual-analytical research. After that comes theory testing research. Following that comes qualitative, interpretive and new theories creating research. The next interesting research model is the design science model. The last research model that will be discussed in this thesis is the mathematical research model.

4.1 JENKINS MODEL AND WALLACE'S MODEL

Järvinen discusses an important question before explaining the research processes. From where do the research ideas emerge? They don't emerge by order. Usually they are discovered by applying some theory to practice and by making observations. They can also emerge upon intuition in the course of debating the matter. The idea can also appear by reading the results achieved by other researchers. The library part of the research plays a different role in different research approaches. When finding out the research topic, the sub-processes can be broken into three main components, according to Järvinen. The first is the originating questions, the second is the research rationale and the third is the specifying questions. A researcher selects thereafter a certain research strategy depending on the research object or the problem. After that follows the experimental design, data capture, data analysis and the last part is publishing the results. (Järvinen, 2004, p. 4-6)

1. Idea

2. Library research

3. Research topic

4. Research strategy

5. Experimental design

6. Data capture

7. Data analysis

8. Publish results

FIGURE 1. Jenkins model (Järvinen, 2004)

Jenkins model of the research process, Järvinen explains, contains 8 sequential steps (see Figure 1). Järvinen underlines that the Jenkins model is an over-simplification, because the research process is often more iterative. The idea starts up first as a study. In fact, before the idea, there can be a certain state of a complex issue occupying our mind, a problem or a question that we need to find out or to get an answer for. What would be a suitable and non-trivial problem to be solved? At an exam the teacher states a problem through writing examination questions. In a study, there is first an identification and definition of a problem and these are a natural part of the process. A researcher must do it, not an outsider. (Järvinen, 2004, p. 3)

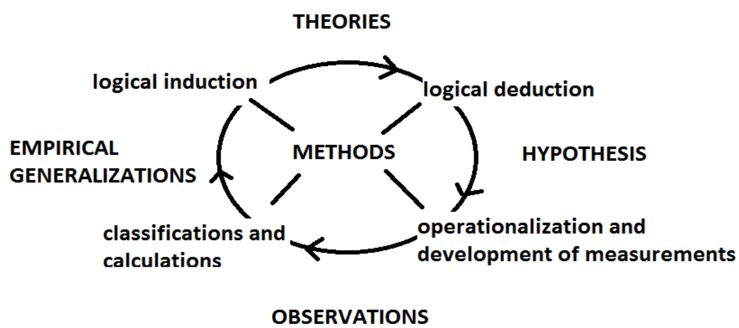

FIGURE 2. Wallace's model (Järvinen, 2004)

Wallace's model (see Figure 2), Järvinen explains, has modeled the research process as a cycle. The cycle is composed accordingly, Järvinen describes. By logical deduction a researcher derives the hypotheses from the chosen theory. In order to test these hypotheses the researcher formulates measurable and observable questions. This is also defined as operationalization, development of measurements, to which the researcher gets observations as answers. After that the researcher then focuses on making classification and calculations of the observations. On the basis of the results the researcher considers whether the results are confirming or falsifying the hypotheses. By using the results and own reasoning, some explanation and imagination by the researcher, an empirical generalization can be made. From this empirical generalization the researcher can decide either that the old theory was confirmed, or by logical induction to derive a new theory. Thereafter the cycle continues to the next round. (Järvinen, 2004, p. 6)

Wallace has put, Järvinen concludes, the method parts in the middle of the research process figure (see Figure 2 4). The logical deduction and induction, operationalization, development of measurements, classification and calculations are methods in the Wallace's terminology. (Järvinen, 2004, p. 7)

4.2 CONCEPTUAL-ANALYTICAL RESEARCH

Järvinen discusses how research theories resemble a conceptual system as a structure. The theory collects, integrates and systematizes previous research results that are separate. The axiom system, where all the propositions of the theory are compressed with a set of basic clauses and axioms, has been considered as the ideal form of research theory. These basic clauses are in such a way selected that all the other propositions of this theory can be logically derived from them. The basic clauses can in principle be reset by using simple logic and undefined basic concepts of the system. Järvinen explains how the theory derived from the axioms by using rules of logic is said to be deductive. The theory derived from empirical generalizations is said to be inductive. (Järvinen, 2004, p. 17)

Järvinen explains how in all research work, both in theoretical and in empirical one, we use concepts or terms referring to different concrete and abstract objects and entities. These can be classified into four classes, Järvinen describes based on Bunge (1967, p. 60). The first is called individual concepts, the second is called class concepts, third is called relation concepts and the fourth quantitative concepts. (Järvinen, 2004, p. 20)

A data system is describing a part of reality, Järvinen explains. In this part Järvinen shows by means of an example how a theory is derived from an axiom. The example concerns an information system that can be considered as a theory or a part of a reality. Järvinen discusses based on Wand and Wang (1996), how some design errors can occur that the users see as deficiencies of data quality. It can be explained as errors in development and application of the theory. Poor data quality can have a severe impact on the overall effectiveness of an organization. (Järvinen, 2004, p. 22)

Järvinen describes different models for representing the real world based on Wand and Wang (1996). These have four assumptions. The first model is called the representation assumption. The second model is called the interpretation assumption. The third model is called the inference model. The fourth model is called the internal view assumption. For a real world system to be properly represented, two conditions must hold. First, every state of the real world should be mapped to at least one lawful state of the information system. Second, it should be possible, in principle to map an information system back to the correct real world state. (Järvinen, 2004, p. 22-23)

Structuring the theoretical study includes the following, according to Järvinen. For a tentative pattern of the deductive study the steps are following. First comes the introduction. The second is selection of method. Then third are the axioms and basic assumptions. The fourth is a derivation of a new theory from axioms and assumptions. The fifth is a comparison between the new theory and the old ones. The sixth and last one is a discussion. For a tentative pattern of the inductive study the following steps are included. First is an introduction. The second is a selection of method. The third is a review of the results from the previous studies, experiences and observations. The fourth is an analysis of concepts and constructs in the previous studies. The fifth is a creation of the new theory. The sixth is a comparison between the new theory and the old ones. The last and seventh step is a discussion. (Järvinen, 2004, p. 34-35)

4.3 THEORY TESTING RESEARCH

According to Järvinen the theory testing research model aims to answer the question, "does a part of reality correspond to a certain theory, model or framework"? Through natural laws and other laws related, the answers to a theory can be found that explain, predict and control the phenomenon under study. Järvinen explains that the purpose is to find a connection between events in theory, to find an explanation for the laws, or to explain recurring phenomenon. The importance lies setting up a difference between what factors are causes and what factors are the effects. (Järvinen, 2004, p. 36)

A controlled experiment is organized so that as many factors as possible belonging to the phenomenon are controlled by the researcher, Järvinen describes. There are independent and dependent variables as well as a neutral observer. There are two parts that signifies a controlled experiment. The first one is if repetition of the initial state is possible, then the final state can be controlled. Another factor that can occur is an intervening variable, not intentionally varied nor manipulated but still has an influence on the experiment. (Järvinen, 2004, p. 46)

A research experiment or design is said to lack internal validity if the results are ambiguous or can be explained by other factors than those involved in the controlled environment, according to Järvinen. In the opposite, a research design is said to lack external validity if the results can be generalized to other groups outside and not belonging to the study, or for those that participated in the original experiment/study. A natural experiment brings the study to an event or process that has already taken place or will take place in the future. In a field experiment the researcher controls the timing and the independent variables behavior, where it is manipulated. (Järvinen, 2004, p. 54)

For a theory testing case research, Järvinen explains based on Markus (1983), that there are three theories concerning how users accept or resist a new information system. The first called people-determined, is when a person or a sub-unit have resisted because of factors internal to the person or group. In the second theory called system determined, the person or a group may have resisted because of factors inherent in the application or system implemented. In the third and last theory called interaction theory, a person or a group may have resisted because of factors involved in the interaction between the user and the system (characteristics on both sides). (Järvinen, 2004, p. 58)

Longitudinal case studies is a broad term, according to Järvinen. It can be defined as research where the data is collected for each item or variable for over a period of time. It can also be described with as where the subjects or cases that are being analyzed, stay the same from one period to the other. It can also mean that the data involved needs some comparison with the data collected over a period of time. It is common for cross-sectional data to be recorded in a survey succession with two or more points across several time periods. In a prospective design the study is planned in advance and the data collected from a certain point along the time period. (Järvinen, 2004, p. 61)

4.4 QUALITATIVE, INTERPRETIVE AND NEW THEORIES CREATING RESEARCH

According to Järvinen, qualitative and interpretive research tries to find the answer to which kind of a model or framework is best suited that describes or explains parts or part of a reality. Järvinen explains, based on previous research made by Miles & Huberman (1994) who have based their research on Tesch's (1994) article, that a research model approach can be divided into four parts. The first is the characteristics of language. The second is the discovery of regularities. The third is the comprehension in the meaning of text/action. The fourth is reflection. (Järvinen, 2004, p. 66)

Järvinen describes, based on other previous research, how a well a grounded theory is discovered, developed and verified through a systematic data collection and analysis of the data belonging to the phenomenon under study. A well-constructed grounded theory will meet four criteria that Järvinen explains further. The first is when a theory is faithful to the everyday reality of the phenomenon under study and it is carefully induced from diverse data, then it should fit the area under study. The second is when representing a reality it should also be comprehensible and make sense in understanding for the person or people doing the research and also for those who are participating in the study. The data upon which the theory is based upon should be comprehensive, the interpretation conceptual and broad. This will bring the research to the conclusion that the theory is be abstract enough to include generality and have it applicable to other related phenomenon. (Järvinen, 2004, p. 70)

Järvinen explains, based on other previous research mad by Glaser & Strauss (1967), about the 8 steps for how to build theories from case study research. The first is getting started. The second is selecting the case or cases. The third is to craft an instrument and a protocol. The fourth is entering the field. The fifth is analyzing the data. The sixth is shaping hypotheses. The seventh is enfolding or retrieving literature. The eight is reaching closure. An explanatory case is where the researcher is allowed to factually record and draw references. (Järvinen, 2004, p. 73-78)

Phenomenography, Järvinen describes, is a qualitatively oriented research method for studying people's conceptions of the surrounding world. The aim with phenomenographic research according to Järvinen is to show a qualitative variation of the understanding in a population. The research in itself is not interested in why people think differently but how a population views something. (Järvinen, 2004, p. 79)

When it comes to contextualist analysis, Järvinen mentions, based on previous research made by Pettigrew (1985), there are important requirements which is to understand the emergent, situational and holistic features of an organism or a phenomenon in its context. This would be better instead of dividing it into dependent and independent variables. Also important, Järvinen mentions, is the balance between the researcher's involvement and the distance, with objectivity in mind. The third is the importance of knowledge coming through with making instead of discovering it through a process of knowing. (Järvinen, 2004, p. 83)

4.5 DESIGN SCIENCE RESEARCH

Järvinen describes how a design oriented research method tries to answer the questions, "Can we build a certain innovation and how useful is a particular innovation?" "What kind of an innovation it ought to be and how are we going to build it?" The design oriented research, Järvinen explains, is normally divided into two parts, basic and applied research. It is typical for a design oriented research, according to Järvinen, for building new innovations and this process is based on existing research knowledge and perhaps new technical organizational advancements. (Järvinen, 2004, p. 98)

There four types of design science research products, Järvinen explains based on March & Smith (1995), namely constructs, models, methods and instantiations. Constructs or sometimes called concepts, are derived from by that it forms the vocabulary of a domain. A model describes a set of propositions or statements expressing the relationship among constructs. An instantiation is the realization of a product or artifact in its environment. A subsection belonging to the building process, Järvinen describes, is the specification process where the purpose is to produce the model of the target. Another important part is the implementation process, Järvinen mentions, that tries to answer the question how could we build an artifact that satisfies the given specifications? (Järvinen, 2004, p. 100)

Each sub part in the building process, the constructs, models, methods or instantiations need to provide performance improvement, Järvinen explains. Evaluation is then the key for making the assessment. When both building and evaluating sub processes belong closely to the same process the characteristic of the research method is called action research. It can be divided into four streams of action, Järvinen explains based on Rapoport (1970). The first is the Tavistock stream, where the psychological part is being evaluated. The second is the operational research stream emphasizing on mathematics, engineering and the physical sciences rather than the psycho biological part. The third is the group dynamic. The fourth is the applied anthropology stream where group dynamics and psychology come together. (Järvinen, 2004, p. 124-125)

4.6 MATHEMATICAL RESEARCH

Mathematical and theoretical research starts with some presuppositions, according to Järvinen. The mathematical language and mathematical notations don't' have a direct connection with reality. The critical question in mathematical research, Järvinen explains, is how well do the models correspond to reality? Mathematical models are often watertight and free from conflicts. Any critical remarks against these must be directed towards pre-suppositions and interpretations of the results. (Järvinen, 2004, p. 128)

The law of Requisite Variety is an entropy law, Järvinen describes, which means that if A is a variable of any kind, the entropy H (A) is a measure of its variety. If A and B are two different variables, then the degree of their mutual dependence is dependent or measured by the entropy difference. The law of requisite hierarchy, Järvinen explains, says that if the regulatory abilities are weak in average and the larger the uncertainties of available regulators. This means more hierarchy is needed in the organization of regulation and control for keeping the balance in requisite hierarchy. (Järvinen, 2004, p. 128-129)

Järvinen discusses based on Aulin (1989), how a dynamical system can have a nilpotent or a full causal recursion. When system is in a rest state then it is called nilpotent. The nilpotent dynamical system comes back to its initial state, also called a rest state, after a finite number of units in time. An external disturbance or stimulus that occurs in the beginning can throw the system out of its rest state to a perturbed state. After that, Järvinen explain based on Aulin (1989), the nilpotent causal recursion throws the system back to its rest state. (Järvinen, 2004, p. 132)

Järvinen discusses based on Aulin (1982), the definition of aposteriorical, which means all knowledge collected together of values, procedural norms and cognitive beliefs. These are then in itself based on a theoretical inference from the actor’s own observations or from the empirical knowledge he/she has from other sources. (Järvinen, 2004, p. 134)

4.7 COMPARISON OF THE RESEARCH METHODS

In the previous sub chapters I have mentioned conceptual-analytical research method, theory testing research method, qualitative-interpretive and new theories creating research method, design science research method and mathematical research method. They differ in method and also how the research questions are created. There are some similarities which is to find the answer to a question or phenomenon. The Jenkins and Wallace’s model only describe the process of the research method.

A conceptual analytical research method collects its theories from previous made research results or from a statement/proposition and assumption to a phenomenon or study. The good sides with this research method is that it refers to previous made studies or known theories which can make it solid when later referred to. The analysis result however can be very abstract and can only describe part of a reality.

For a theory testing research method the case is different or opposite of the conceptual research method. Here the emphasis lies on finding facts or evidence for a theory that is proposed or for a statement made. The research method undergoes strict testing in order to give proof for a theory which is under scientific observation or undergoing controlled experiments. Here the difficult part is making a clear separation of what the dependent and independent variables can be.

A qualitative, interpretive and new theories creating research method is the most creative when it comes to ideas for research. Here there are more possibilities for finding new theories when a phenomenon under study is being researched or a theory is being under observation. When unpredictable events or results start occurring new theories are built. Here the importance lies in correct evaluation of the results and making sure the research process went as expected in case there were any circumstances affecting the results.

The design science research method is the method that I used for this thesis. It tries to answer the questions to how something should be built and will it be useful from a user's point of view. Here the emphasis lies in the process with modeling, constructing, specification and evaluating. After all this is done then comes the final implementation phase. Depending on what is being constructed this research method has its strength in making sure that final design meets its goals or design purpose. The weakness lies in deciding from the start what phases should be more important or done first depending on what is being constructed

The mathematical research method tries to use a mathematical model to a research questions or phenomenon being under study. Here there are presuppositions and mathematical formulas that are used for describing part of a reality. Mathematical formulas are often solid and correct, here it is important that the definition of the objects are made correct.

5. AUDIO VOICE FOR COUNTDOWN

So far this thesis has described in general what digitization means, what different approaches to scientific research methods exists and some of these have been partly used for this thesis, in brief what happens at Esrange Space Center. This chapter will now focus on the new digital audio voice. This chapter will begin by describing the specific requirements and needs for the new audio voice. After that a brief description will be given about the technical background and environment of the new audio voice. Later on in this chapter the solution of the new audio voice will be explained. The user interface will have a section of its own. The next section will have a description of the different stages of the work and implementation made of constructing the new audio voice. In the final section the testing of the new audio voice will be summarized.

5.1 REQUIREMENTS FOR THE NEW AUDIO VOICE

When sending up scientific rockets into space, an important quality factor is that the performance of each part and activity is done and made according to plan. For this a correct time is needed. The time can be communicated out through several different ways for example video screens, displays belonging to an equipment, or acoustically through the loudspeakers. Handling of the acoustic time, is done up until the moment when this thesis started, by a person sitting and reading the time from a display and reading out through the loudspeakers (see thesis assignment description, p. 31).

The objective is to avoid the manual part of acoustic system and to use the personnel resources in a more efficient way. The timing system is part of a larger system with several timing references and different management systems (see thesis assignment description below.

<u>Master's thesis - Automated acoustical countdown system</u>

At SCC we provide our customers with access to Space for the benefit of the earth. With our 600 members of staff, employed throughout the world, we provide cutting edge specialization within developing, testing, launching and maintenance of different kinds of space flights and space systems.

Esrange Space Center, which is located outside Kiruna, is SSC's facility for launching high altitude balloons and sounding rockets. It has also in operation one of the world's most widely used civil mark stations for satellites. With many years of experience in launching rockets and scientific high altitude balloons, including controlling and keeping satellites in operation, Esrange Space Center has become a European center for space research. It is also an active space station. The department assigning this master's thesis, works with launching rockets and scientific balloons.

MASTER'S THESIS - AUTOMATIC ACOUSTICAL COUNTDOWN SYSTEM

Background for this master's thesis:

One important quality and security factor when launching rockets is that all stations perform their respective activities in accordance with the plans prepared. To be able to do this requires the correct time. The time is communicated in several different ways, for example through video screens, displays at equipment's and acoustically through the loudspeakers. Handling of the acoustical time is currently done by one of our staff members who sits, reads from a display and speaks out the time to the loudspeakers.

The target is to avoid in the future this manual handling and thereby be able to use staff resources more effectively in our activities. The countdown timer is part of a larger timing system with several time references and different management systems.

The thesis description:

The work itself consists of finding a solution with some sort of a synthetic voice or recorded voice that can be spoken out through the loudspeakers. The voice will be controlled by the time in the timing system. It should be able to stop the time, move the time forwards or backwards and also there should be a way to choose the starting point and end point of the time when the time is spoken out. The work extends to 20 weeks and is full time, placement Kiruna.

The work consists of finding a solution for some form of a synthetic sound or recorded voice that can be played out through the loudspeakers during the countdown. The voice/sound should be controlled from the time in the countdown system. The sound should be able to be stopped at any time. There should be a possibility to manage the sound so that it can be moved forwards or backwards and also to choose at what times the time should be read (see thesis assignment description above).

In addition to the voice there should also be an extra sound each time when a minute has passed. This could be heard as a digital beep sound. First the voice speaks out T minus 10 min and counting, and followed by a beep sound. This sound will continue each minute even after the launch has passed at 0 minutes. With each launch there might be a different standards required to the sound and voice. For instance depending on what kind of instruments or type of payload is carried up into space there might be specific needs for the equipment release, altitude or time schedule. For this reason there must be a possibility to adjust the sound and voice for each launch according to requirements needed at that time.

For documentation purposes, with quality in mind, a recording system is used and exists that records the sound and voice. This has been done previously when manually speaking out the countdown through the speakers and this recording system should continue recording with the new sound and voice. Another part that belongs to the audio voice is that the sound should start automatically when the countdown begins and that it should be adjustable according to specifications from customers.

Another aspect to think about coming from the staff members was adding in the future a video recording system to the device for the purpose of documentation. This means that the computer running the audio voice could also connect the video streaming from the launch platforms. Discussion was also held if the recording system needed to be updated, but this did not belong to the scope of my thesis work.

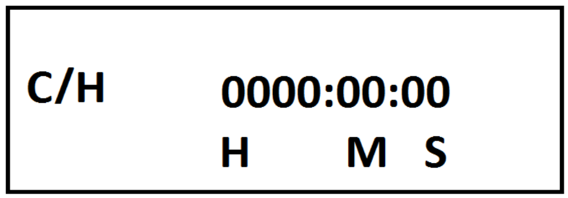

FIGURE 3. Timer to be shown in the user interface

The user interface should include the time in UTC (Universal time coordinated) with the hours, minutes and seconds showing on screen (see Figure 3). There are two launch platforms, the user should also be able to see the relative time RT related to the launch platform that is being used for example RT1 or RT2. Another part that needs to be added to the relative times RT1 or RT2 is count/hold C/H. Whenever the countdown is put on hold or is counting the minutes the C/H will switch accordingly. Another thing that was mentioned that should be included in the user interface was the ability to make changes to the audio voice if needed. Also the audio voice should have a delay of about 10µs from the countdown of the timing system.

5.2 TECHNICAL ENVIRONMENT FOR THE NEW AUDIO VOICE

Esrange consists of many facilities when considering where the audio voice is supposed to be heard throughout the loudspeakers during a countdown. First there is the main building where also the operations center is situated. Then there are rooms or facilities for safety, scientific, telemetry, radar, flight control or launching. An extra radio channel/channels has been reserved for any possible client/clients. There are two different launch platforms as previously mentioned, RT1 and RT2.

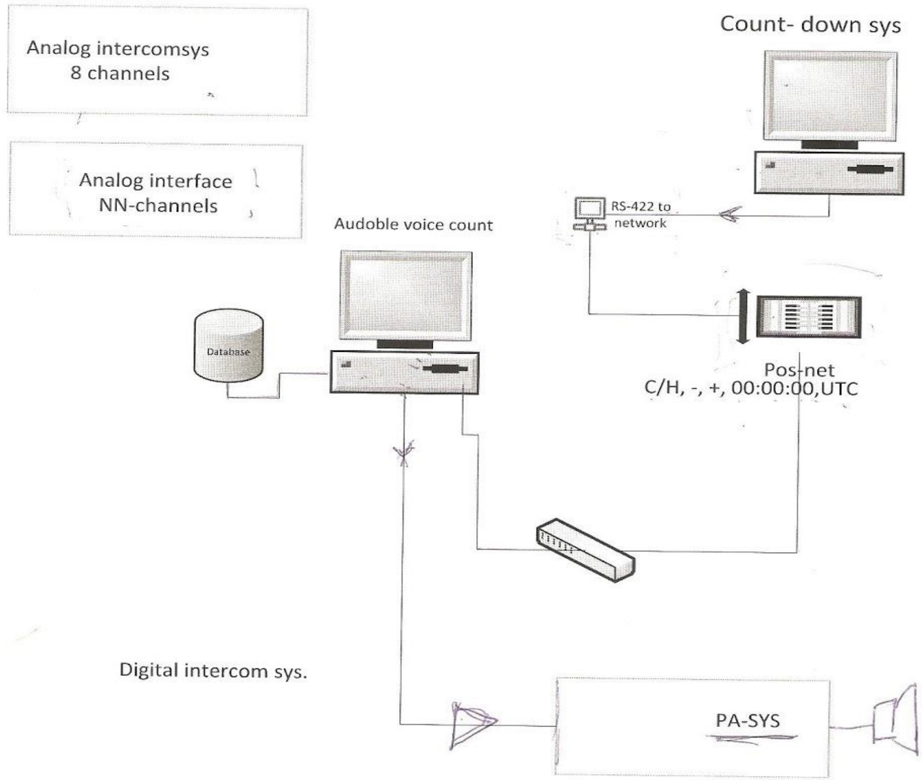

FIGURE 4. Network for new audio countdown system

The launch process is planned a long time ahead before the actual launch, it is conducted in teams where all the teams are coordinated together. The time span could be several months where eventual extra equipment and material are ordered if needed. The teams are coordinated together minute by minute and extensive detailed rehearsals are made before the actual launch. At the operations center the main operations team is given the GO/NOGO for a launch. The other teams are spread out through the other facilities according to their tasks.

A draft can be seen of how the new digital audio voice is supposed to be connected with the rest of the environment (see Figure 4). Digital intercom system has several parts. There is the analog intercom system that has 8 channels. Then there is the analog interface that has also the same amount of channels as there are intercom channels. Then there is the PA system (public address system) that is directly linked to the new digital audio voice. Also the recording system is also directly linked to the new digital audio voice. The timing system inside the internal network (POSNET) is also included. The new digital audio voice needs to connect through the internal network before reaching the countdown system.

The manual audio countdown system consisted of a panel with several buttons and switches including a microphone for the staff member to speak out through the loudspeakers. The switches consisted of connecting the manual audio voice to the different facilities, Operations center (OP), Safety (SA), Scientific (SC), Telemetry (TM), Radar (RD), Flight Control (FCO), launching (LA) or client/clients (US1). There was also a button, Push to talk (PTT), connected to the microphone. There was also a small display for showing the time of the countdown coming from timing system inside operations room. Another switch, public address (PA), was also included to the manual audio device. This switch can address all facilities at the same time if needed. The manual audio voice device was connected to the recording device inside the same room. A switch for connecting either to RT1 or RT2 launch platform exists.

POSNET (position data network) the internal network

Servers:
- File server
- Time server
- DHCP server (dynamic host configuration protocol)

Services:
- Logging service
- Playback service
- Nominal trajectory service
- Relative time service

Connected to the audio voice in the recording system is a database (DB) for storing audio and video files. Before the launch the control team at the operations center is given the authorization for a go or a no go. When the countdown begins it starts recording sound (audio from the launch platform) to follow that everything is proceeding as normal. The countdown continues even after the launch. The reason is to follow the trajectory of the rocket. Before the launch estimations are prepared to calculate the duration of the rocket when it lifts off from the earth and also the trajectory. The countdown will end according to the estimations. The countdown system needs to be flexible in order to remove audio sound from the countdown index numbering that the client may wish to remove or not to be heard in the recording after it has been recorded.

Some of the questions regarding the technical environment that needed answering were the following:

- What equipment and tools are in use?
- What programs are in use and how to synchronize the systems, networks and servers with each other?
- Any client specifications?
- Digital signal coming and going to the launch platform?
- Network system?

The new computer for the digital audio voice needed to have a fast working memory. It also needs to have all the necessary outlets for the intercom channels. It should also be possible to connect with the internal network. For this reason the same computer model was planned for the new digital audio voice as was used by the countdown system.

5.3 IMPLEMENTATION STAGES FOR THE NEW AUDIO VOICE

For the different stages of the thesis the first part consisted of visiting the premises. It was for a period of six months and during this time also the background work and interviews was conducted for this thesis. Since the manual system was still in use, it gave an insight to what was needed to be replaced. The next step was to find out the technical aspects of the environment surrounding the audio voice system. At the same time the interviews were done and a draft was building up for how the new automatic audio voice system should work and look like.

Since the automatic audio voice would be using the timing system which was written in Java programming language, the best solution to begin with was to find a similar programming code that could through the network communicate with the timing system. For this reason books and dictionaries in Java programming language was needed. Since I would not be able to test the audio system when there was a rocket launch together during a countdown, I needed to create a small version of a manual countdown clock to test the audio voice together with it. After this the next step was to create some sort of a digital audio voice that could be used in the manual countdown system. This was tested without using the countdown timer given from the timing system through the internal network. This was all tested on a home based personal computer before installation and handover to the actual computer in the timing room to be used later in the final version.

During the stages of creating a digital audio voice also another sound was added that was part of the initial requirements given, for example a beep sound. The digital audio voice, beep sound and the manual clock was then combined together. The next step was to find suitable user interface for the manual countdown clock. In the programming it was important to add a place where the linking to the timing system in the internal network would be added later. From there the programming code will automatically read the correct time in the timing system during a countdown and the control will be taken over by the timing system.

When the user interface and the digital audio voice was working a presentation was given to the staff members where they could ask questions and also hear how it would sound like. One question was about the setting the timer one second before the internal audio voice timer starts and finishes. This was because in the Java code the timer in the digital audio voice system was set to smaller or equal to the time it should start or finish the digital audio voice timer.

The last stage was to install the applications needed for the digital audio voice into the computer used in the final version that was similar to the one used for the timing system during a countdown. A detailed training was given to one of the staff members explaining the different parts of the programming code and how to set the timer in the digital audio voice. A link to the timing system through the network was later to be added by the staff members.

5.4 SOLUTION OF THE NEW AUDIO VOICE

The purpose for this thesis was to create an automatic audible count down system that could replace the existing manual audible version. This would become a part of the countdown system including using time systems, various management systems and different time references. For the audible part it was thought to be either a synthetically created voice or a recorded voice that could be heard on the speakers. The voice is controlled by the countdown system and the user should be able to stop the timer and change the time backwards or forwards. Also the user should be able to choose at which starting time the voice will be heard and when it will stop.

Tools used and installed

1. Eclipse with JForm editor (http://www.eclipse.org/downloads/index-java8.php)

2. FreeTTS (http://freetts.sourceforge.net/docs/index.php)

3. Java Runtime Environment for software developers (JRE) (http://www.oracle.com/technetwork/java/javase/downloads/java-se- jre-7-download-432155.html)

For setting up the automated audible count down system first java runtime environment is needed to be installed if not already existing. The next step is to install the free eclipse compiler software for creating the program codes needed. Inside the eclipse software there is also the possibility for using Jform editor for the design of the display. In case the Jform editor is not already installed on Eclipse it can be retrieved by going to menu bar under – “help” and –“install new software” (see Figure 5). The Eclipse version that has been used was called Kepler. Under “General purpose tools” the Jform editor was found and selected for installation.

For the audio voice freeTTS was used for creating a synthetic voice that could read text from a program code. After completing the instructions for installing the freeTTS software, the Eclipse compiler could start using the libraries for using an audio voice when running a program. Inside eclipse when starting a java project it is important that the freeTTS libraries are added to the java project (see Figure 6). This can be done through the project properties and selecting “Java Build Path”. When adding the freeTTS jar files and libraries the file path is the same as the directory where the freeTTS was installed.

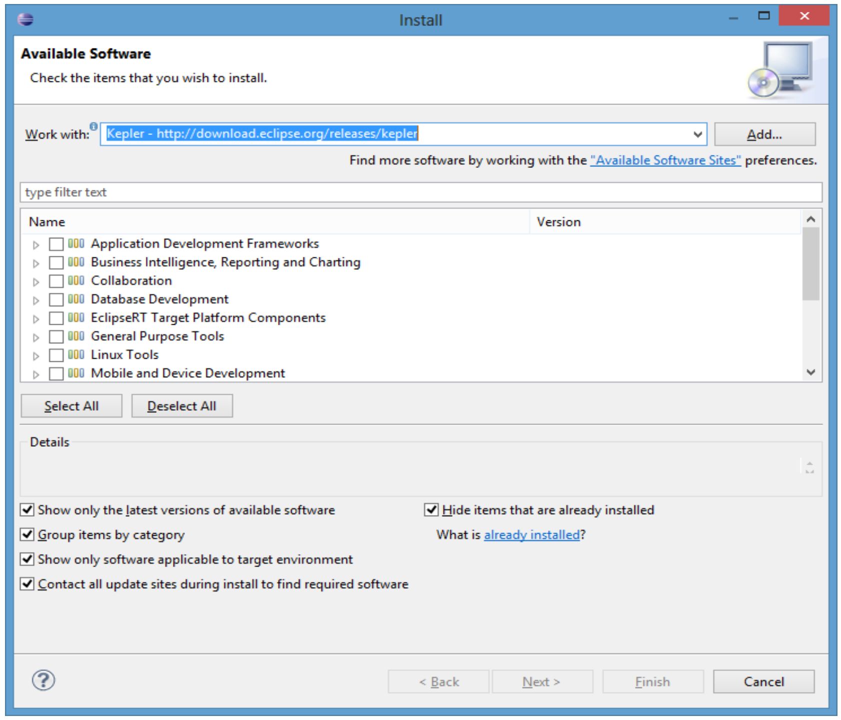

FIGURE 5. Installing new software inside Eclipse

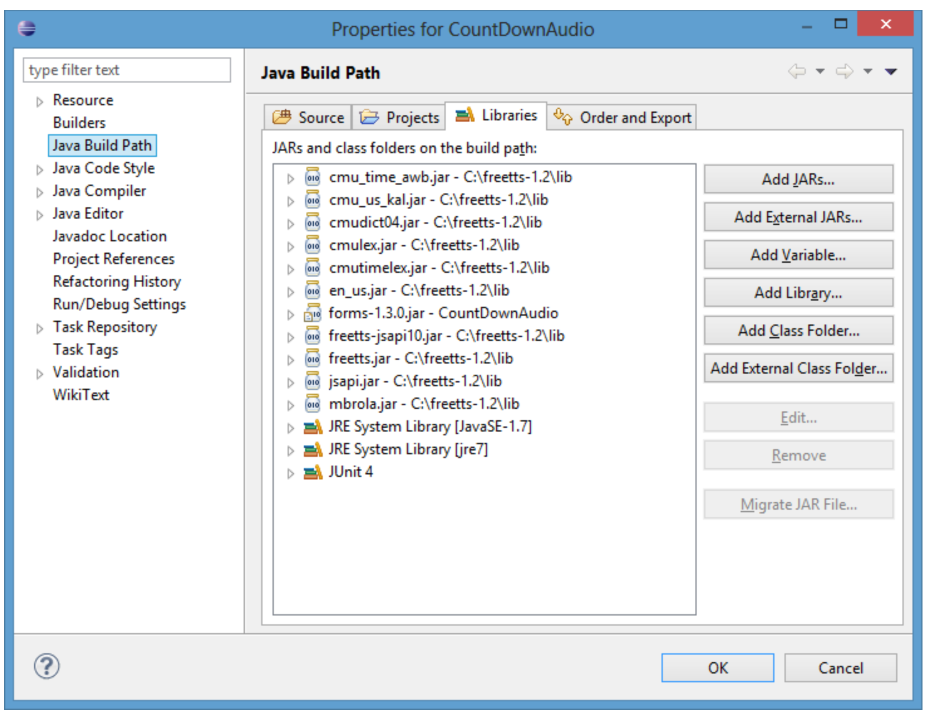

FIGURE 6. Retrieving audio voice libraries for the compiler and java project

After the installation is completed and libraries added inside eclipse the compiler will automatically use the audio voice in the program code where it is needed. In the program code you will also need to import the following parts for the compiler to be able to link to the Voice and Voice Manager.

```
import com.sun.speech.freetts.Voice;
import com.sun.speech.freetts.VoiceManager;
```

Retrieving RT1 and RT2 times from network

On program start-up it will automatically retrieve the RT1 and RT2 times from the network and to display the time of the countdown. There are pre given start time and end time for the audio voice. It is also possible for the user to retrieve the RT1 and RT2 times from the network by pressing "UPDATE" button on "Timer settings".

Manually setting RT1 and RT2 times

If the user wishes to set up manually the RT1 or RT2 time it can be done through "Timer settings" and selecting the values for hour, minutes and seconds. The RESET button will then retrieve both RT1 and RT2 times that were manually set in "Timer settings" and display them in the window below. The time is shown in hours, minutes, seconds and milliseconds since the millisecond is used for the timer listener. When setting up the time, the timer listener will have a time delay of 10 ms for the audio voice, both in automatic and manual settings for the countdown timer.

When the user wishes to start manually the timers for RT1 and RT2 then the "COUNT" button will start the timers after selecting RESET button. The timer for the countdown time will start.

The countdown timers for RT1 and RT2 can be stopped and continued again after selecting the HOLD button that will appear after the COUNT Button has been selected. The HOLD button will hold the current count down times for RT1 and RT2 and continue again from the previous values after pressing COUNT.

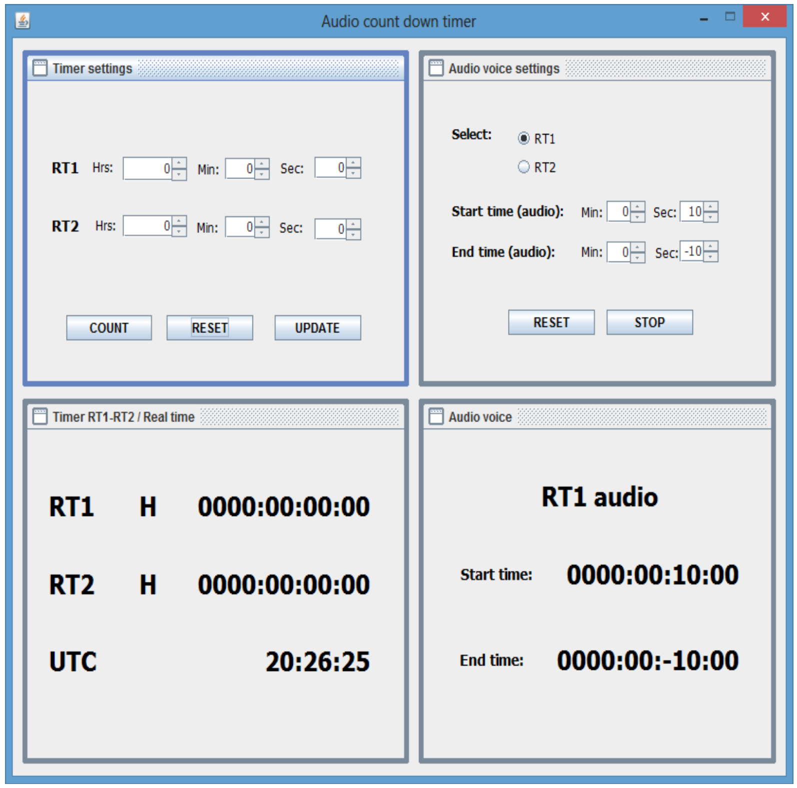

FIGURE 7. RT1 timer selected

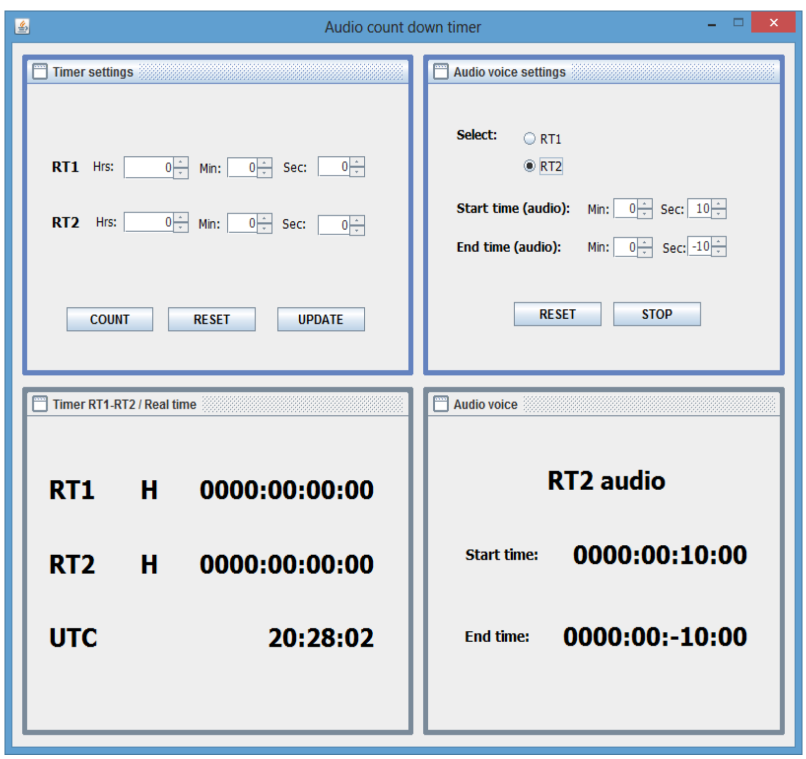

FIGURE 8. RT2 timer selected

Manually setting up start and end times for audio voice

In audio voice settings the user can set up start time and end time for when the audio voice will be heard according to the countdown time. If the audio voice should continue to be heard after 0 then the end time will be set for example in -10 seconds. When the time for example is set to after – 1 minute and 10 seconds then the user sets the minutes to -1 and the second to -10. If the user sets the minutes to -10 and the seconds to 10 then the time will be displayed and used as -50 seconds. When setting the new values the user needs to make sure that the right radio button RT1 or RT2 is also selected (see Figure 7 and 8). The audio voice will use only one of them at a time (RT1 or RT2). When RESET button is selected for the audio voice settings then both the manual and automatic count down timers will use the new settings automatically without the need to start over the count down.

If the user wishes to stop the audio voice from being heard the STOP button inside “Audio voice settings” will do this. This will stop the audio voice internal timer so use this STOP button only when the audio voice needs to be stopped, reset is for the next countdown. The timer would not be able to continue according to the current count down timer after STOP.

The audio voice will start at the given start time value and then for each minute speak out “T minus x minutes and counting” and a beep sound afterwards. For each 10 seconds before 0 the audio voice will speak out “minus x seconds”. When 10 seconds before 0 the audio voice will speak out “minus 10”, “9”, “8”, “7”, “6”, “5”, “4”, “3”, “2”, “1” and “0”. After “0” it will only speak out the number and no use of “minus”. For each minute the beep sound will be used after the audio voice has spoken the minutes.

5.5 USER INTERFACE FOR THE NEW AUDIO VOICE

The user interface to access the digital audio voice includes a manual countdown clock and a timer for when the digital audio voice should start and finish. The user should be able to choose first if it is a countdown for RT1 or RT2. There are separate windows on display for the manual countdown clock and the audio voice timer. In each the time is shown in hours, minutes and seconds. Also the date and UTC time is shown with the correct and actual real time.

In the window where the audio voice timer is placed there is a reset and stop button where the user will to be able to stop the sound and reset the timer for the audio voice. For adjusting the audio sound according to specific needs for the customer this can be done inside the program code before starting the timer and before when the actual launch will start. Later when the launch starts the manual countdown clock is not needed anymore and the audio voice timer will instead read and be controlled by the timing system in the operations center.

The user interface had many phases before it took a final shape. At first the interface would resemble the manual audio system inside the timing room. There were several buttons with links and connections for the audio voice to all facilities on site and rooms. At first there would be an interface where the user could choose in what facilities the audio sound could be heard, which was later on removed. Also a user interface for recording the digital audio sound including the sounds during a launch was created. This was also changed and removed because of the technical quality of the recording system which would perhaps not be enough compared with the existing one.

One of the main requirements for the user interface included that the digital audio voice would be easy to switch on and automatic once the timing system is commenced during a launching process. The digital audio voice should be easy to use and not required or needing constant supervision. For this purpose a simple program icon for pushing and opening the digital audio voice would be created and used.

5.6 TESTING OF THE NEW AUDIO VOICE

Before installing the new audio voice within the real environment, a test version was initially installed separately. All the needed software and applications for the audio voice, were used also in the test version. It was also in the test version that the construction and programming was done and modified.

After a successful installation and testing of the new audio new audio voice on a home portable PC, the next step is to install it into the actual environment where it is supposed to be used. Inside the room where the manual audio countdown voice was, a new computer was installed that was similar to the one used in the timing system. The next step was to see where to place it so that it can connect to the internal network and also the device that is recording (documenting) the audio sound during a launch progress. Also important was that the connection for the audio sound system would be available for the new computer.

What was needed next was to install all the needed software and applications. Another aspect to think about was to have IT security in mind during the installation since the internal network would be using the internet and therefore vulnerable for network security issues. To complete a safe installation it was that the internal network was not used during the application and software installation.

During the installation process also the connection to the internal network was tested. I needed to see if the new digital audio voice would be able to connect to the internal network and use the timing system. This was done by testing with normal Ping messaging. After a successful testing of the internal network connection, the next thing was to see if there is any sound coming out from the loudspeakers inside the timing room. The other loudspeakers would work also if the one inside timing room works. When the audio sound is supposed to reach all parts and facilities at Esrange then a Public Address is used for the connection.

To test the sound system a simple programming code was used and tested without the user interface. The first try was unsuccessful since some of settings in the new computer were not correct, but needed to be set manually. The new computer had special socket outlets for the audio voice and also for the recording device inside timing room. Once the settings for the audio outlet was fixed the digital audio voice worked. The next step was to install the user interface and the rest of the applications needed for the digital audio voice.

One of the staff members was present during this testing phase and was also at the same time I gave instructions and training of the programming code and how to use the new digital audio voice. During the presentation for the staff members the digital audio sound was run and given as a demonstration. All the programming codes was saved as a backup in a memory stick including the application installation files.

6. DISCUSSION OF THE RESULTS

Comparing with previous research the technology for this thesis already exists for a digital audio voice. It has been used in many ways throughout society as previously mentioned, for example in local traffic. However the technology is used and applied in a unique way for this thesis. The digital audio voice had also an additional sound that could be heard according to client specifications.

The main objective for this thesis was to find a solution for a digital audio sound that could replace the manual human voice. This would save staff time and also make the process more automatic with a higher quality of sound in mind. The solution was found for a digital audio sound and also installed inside the environment where the idea was to have in use in the future.

Together with the new digital audio voice the user interface was also created and designed. The design was met with the specifications when using the manual countdown timer so that the sound can be tested without the timer given from the timing system during a launch. This led to extra features in the design that perhaps not needed later after the installation. If later in the future more launch platforms are built then additional changes is needed in the user interface. This is possible through the programming code of the user interface. The design of the user interface changed since initially also the device recording the sound would be installed in the same place using the user interface of the digital audio voice.

What could have been done also during the installation process, was to oversee what network security software is applied to the device where the digital audio voice is installed. This could slow down the internal working memory of the device. Also if the applications have been updated after several years of usage, the memory could be full or the processor of the device could also slow down causing the digital audio voice to be slow.

Another perspective to consider inside the programming code of the new digital audio voice was to include error reports or error messages. This was neglected due to time issues. The error messages could be vital for the staff members using the timing system so that they could be informed when something is not working or has stopped unexpectedly in the digital audio voice system.

7. CONCLUSIONS

The main purpose of this thesis was to find a solution for an automatic digital audio voice that could replace the manual voice in the countdown system when launching sounding rockets into space. The solution was found using a programming code separately from the timing system that controls the digital audio voice from the operating room. Testing of the digital audio voice was made with successful results without using the timing system inside the internal network. The device that had the installation of the new digital audio voice was tested with success for possibility of connecting to the internal network.

The user interface for the digital audio voice had the requirements of stopping and setting the timer of the audio voice. Once the timer starts the digital audio voice is automatic and does not require supervision by a staff member. The sound and timing of the sound can be adjusted inside the programming code. The voice can also chosen from a list inside the settings with three kinds of different voices, or if additional applications are installed there are more voices to choose between.

Another aspect for development in the future with the user interface is removing the internal manual countdown clock of the digital audio system. Since the digital audio voice while it was installed was tested without using the timing system inside the internal network, the internal countdown clock is no longer needed. The link to timing system, once added to the digital voice makes the system and voice automatic.

While installing the digital audio voice there came many aspects to consider in the future. The computer holding the installation of the digital audio voice needs updating of internal software applications. Once connected to the timing system it is important that no firewall or other software is blocking the access to the internal network.

The conclusion is that digital audio sound is working and can be used when launching sounding rockets. The user interface can be adjusted and also the sound can be different while there is a choice between different voices. Network security is important to consider also so that the system is protected and not linked to the outside network, only to the internal when used.

As a summary, the new synthetic audio voice that was chosen, ended up being the computerized digital audio voice instead of a recorded voice. In order to customize the audio voice according to customer needs the audio voice can be adjusted inside the programming code. The hardware for the new audio voice was a new computer similar to the one used inside the timing system at operations center. The software which was needed for the new digital audio sound was java runtime environment, eclipse and FreeTTS voice software that can be downloaded. The programming code inside the new digital audio voice was Java since the programming code inside timing was also java. A space was left inside the programming code for linking the new digital audio voice to the timing system inside the internal network POSNET.

The hardware and software for the new digital audio voice was installed inside timing where the manual system was and also where the recording system existed. The digital audio sound was going to be recorded, important was to connect to the device. Possibility for connecting to the internal network was found inside timing. An additional sound was added, a digital beep sound that could be used in the sound system when a minute passed. There is possibility to add additional digital or recorded sounds inside the programming code if needed. The user interface or framework for the device should be basic with the frame displaying the countdown time and also buttons for stopping or moving forward the timer for the audio voice. The framework should include a frame for selecting the starting time and end time of the new digital audio voice.

There are perhaps other similar software like the FreeTTS that could be used, more research in finding others needs to be done in that case. The new digital new audio sound was used, question remains how much of the user interface or framework remained unchanged. The sound worked and the framework for it gave the basic tools for adjusting and setting the digital audio voice.

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