OULUN YLIOPISTO
UNIVERSITY of OULU

Department of Process and Environmental engineering

Master thesis

Usability analysis of the FDT standard Device Type Manager (DTM) in the plant life cycle

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Author: ______________________________
name in block letters

Supervisors: ______________________________
name in block letters
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UNIVERSITY OF OULU **Thesis Abstract**

Faculty of Technology

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Author		Thesis Supervisor	
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Abstract

Fast development and complexity of modern automation has brought many challenges to automation solutions providers. One important part of modern automation is Plant Asset Management (PAM) tool, especially in field devices business where Company X is market leader. The communication between the field device and PAM tool is done via Device Type Manager (DTM). DTM is a Human Machine Interface (HMI) which provides the high sophisticated parameters of the device to a one interface. HMI or SCADA (Supervisory Control and Data Access) systems developers are facing serious problems to give users needed information in a package which is usable.

This research will concentrate to clarify and improve current DTM usability for Company X (CX). First, the thesis will go through CX DTMs user types. User type's clarification will be the basis information for usability benchmarking tests with the biggest competitors of CX. Benchmarking tests will concentrate on commissioning, because it is the most time spending and that is why the most money consuming, regular task in a field device plant life cycle. In the end, master thesis will provide a clarified user types with the user needs and goals towards the DTM. Plus the main thing, to a have an improvement proposals for DTM usability for today and future.

Tests showed that CX is way behind in the efficiency and also in the satisfaction towards competitors. In usability satisfaction, CX was competing against Company M from the last place when Company V and Company E are fighting of the first place. Quite describing is the average rate of satisfaction, for Company E it was 6.05, Company V 5.71 and then comes CX with average rate 4.56. Only Company M had worse users` satisfaction rate with 3.91. In the efficiency the situation was similar, CX where competing of the last place when Company M and Company E were almost twice faster. According to the benchmarking tests, in effectiveness CX where only one who had DTM where users made faults. In other issues, tasks performers asked help if there were problems.

Fast development and complexity of modern automation has influenced also to CX DTM usability, making DTMs huge and complex from the usability and structure. It is shown in the test that DTM usability hasn't been the focus of CX by this far. Anyway, now it should become one of the tasks to make a serious improve.

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OULUN YLIOPISTO **Tiivistelmä opinnäytetyöstä**

Teknillinen tiedekunta

Osasto		Koulutusohjelma (diplomityö) tai Pääaineopintojen ala	
Prosessi- ja ympäristötekniikan osasto		Prosessitekniikka	
Tekijä		Työn valvoja	
Kanto Markku		Haapasalo H, Professori	
Työn nimi			
FDT standardisoidun Device Type Managerin (DTM) käytettävyysanalyysi elinkaaren aikana			
Opintosuunta	Työn laji	Aika	Sivumäärä
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Tiivistelmä

Automaatioteknologian nopea kehitys ja monimutkaisuus ovat tuoneet uudenlaisia haasteita automaatioratkaisuja tarjoaville yrityksille. Kenttälaitteita tarjoavassa liiketoiminnassa, jossa Yritys X (CX) on markkinajohtaja, laitostenhallintatyökalut ovat yksi tärkeä osa modernia automaatiota. Laitostenhallintatyökalujen ja kenttälaitteiden välillä Device Type Manager (DTM) on puuttuva kommunikoinnin palanen. DTM on ihmisille kehitetty käyttöliittymä (Human Machine Interface - HMI), joka tarjoaa laadullisesti tarkkoja mittalaiteparametrejä yhdelle näyttöpäätteelle. HMI ja SCADA eli käytön ja tiedonsiirron ohjauksen hallinta työkalu (Supervisory Control and Data Access) systeemin kehittäjät ovat kohdanneet todellisia haasteita yrittäessään tarjota tarpeellisen tiedon, joka olisi samalla myös käytettävyydessä toimiva.

Diplomityö tulee keskittymään Yritys X:n DTM:n käytettävyyden analysointiin ja kehitykseen. Ensiksi diplomityössä tarkennetaan jo standardisoituja CX:n käyttäjätyyppejä, jonka jälkeen saatu tieto tullaan käyttämään alustavana tietona CX:n suurimpien kilpailijoiden vertailututkimukselle. Vertailututkimus tulee keskittymään käyttöönottoon, koska tämä on eniten aikaa vievä vaihe ja täten myös kallein normaalisti tehtävä työvaihe kenttälaitteiden elinkaaren aikana. Diplomityö tulee tarjoamaan tarkennetut käyttäjätyypit ja niiden tehtävät sekä tavoitteet DTM:lle. Lopuksi diplomityö esittää parannusehdotuksia DTM:n tämän hetkiselle ja tulevaisuuden käytettävyydelle.

Testit osoittivat että CX:lla on paljon parannettavaa käytettävyyden suhteen. Sekä suorituskyvyssä että tyytyväisyydessä, CX oli vasta kolmannella sijalla, selvällä erolla kärkikaksikkoon. Myös tehokkuudessa huomattiin selkeitä puutteita CX:n DTM:ssä. Kuvaava tieto CX:n heikohkosta menestyksestä käytettävyystesteissä kertoo käytettävyys tyytyväisyyden keskiarvot. Yritys E:n keskiarvo oli 6.05 ja kakkosena olevan Yritys V:n 5.71. Seuraavaksi tuli CX selkeällä erolla keskiarvoin 4.56. Ainoastaan Yritys M:n DTM sai huonomman keskiarvon 3.91.

Nopea kehitys ja monimutkaisuus automaatioliiketoiminnassa ovat vaikuttaneet myös CX:n käytettävyyteen, tehden siittä valtavan ja monimutkaisen rakenteeltaan että käytettävyydeltään. Testit osoittivat että CX ei ole keskittynyt DTM:n käytettävyyden parantamiseen, joten nyt olisi aika alkaa tekemään todellisia uudistuksia käytettävyydenkin suhteen.

Säilytyspaikka

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Last chapter of acknowledgments I want to dedicate to very special person – to my love Iida. Your support is something which matters the most and you were there always when I needed it. Even your huge help to correct the thesis linguistic form was definitely crucial. So thank you Iida ;)

Markku Kanto
8.8.2012

Abbreviations

AG	Aktiengesellschaft (cf. Osakeyhtiö Oy)
AT	Attitude towards Using
CoDIA	Common Architecture
CommDTM	Communication DTM
DCS	Distributed Control System
DTM	Device Type Manager
FDT	Field Device Tool
FF	Foundation Fieldbus
GUI	Graphical User Interface
HistoROM	Memory module
HMI	Human Machine Interface
ISO	International Organization for Standardization
I/O	Input/Output
NASA	The National Aeronautics and Space Administration
NASDAQ	Stock market, comes from words "National Association of Securities Dealers Automated Quotations"
PAM	Plant Asset Management
PEU	Perceived Ease of Use
PEUU	Perceived Ease of Use + Usability
PLC	Programmable Logic Controller
PU	Perceived Usefulness
SCADA	Supervisory Control and Data Access
SUMI	Software Usability Measurement Inventory
TAM	Technology Acceptance Model
PC	Personal Computer
PLC	Programmable Logic Controller
USB	Universal Serial Bus

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1 Introduction

1.1 Research Background

The world today is quickly variable, hectic and more uniform because of developing communication technologies. For individual, development has a pros and cons impact. Fast information exchange and services makes the normal day tasks easier to carry out. On the other hand, more flexibility, learning and complexity are required. In the process automation the phenomena is similar. Tougher competition strive companies to focus on better product quality and higher output regulations. Larger and complex factories with more complex instruments are quite describing of today's scenery on the factory side. Commissioning time of a large and complex factory is a key factor of the customer. The commissioning time is also determined by commissioning of the individual devices that could have a huge number of parameters. For individual it is not feasible to know every process equipment in detail. Therefore, it's an important success factor for the manufactures of process instruments to allow users a simple, fast and comprehensible guidance at any time and for any application that leads to a reduction of commissioning time and avoid humane mistakes during that process. To achieve this, it is an essentially important to understand the major customer workflows and usability behaviours.

This work will concentrate on clarifying and understanding Company X (CX) user types. Their demands and expectations will be specified via empiric usability study and the CX situation among the other competitors will be tested by benchmarking. The work will be done for one specific device which will be representative for level measurement devices. Only one device has been chosen because of the limited time to accomplish the master thesis.

CX is recognized supplier of industrial measurement and automation equipment, providing services and solutions for industrial processes all over the world. CX is solutions provider for measurement devices and for digital communication. Master thesis is done in Department Y (DY) which has an important role for developing solutions for CX. DY has, among others, Software Tool (ST) which is a frame application for communication of process automation devices. For ST, Department Y has done a lot of research and development regarding to customer satisfaction and usability. ST is using FDT (Field Device Type) / Device Type Manager (DTM) technology to "bridge" between physical plant device and Plant Asset Management – software. On other words, DTM is a driver which makes all the field device parameters available to one out source, for example laptop screen where is ST running. Therefore, example ST is working as a frame application for all device information provided by DTM. (Anonym. b)

This research is done to get overall picture of the current DTM usability state from the view of customers and to get better understanding about users` main workflows. Afterwards, apply this information to improve usability of new DTMs according to user requirements.

1.2 Research problem and questions

The basis of research problem is a complexity of modern process automation. Complex devices with thousands of transactions, changing environments, different user workflows and not forgetting that all listed features are changing rapidly, are together creating the contest for this research. This research will have a scope to understand and clarify the typical user types and workflows for the basis to a further usability benchmarking study in the master thesis. At the end of the day, there should be a solution, which would clarify where the CX is at the moment from the eyes of users by comparing to the biggest competitors and what CX should do to improve the current state. The first research question is about defining usability.

RQ1: How to define and measure usability?

RQ2: What are the users and how usability of DTM could be analyzed?

RQ3: What should CX do to improve the usability of DTMs?

1.3 Research process

After correct research questions were formulated, was research focusing on literature reviews. Literature reviews were basically shared into two groups: user type's clarification and usability analysis. Authors, such as Holden and Rada (2011), Lazar (2006), MacDorman et al. (2011) and Preece (1994, 2001), are the main sources for literatures about usability analysis (RQ1). In this research, usability guru Nielsen`s literatures (1993. 2003, 2011) were widely used to get basic knowledge about usability. At the beginning of the research author Sinkkonen (2002) was an important role to create knowledge of usability philosophy. Interviews about user type's clarification were the first step in the empirical part, giving clarified user types and user types goals/needs for further research (RQ2). Selected people for interviews were persons who had a long history with the evaluated product. The most important fact was that the selected persons are representing different aspects of the product life cycle for example sales, developer and product management. From these views were supposed to find similarities and also differences that possible user type's goals and needs could be defined. This was the input for benchmarking tests to create tests where all types of users were noticed. Benchmarking tests were based on the newest usability researches. Upcoming usability problems were solved with new improvements to usability. These improvements were summary of literature review and benchmarking tests results. In the end, research have defined user types and proposed improvements for usability (RQ3). (Fig.1)

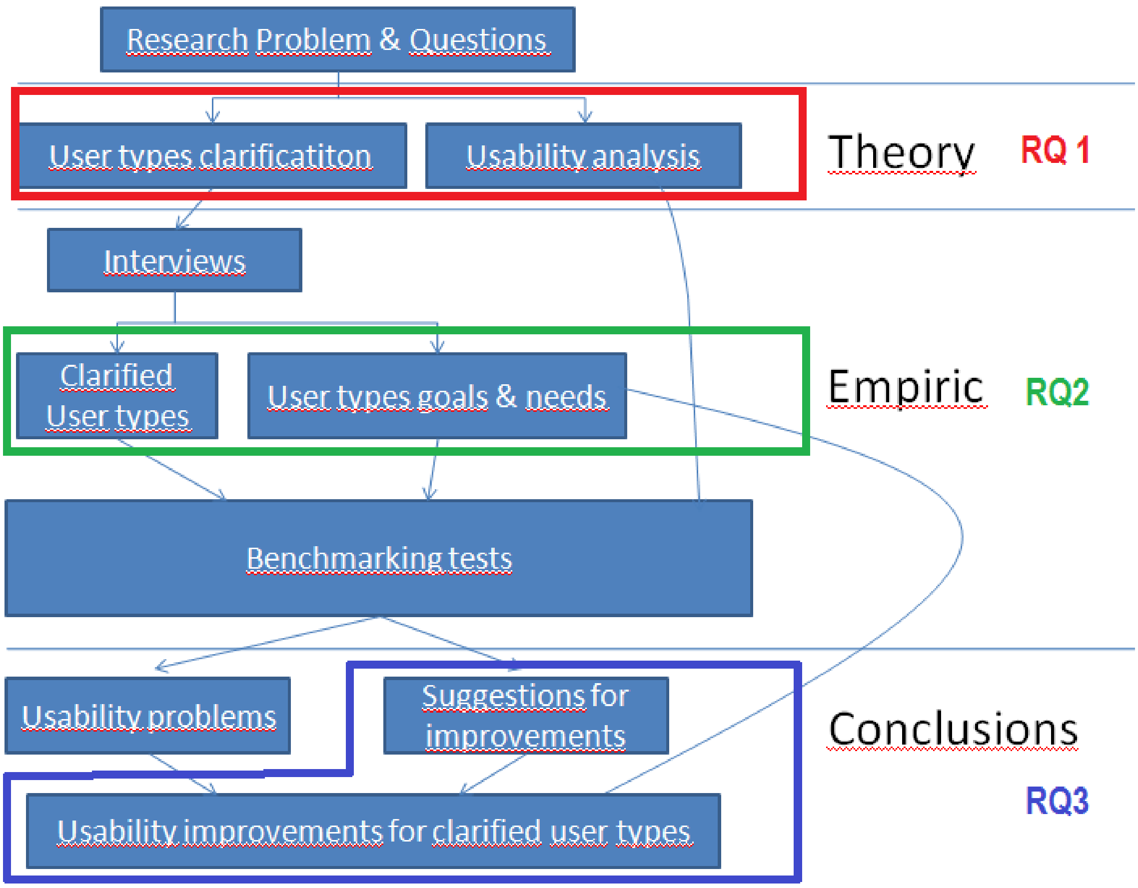

Fig. 1. Research process.

2 What is usability?

Usability has been under “magnifying glass” soon twenty years. Many studies and researches have been done but still there is much to do. After computer giant Apple Inc. managed to make huge market possession in the last seven years mainly because of easy usability and beautiful topology, (NASDAQ 2012; Wyss & Hoh 2012) has usability come up with one of the continuing topics at least in the branch of technology. Usability is a feature of a product what measures how well the user is able to take advantage of the product (anynom. c). Usability is a co-influence of different abilities and for example easiness of use is not enough for making product usability. According to Dziba (1995) usability is a general term for ergonomic product quality and replaces colloquial terms such as user-friendliness or ease of use. (Babbar et al. 2002)

Usability is everywhere and everything what has to be done is somewhat connected to usability. Most of the cases people don’t think about usability and it is more or less just a part of a common procedure. Anyway, it is a huge boost for the product value to own an excellent usability. Most of the cases it is not straight connected to better sales figures because product users have different reasons to select the products, for example habit to buy exactly same milk every day. So the meaning of usability will in most of the cases come on delay. In the example before, it is much easier to use a carton of milk with a cork for pouring than without. For products with higher prices and longlastiness, the meaning of usability is even stronger because the purchasing process will consist of more thinking, evaluation and comparison. According to Shackel (1991) “user or consumer is assumed to compare product features with required sacrifices. Hereby, at the purchase situation customer will compare product utility, usability and pleasantness with the expenses of the product, and in the end best option will be selected.” Of course there are products for what example efficiency, which is also a one important feature of usability but definitely not only, is exclusively the main feature but products with high usage hours the complete usability will step strongly up.

2.1 How to define and measure usability

Shackel (1991), Nielsen (1993) and Lu & Yeung (1998) defined usability to be part of product or system acceptance. Therefore, in their models usability has straight relationship with acceptance of system. As mentioned previous chapter, Shackel described usability to be one characteristic of system acceptance which will go to user comparison while selecting the system. According to Shackel (1991) the product acceptance will be a function of perceived utility, usability, likeability and costs. Nielsen (1993) slightly disagree with Shackel (1991) and suggesting that usability and utility is part of usefulness. Usability being a measured by users ability to do possible functions with the system and on the other hand utility is systems possibility to success with different functionalities. Nielsen also claims that Shackel (1991) mentioned perceived system attributes will lead to practical acceptability of a system. For defining usability, Nielsen (1993) underlines that usability consist of five major characteristics: learnability, faultlessness, memorability, efficiency and pleasantness. International Organization for Standardization (1997) is adding effectiveness to the list. Preece (Preece 1994: Preece & Rodgers 2002) is between of Shackel and Nielsen by describing usability to be a combination of effectiveness, efficiency, safety, utility, learnability and memorability. Lazar (2006) again wrote that easiness of system use and predictability are the needed characteristics. Schneiderman (2002) is quite a lot in the same opinions with Lazar by telling that consistency and user control are the factors for usability.

As you can read before, usability is described as many times and ways as there are published documents. Still there is much same in all description. One important attention to be notified is that in the latest usability studies the concentration has scoped for subjective usability, which is many times called satisfaction. More detailed to avoid situation where user doesn’t understand the contest. This is extremely important in web page usability because the site has often only one change to satisfy user and if he is not pleased, in a split of second user will be another competitor’s customer. Nevertheless, the result of users misunderstand will be frustration, what is a major issue to be avoided for professional applications such as ST and a device DTM. Why mentioned web usability aspect then, because it should be in the mind that most of the latest studies are made for improving website usability (Lazar 2006: Casalo et al. 2010) and there are slightly differences in the circumstances and the values what are important to take consideration.

User should not end up to situation where he feels like it is too hard to use system. This will end up to user mistakes and frustration. (Lazar 2006) Frustration has been identified as a major issue exceptionally for novice users. (Bessiere et al. 2006: Kang & Yoon 2008: Kjeldskov et al. 2005) Lazar (2006) & Schneiderman (2002) mentioned predictability, consistency and user control for avoiding situation where the mistakes, faults and frustration are able to come. ISO`s (1997) mentioned effectiveness, has these all aspects included as far as from the measured usability can go. Effectiveness will decrease if user doesn’t understand the workflow for tasks and that way the predictability will suffer. This will also affect to users trust towards the product and to feel of the user control. It is an important to keep user informed what his or her actions will do. To have understanding more deeply of subjective opinion of the user, it is good to use interviews or any different kind of methods where the focus will be on the subjective usability. Technology Acceptance Model (TAM) is one model which is focusing to figure out these subjective “opinions”. TAM model will be more detailed later of the master thesis.

Effectiveness, efficiency, learnability and satisfaction are attributes which are somehow in many definitions. (Hassan 2005) Still Nielsen`s (1993) mentioned memorability and faultlessness are also good to be in mind while defining usability. Basically learnability and memorability are the major abilities for system understanding. Most of the cases, starting by understanding of a system in a whole is a better approach than mechanic training or learning. (Kalakoski 2007) For device, it would be an ambitious approach to make product so easy to use and understand that while learning the device the understanding of a system will increase as well. (fig.2) Nielsen (1993) mentioned faultlessness is on the other hand highly part of effectiveness and also the state of product where every software developers aims to – bug free software.

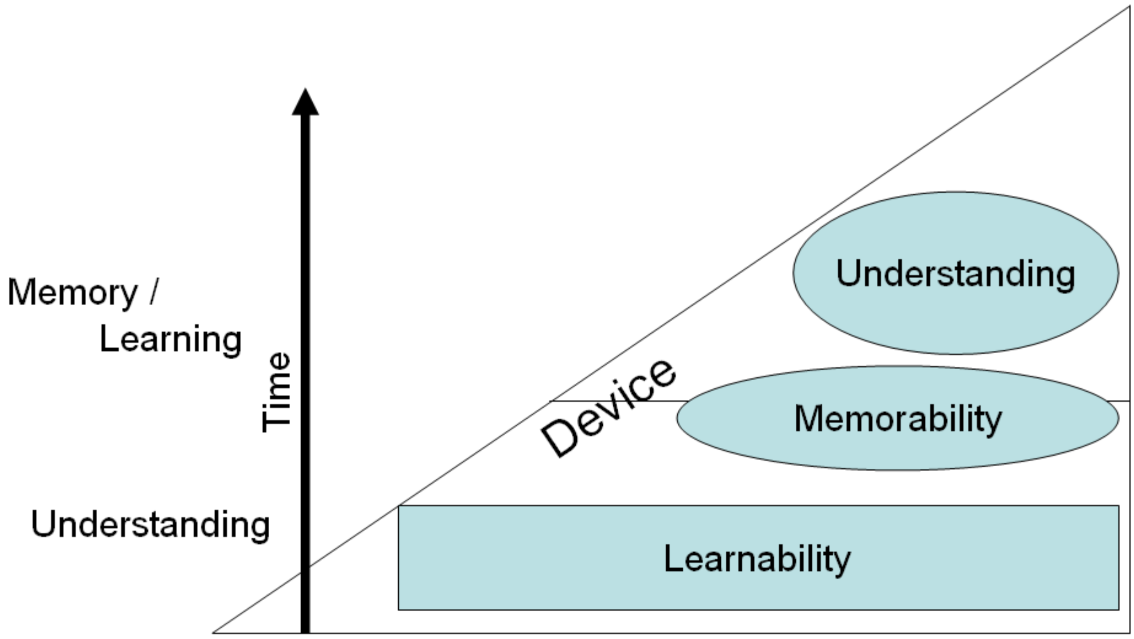

Fig. 2. In the most of the cases learning of system will or should start from understanding the bigger picture than mechanic learning. But for the device developers it would be a goal to create device where understanding happens while learning.

Remembering previous abilities while making new software or developing the old would not lead badly wrong. Nevertheless, these are just abilities where to scope but doesn't tell at all how, so possibility to go wrong is still high. ISO (1997) defines that there is no such thing than general good usability because usability is always depended on context. Hence, usability is always under influence of tester background and experiences, features of usage equipments and services, the abilities of tested tasks and quality of guidance. When the content is known, it is a possibility to measure the product efficiency for example by benchmarking tested product with competitors. (Kalenius 2005) Later in the research, benchmarking will be in closer review. Next will be clarification of characteristics mentioned above:

Learnability: Practically, how easy the product is to learn. What includes among others, that the first configuration must be smoothly to execute and most of the times fast. It is profitable for company to make product what is ease to learn because in a long run it will be rewarding in the form of fewer training fees and working hours. According to Nielsen (1993) the learnability is the most important characteristic. This is close to truth with web pages but professional applications, such as DTM, it will be more or less same level than other characteristics. ISO (1997) claims learnability to be a combination of output, efficiency and pleasantness. Nielsen (1993) adds uniformity to picture. In the figure below, is possible to see needed abilities, how to measure it and suggested test method to evaluate learnability. (fig. 3)

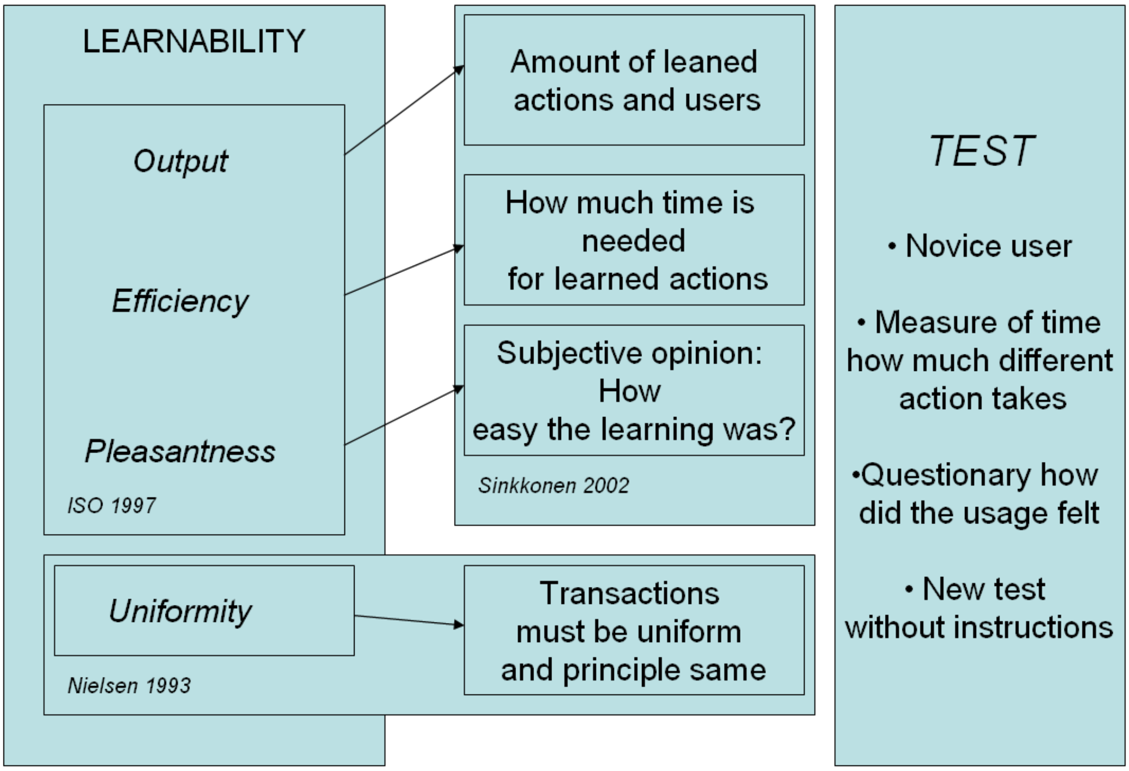

Fig. 3. In the figure, can be found abilities for learnability and how those can be tested. (Sinkkonen et al. 2002: Nielsen 1993: ISO 1997)

Efficiency: From the usability point of view, efficiency is a possibility to test with the users who are willingness to do more with product and want to improve existing knowledge. (Kalenius 2005) It is tightly connected to usage speed and easiness of the product topology what makes it possible to be operationalized using performance metrics. (Brinkman et al. 2007: Lindgaard & Dudek 2003) Efficiency is typically operationalized by metrics as completion time, preparing time before execution, deviation of optimal path and use frequency. (Hornbaek & Law 2007) Further, is a figure where are efficiency, characteristic of efficiency such as completion time, and effectiveness added into same picture. Characteristics, which are banded to each other, are connected with arrows between efficiency and effectiveness. (fig.4)

Effectiveness: Is clarified with completion of tasks without any "drawbacks" and also with time. If efficiency is answering to question "how much?" then the best describing question for effectiveness is "How pure is the output?". (Illikainen et al. 2011) Hornbaek and Law (2007) wrote that effectiveness is easily operationalized by such metrics as error rate, binary task completion, spatial accuracy, outcome quality and recall. (fig.4)

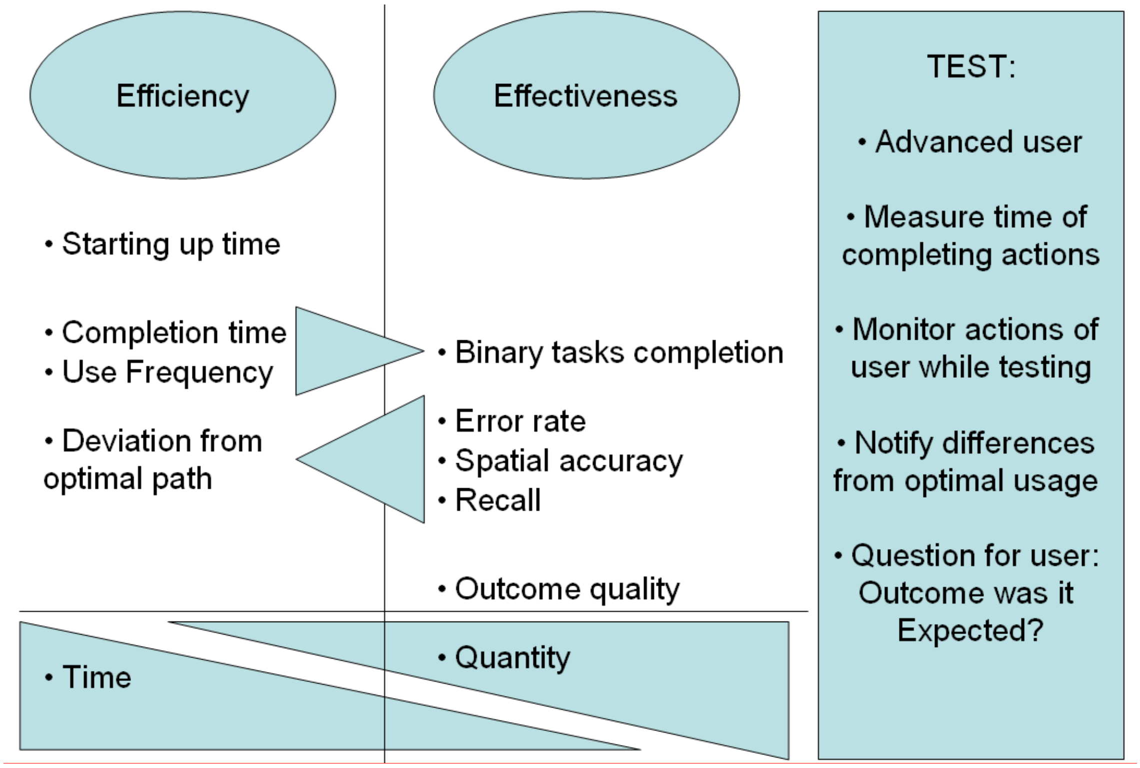

Fig. 4. Efficiency is straight connected to time when effectiveness is more about quantity and quality.

Memorability: is affecting to user straight when he/she starts to learn because memory is usually considered as some kind of warehouse, where the gathered information from surrounding is placed to either short-term- or long-term memory. (Eysenck 1993) Short-term memory is used in a beginning of learning process and after while when for example topology of product is starting to be known, starts the long-term memory become more controlling possession. Hence, uniformity is also important for memorability as it was for learnability, (Nielsen 1993) can memorability be made easier for user if the product topology is categorized rationally, describing drawings are shown, not too many steps for one task and logic of usage is simple. Best testing group would be users who use the product every now and then.

Faultlessness: Is ability what needs to keep user aware if something remarkable is going to happen from his or her actions. It is kind of guidance for user what makes him or her to think through what is about to happen. It is made to keep mistakes less as possible and also to improve user satisfaction. Normally informing is accomplished by notification, warning or error sign, also sound is used to gain user attention. (Kalenius 2005)

Pleasantness or better known as satisfaction: User satisfaction is subjective which cannot be measured. (MacDorman et al. 2011) It is influenced by cultural background of users, also aesthetic, language and users values. Conclusion for satisfaction is combination of all six characteristics added with all subjective views. Objective user is “brutal” towards all disadvantages and every drawbacks influence to general overview of the product – what is called satisfaction. Later deeper view will come how to approach subjective experiences. (Kalenius 2005)

Trust or confidence to system: This is an important ability for user to be guided and informed what are coming to happen. Good trust to system will improve the user confidence to system and as well confidence to himself. (Fisher et al. 2008: Casalo et al. 2010)

Measuring subjective usability

Subjective usability or satisfaction of user is only possible to evaluate with interviews of users after the test or/and notifications made while tester is executing the test cases. In other words, to get straight subjective feedback from the tester or/and third person objective view of tester satisfaction while testing. Next will be presented couple of indicators or used scales to have subjective opinion gathered from the user. There are made much of different methods to figure out subjective satisfaction about the product. Testers attitude, use friendliness and stressful are the topics where researchers have made different kind of theories and methods how to get right information out from the testers. (Keinonen 2007) Next will be mentioned couple of different methods:

Software Usability Measurement Inventory (SUMI) is made for measuring observations and feelings of user. (Porteous et al. 1993: Kirakowsky 1996) It has a perspective of objective attributes focusing on emotional output. Model includes following characteristics (Keinonen 2007):

- Affect, usage of product will give different emotions to user and it should be autonomous of practical demanding.
- Efficiency, which consist of user exhausting, expectations, suitability to task and perceived time to execute stages.
- Helpfulness means how clearly different steps are guided and how useful given advices are.
- Control will come up with how well and smoothly product is following different orders from user, and how well it goes past error situations.
- Learnability consists of learning work rate, easiness to remember learned and quality of instruction guides.

NASA Task Load Index (NASA TLX) is made to measure the mental stressful of work where is observed six attributes affecting to strain. Attributes are weighted according to tasks. At the end average will be calculated. Attributes are (Keinonen 2007):

- Mental strain
- Physical strain
- Demanding due to timing
- Demanding of execution
- Effort
- Frustrating

The most known and used *Technology Acceptance Model* (TAM) describes relationship between the noticed features of the device, emotional attitude and the actions of user. (Davis 1993) TAM is a theoretical model that predicts how a user comes to accept and use a given information technology. It specifies casual relationships among external variables, belief and attitudinal constructs, and actual usage behaviour. (Hubona & Kennick 1996: Holden & Rada 2011) In this model, objective attributes works as psychical stimulations for user, resulting in the consciousness of the user's beliefs, then to attitude and finally to actions. The model is shared to three branches (Davis 1993):

- Perceived usefulness, the degree to which an individual believes that using a particular system would enhance his or her job performance.
- Perceived ease of use, the degree to which an individual believes that using a particular system would be free of physical and mental effort.
- Attitude towards using. (fig 5.)

Many researchers in various disciplines have developed a multitude of revisions and extensions to the TAM (Burton-Jones & Hubona 2005: Davis 1993). Holden & Rada (2011) adds usability to perceived ease of use and creates a concept Ease of Use + Usability (PEUU. This has been found to have a stronger connection and explain more of the variance in usage behaviour than Perceived Ease of Use (PEU) alone. That is why in Holden and Rada TAM –model is PEUU as one tested group. Also researches have proven that PEU directly influences to Perceived Usefulness (PU). Nevertheless a Critical limitation of the TAM -model is its lack of emphasis on the system characteristics, which may influence user acceptance. In this research, the testers will be selected the way that they will have understanding to the branch of the study and the used system technology. (Holden & Rada 2011)

Table 1. Perceived Ease of Use (PEU) and Perceived Ease of Use + Usability (PEUU) Measures

Statements	Measure	Element
My interaction with the technology is clear and understandable.	Understandable	PEU + PEUU
Interacting with the technology does not require a lot of my mental effort.	Mental Effort	PEU + PEUU
I find the technology to be easy to use.	Ease of Use	PEU + PEUU
I find it easy to get the technology to do what I want it to do.	Ease of Use	PEU + PEUU
I find the technology to be flexible to interact with.	Flexibility	PEU + PEUU
Learning how to perform tasks using the technology was easy.	Learnability	PEUU
The technology has good functionality (features).	Functionality	PEUU
I feel I have an intuitive sense on how to operate the technology.	Navigation	PEUU
I find it easy to remember how to perform tasks using the technology.	Memorability	PEUU

Table 2. Perceived Usefulness (PU) Measures

Statements	Measure	Origin
Using the technology improves my performance in my job.	Performance	Original PU (Davis, 1989)
Using the technology in my job increases my productivity.	Productivity	Original PU (Davis, 1989)
Using the technology enhances my effectiveness in my job.	Effectiveness	Original PU (Davis, 1989)
I find the technology to be useful in my job.	Usefulness	Original PU (Davis, 1989)
In my job, usage of this technology is relevant.	Relevance	(Viswanath Venkatesh & Davis, 2000)
I have no problem with the quality of the technology's output.	Output Quality	(Viswanath Venkatesh & Davis, 2000)

Table 3. Attitude toward Using (AT) Measures

Statement: All things considered, my using the technology is….

Pairs		Origin
Bad	Good	Original AT (Davis, 1989)
Foolish	Wise	Original AT (Davis, 1989)
Unfavorable	Favorable	Original AT (Davis, 1989)
Harmful	Beneficial	Original AT (Davis, 1989)
Negative	Positive	Original AT (Davis, 1989)

Fig. 5. Questions made for users according to TAM –model (Holden & Rada 2011)

3 What are the used methods of the research

Benchmarking is a measuring method widely used by companies to improve many areas of activities including human resource management, information systems, customer processes, quality management, purchasing, and supplier management. (Elmuti 1998) The common goal of this approach is to identify the "best practices" of other competitors so that it can be implemented for own operations. (Hassan & Li 2005; Nielsen 2003) On the other words, the benchmarking is normally used for bridging the gap with competitors and moving from where one is now to where it wants to be. Benchmarking can be also made inside the company to make whole catalogue more uniformity. Benchmarking is valuable piece of tool to have updated information what are the customer needs at the moment. (Chang & Kelly 1995) This all will be approached by identifying strengths and weaknesses.

There is made eight steps model for benchmarking. (Chang & Kelly 1995; Codling 1992; Branham 1997: Anderson & Petterson 1992) Because of general nature, the model is compatible for all kind of benchmarking. According to Chang & Kelly (1995) will be introduced phases of benchmarking step-by-step. (fig.6)

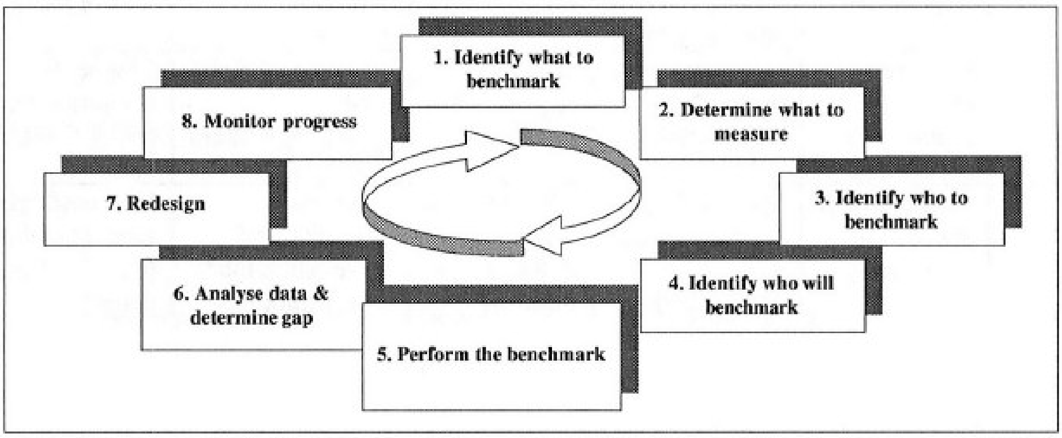

Fig. 6. 8-Steps for successful benchmarking (Hassan & Li 2005)

Step 1: *Identify what to benchmark*: In this case, earlier mentioned characteristics such as efficiency, pleasantness/satisfaction and effectiveness. The decision must be made where the benchmarking will concentrate on, to all factors with different "weight" value or just to some. This will depend on time constraint and how many people will be involved in the tests.

Step 2: *Determine what to measure*: What will be the measured value for different factors. Quantitatively or qualitatively approach for what abilities?

Step 3: *Identify who to benchmark:* Depends what kind of benchmark will be done. Is it internal or external? In case the benchmark will be external, it is important to know who are the biggest competitors and make the benchmark for those at least.

Step 4: *Select Evaluators*: Important factor for evaluators is that they know the benchmarked environment well. There is not needed to have so much knowledge about the product but process or system knowledge is mandatory to have. In fact, the best option would be to have a evaluator who has no experience from the tool and on the other hand evaluator with high know how of the tool, to get the deepest perspective from the various kind of end users.

Step 5: *Perform the Benchmark:* After you have done all steps before, can be done the real benchmarking. First is important to have test environment prepared with all necessary equipments. Then it is necessary to make little briefing session to evaluators that they have understood how to act. Then confirm question about the understanding is good to ask. On request, little demonstration would be appropriate. Then tasks will be given on a paper and evaluators can start the benchmark.

Step 6: *Analyse Data and Determine the Gap:* Make analyse of data. Create charts and lists where comparison is easily done. By comparing subjective results with objective measurable results, the possession where CX is at the moment from different abilities should be then possible to do towards other competitors.

Step 7: *Redesign:* Make requested changes. Then will come up the step 8 - monitoring progress. This is the way to make sure that new changes have made progress. The best is to do retest among little test group before letting new design published. In this research step 7 and 8 will be done if there is time. (Chang & Kelly 1995)

3.1 Focus on benchmarking

In the master thesis the usability will be approached by benchmarking. More detailed master thesis will focus on commissioning. The plant device life cycle has a three major phases: engineering, commissioning, operation and troubleshooting. The master thesis will concentrate on commissioning, because it is the most time spending and that is why the most money consuming, regular task in a field device plant life cycle. That is why benchmarking will be done for commissioning and from there more detailed to commissioning attributes such as effectiveness, efficiency/performance and satisfaction. Workflow of commissioning is in special focus. This is an important factor of effectiveness. It will increase of understanding towards the product when it is done logically. On other hand it can be misleading and frustrating to user. Then this would mean more mental effort for user and the same time effectiveness of usage will suffer. First will be workflow in deeper look.

3.1.1 Effectiveness - content of workflow

Nielsen (2011) underlines importance of workflow. User must be aware what will happen from different transactions. By Nielsen (2011) words “Actions at one step of application impact subsequent steps. When users don’t understand this relationship, usability suffers." More clearly this can be seen in topology tree. There are snapshots from old and new DTM user interface. The old topology tree is more directed for developers because of technical content and the new one is clearly pointed for different users – customers. In new DTM the menu folders are shared according to standard 1xx specified user types. This is an improvement because users have a better picture of the folder content. For example by clicking one of the folders, the opening folders should be predictable – and if those weren't, after clicking and seeing the content, the content should be at latest clear. Of course, the understanding of content always depends on users know how. This kind of customization is a good approach for DTM development.

According to Nielsen (2011) there are three main consequences after bad and uncomprehending workflow. These three consequences are; (1) *Undiscovered errors* that occur when users don't relate what happened on screen. (2) *Abandonment,* where users simply give up on something they don't understand. (3) *Frustration,* which arises when an awkward process takes much more time than it should. Individual technical elements are mostly reasons for user delay, thus poor workflow can be really frustrating to user.

In 2001, Jeffrey Zeldman introduced three-click rule claiming that it "can help you create sites with intuitive, logical hierarchical structures". This is sure true that better to keep structures in some kind of limit clicks, but why on three clicks? Porter (2003) made study about the topic and noticed that "Hardly anybody gave up after three clicks". The more important is to understand the connection of different steps, not the exact amount of clicks.

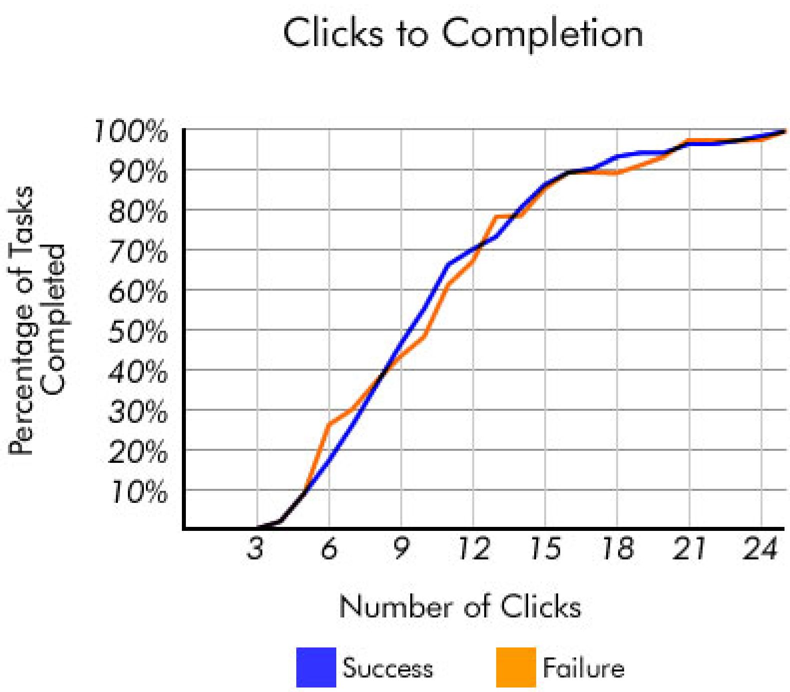

Fig. 7. Number of clicks shown in figure of completed tasks. (Porter 2003)

Last point for workflow is the motoric align what means to have a list of things in too little space, even a way that there will be part of the text missing. Too less space for the text makes the navigation much slower than text in well scaled window. Motoric align problems can be happening in vertical- or in horizontal axel. This problem is important nowadays because of different platforms to use software. Hand held device with 8-

inches screen is different that 20-inches desktop monitor and that is necessary to keep in mind when developing new software or features.

Also the important for effectiveness is to keep track on faults and needed help for using the software. By keeping the tests uniform between different benchmarked devices the results between amount of faults and needed help is possible to compare among tested devices. Just the result of faults and needed help is clear sign if there is a usability problem or not, in this case lack of effectiveness or not.

3.1.2 Efficiency and satisfaction

Efficiency and satisfaction will be also attributes which the benchmarking tests will clarify. In the tests the performance of different tasks is measured. With background information of the users the performance results are easily comparable with other (3rd party) devices. For satisfaction benchmarking is need to have tester possibility to tell his or her feelings while performing the tasks. After the tests is also need to make questionnaire sheet of questions concerning on satisfaction.

3.1.3 Personalization or customization

Personalization or customization is nowadays needed in almost every business area at least some level. Information is available everywhere and comparison is easy to make. At the same time customer knowledge and demanding have raised. For customers this is a blessing but for companies it is a challenge. "Over the wall approach" is nowadays old thinking, where company had the knowledge not only for the product requirements but also what customer wanted or needed. Nevertheless, as specific area as measurement devices, knowhow of vendors is still definitely the highest from the point of used technology. Anyway, in the world today the comparison is easy to make and that is why vendors is forced to concentrate on changing customer needs. It is important to know your customers and modify your product according to them.

What is the difference between customization and personalization? According to Nielsen (2011) customization is under direct user control and personalization is driven by the application which tries to serve up "individual" services. Cliff Allen et al. (2001) defines customization with letting the reader control his or her experience and personalization to be in guidance for user's experience. One exiting point what Allen et al. (2001) brought out about personalization is the "Aha" experience, when the content adapts itself based on the user's profile, and provides something new, different, and possibly unexpected. In this research, important task is to figure out main customer workflows and that is why personalization or customization would be one good and ambitious approach for the research – to offer users services what they want.

According to Sinkkonen et al. (2002) personalization is simple and practical. It is a good solution to get your product looking like a customer. Still in personalization is important to remember couple of thing. Customization has a same things to remember just the user control is higher- user controlled.

1. Main task is not to gather as much information as possible, more likely the focus should be on decreasing the amount of content.

2. Customer categories are needed to select carefully and the information must be based on facts, not assumptions. In customization, user itself selects the category where he or she belongs. Anyway, the user types for products are needed to "know" to be able to offer user correct selection possibilities.
3. The user part in personalization is minimized and it is effortless. In customization user makes the selection.
4. The user must have an option to select "all" and it must be clearly available. The information which is not surely needed can be left out of personalization or customization.

Personalization or customization approaches have good possibilities to achieve ISO mentioned six characteristics which were mentioned in the usability theory. Personalization and customization have straight connection to learnability, satisfaction and memorability, but also effectiveness and efficiency are at least partly under the influence of personalization and customization. Users` trust will also increase when the product is offering services which are for the user. Less connection is with faultlessness because the mistakes of users is probably reduced by making more focused interface but the technical faultlessness will still be the same. (fig.8)

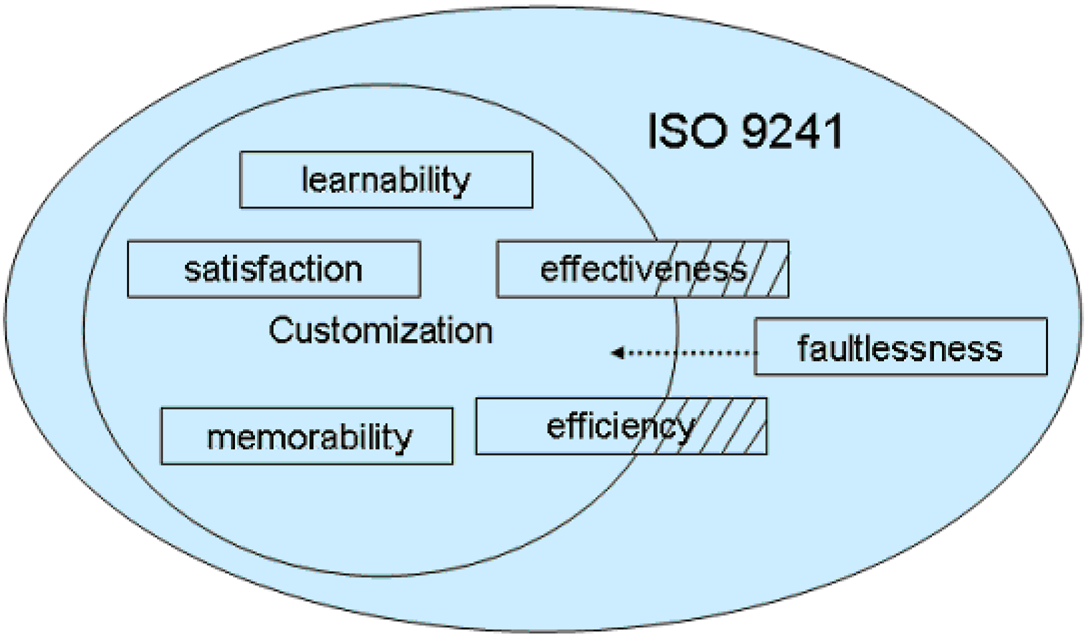

Fig. 8. Customization (or personalization) is an approach with what is able to fulfil abilities belonging to usability.

4 Used technology in the research

4.1 Fieldbus

Fieldbus is an industrial network environment for communication and implementing in a real-time. It is a digital communication system that connects field devices to PLCs and is the basis to transfer data (input and output). ISO 7 Layers model defines seven layer for industrial network, such as Fieldbus. From those seven layers there are three layers gathered in the figure 9: Human Machine Interface (HMI), programmable logic controllers (PLC) and smart field devices. (Morris 2001) The communication in fieldbus is based on two way digital communications which allows to be connected with only one network to a lot of device based on physical limitations of fieldbus protocol. In reality, specific numbers of field devices are connected per segment, 16 in Foundation Fieldbus (FF), 32 in Profibus PB and these are extendable by repeaters unlike old analogy communication, there is possible to have many devices bridged among a one cable. The entire network can be managed from one spot via application such as ST. (Anonym d: Mahalik 2003)

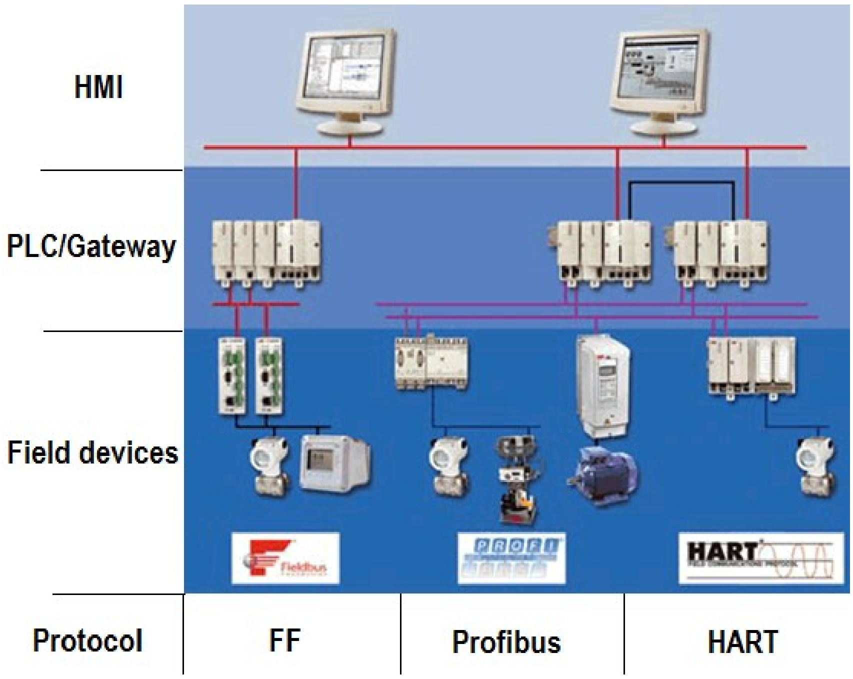

Fig. 9. Different layers/interfaces of fieldbus. (Anonym e)

Communication protocol HART

In the markets, there are many options for fieldbus protocols and specifications. Even thought the number of protocols has reduced rapidly because of concentrated markets, manufacturer unions and standardization. Nowadays the most commonly used fieldbus protocols are: Foundation Fieldbus/H1, Profibus DP/PA and HART. Actually, Hart is not exactly fieldbus protocol. In Hart communication, all devices must be connected with its own physical wires. Nevertheless, HART communication is using digital communication and every device has its own processor — so called smart device. Basically the HART technology is mixture of analogy and digital communication. (Anonym. d) HART is a command based communication system. HART commands are physically transferred via the 4-20mA connection between device and PLC via modulation. In this master thesis the HART communication will be the protocol what will be used in the tests.

4.2 Human Machine Interface (HMI) – Field Device Tool (FDT)

FDT/DTM technology is a driver technology like a printer driver in order to have access to device for the purpose of configuration. FDT/DTM technology offers a HMI application for fieldbus protocols. More detailed FDT provides standardized communication application for process companies. Application where FDT defines how the application should look like, and where important actions will be located. This is a guarantee that any, who has joined with FDT, application is able to use any others FDT driven by applications. For field device vendors it is not important how the frame looks like, more important is the driver features to configure a device. By CodeWrights words "FDT is the acronym for Field Device Tool. It is a technology defining a communication interface between field devices and operation systems - it is not a protocol or programming language." FDT is a standard way in which device vendors create user interfaces for advanced device management. (FDT 2007) The FDT technology divides automation architecture into three categories; 1. Software applications like Asset Management Tools and DSC systems; often referred to as "FDT frame applications", 2. Device drivers representing field devices, referred to as "Device DTMs" (DTM = DeviceType Manager). 3. Communication Drivers that represent the communication hardware needed for connecting the field device to the automation software, referred to as "Communication or Gateway DTMs" (Anonym f).

Device Type Manager – DTM

Device Type Manager (DTM) is sort of a communication bridge between physical plant device and frame application for example Fc. According to FDT-group "DTMs can reach from a simple graphical user interface for setting device parameters up to a highly sophisticated application."(Anonym. b) In other words, DTM is a driver which makes the all measured parameters available and understandable to one out source, for example laptop screen. (fig.10) DTM is not stand-alone executable software, it requires a supporting program/ frame application, like ST, from which it can run. (Vega 2007)

A Device Type Manager (DTM) is a part of the FDT standard that is a software component for a device that contains the device-specific data, functions and logic elements. DTMs can reach from a simple graphical user interface for setting device parameters up to an application that, for example, can perform complex calculations for diagnostics and maintenance purposes or can implement arbitrarily complex business logics for device calibration. The DTM also contains FDT-compliant interfaces to enable communication with the connected system or tool. DTMs are classified as Device DTMs, which represent a field device, and CommDTMs, which represent communication components (gateways, remote I/Os, couplers, etc.). A typical FDT based application will contain dozens, hundreds, or thousands of Device DTMs and CommDTMs from a variety of manufacturers to make up the system (Anonym b; Vega 2007).

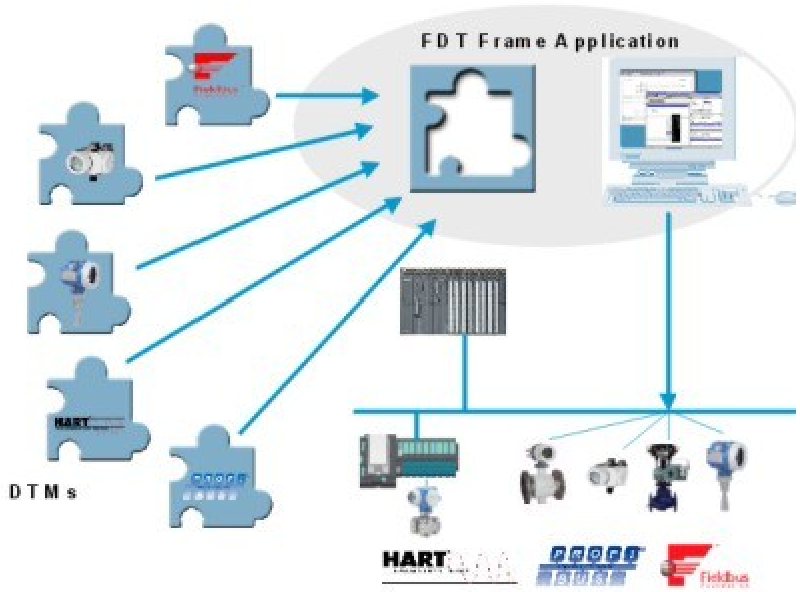

Fig. 10. DTM is a "missing puzzle" which guarantees the communication between field devices and FDT frame.

4.3 Intelligent field device

Field instrument is called to intelligent if it can execute all necessary tasks demanded for digital communication and automation. It must be possible to program and configure both manufacturers and customers. (Anonym. d) CX have five different types of intelligent devices for measuring: flow, pressure, temperature, analysis and level. For these devices CX has thousands of different models when will be taken consideration of modifications to hazardous area, housing, electronics, different protocols and for example different usage environment. Nevertheless, part of the research is to compare with competitor's devices where CX is at the moment. Because of the time limit and complexity of each device, this study will concentrate only one type of device.

5 Framework for empiric usability analysis

5.1 How user types and their requirements will be clarified

Master thesis will clarify user goals, workflows, user types and user needs inside the Company X then compare the information between CX standard 1xx. Information will be gathered from the interviews where will be involved CX workers in different positions inside the CX, from service technicians to product manager. This study will be as background information for further usability studies. The main scope of the master thesis is to clarify and compare the DTM usability at the moment especially in the commissioning phase. The used technique, to find out current state, is a benchmarking the biggest competitors. In this case the biggest competitors are Company V, Company E and Company M. The situation will be approached by observation and measuring the commissioning executor during the benchmarking task performs.

5.2 Usability – how it will be analysed?

Measured attributes will be ***efficiency***, ***satisfaction*** and ***effectiveness***. The benchmarked task will be basic commissioning to all devices. The efficiency measurement will mostly based on questions: "How long the task performer needs for different tasks and what was the total time?" This is the way to figure out efficiency to operate with device DTMs. Effectiveness will be measured by needed help and faults. Also the users` workflows and actions while commissioning will be monitored and recorded. In the end, he will also answer some questions to figure out his or her subjective opinion - satisfaction. This questionnaire will base on Technology Acceptance Model (TAM) edition from Holden and Rada (2011). The main focuses in the model are Perceived Ease of Use + Usability (PEUU), Perceived Ease of Use (PEU) and Perceived Usefulness (PU). The got results will be benchmarked with competitors and the current state of CX DTM towards competitors will be clarified. Hoping, that at the end of the day, CX would have an improved DTM where can be found the best practices from others, and the best from CX, to have a product which will be unique but also better from the parts where is need to make improve.

In the conclusion will be the information gathered together and the proposals for improvements will be step-by-step gone through.

6 Clarifying user types and their requirements

6.1 Understanding user needs

After having an overview of different user types for the device, next important task is to understand user needs in usability studies, especially to understand task workflows for different users`. The understanding of basic things, such as goal, important tasks, environment etc. is more or less mandatory before you can approach more detailed information. Basically, it is a necessary to understand in a big picture what the tasks for different user workflows are. By this way it is possible to understand what are the user expectations and requirements for the product, which are well categorized in a Kano figure below. (fig.11) Kano model has a three parts: Must-be-, expected- and attractive requirements. These three things make the users satisfied or not. Must-be requirements are mandatory to have and expected are something what customers are expecting. The attractive group is requirement which was unexpected or somehow more than was expected. The latest studies have extra indifferent and reverse attributes. Indifferent attribute has no effects neither to satisfaction nor dissatisfaction. Reverse attribute leads absolute dissatisfaction and must be avoided. (Rashid 2010; Rashid et al 2011) In the Kano model x-axis is for requirements; fulfilled or not. Y-axis is describing the customer satisfaction. Models idea is to give more pressure to the requirements which are expected and attractive for the customer. (Sauerwein et al. 1996) This is the way to differentiate and the same time make users satisfied. In a long run, easily the picture of development and end users drifts apart, thus the missing of content from each other. That is why situation update is desirable to do time to time. In the article, “Usability Engineering Methods for Interactive Intelligent System” (Spaulding & Weber 2009) was written six points what should be simplify from the user types:

1. The goals that the users want to achieve with the system (for example setting up 2000 flow devices simply and as fast as possible);
2. The specific tasks that they want to perform with it (for example “make it run”);
3. The contexts in which they want to perform with it (for example oil plant);
4. The existing work patterns that they may want to maintain (for example they want to have 500 devices per day running);
5. The properties of their computing devices (for example handheld mobile device);
6. The criteria that they expect their interaction with the system to fulfil (for example have faster and more precisely set up all devices as without tooling).

Plus these six's questions equally important are the users desire to use the system. These can be found in Kano model's as attractive requirements. (fig.11) (Spaulding & Weber 2009)

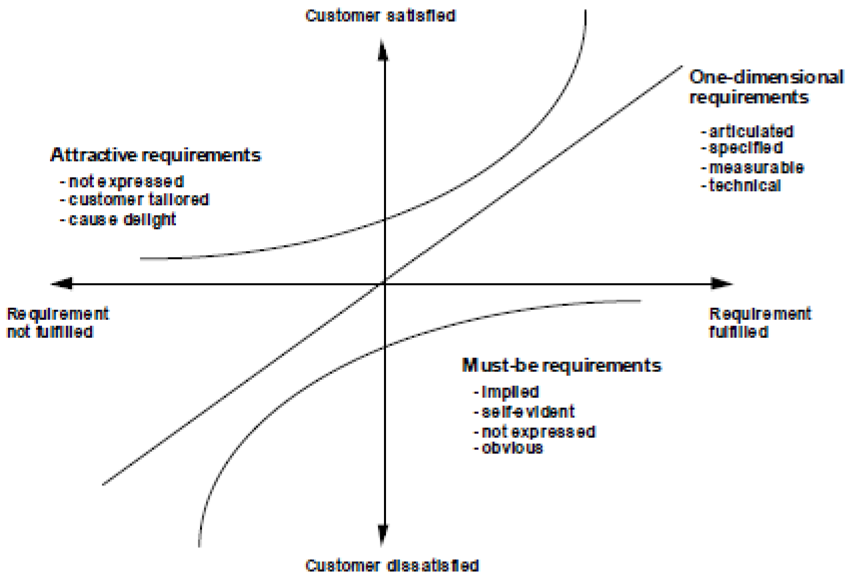

Fig. 11. Kano model for describing customer satisfaction in function of requirements (Berger et al. 1996: Sauerwein et al. 1996: Haapasalo 2010)

7 Usability analysis

7.1 Test group

Test group was selected carefully, keeping in the mind three main qualities. Those qualities are experience towards; software, physical device and work, in this research it meant DTM, Device and commissioning. Test group is combined from participants who represent different qualities from all categories. There will be performers with experiences from all qualities mentioned earlier, from novice to regular user. By this way, most of the objective and subjective usability characteristics are meant to be achieved. In the master thesis the usability characteristics are effectiveness, efficiency and satisfaction. Secondary selecting factors for test group were age, profession and gender. All these secondary selecting factors are important to know before start to analyse the data. From appendix 1 is possible to see questions to figure out background of test performers.

7.2 Performing the test

Test was carried out in group of tasks which are necessary to be done in commissioning phase. These tasks are performed as they would be done in the real life when it comes to DTM performed duties. From appendix 2 is possible to see one example of given task. Task performers were monitored by two persons. One is responsible for overall test guidance and monitoring reactions of tester. The second person is responsible for taking time, in overall and task-by-task. Appendix 3 shows the papers of task observers. After the performed tasks, the tester was needed to fulfil application which had questions of subjective usability. The subjective usability questions were evaluated by using 7- point Likert scale. In the appendix 4 is possible to see the given questions.

Before the questions or tasks, the tester was informed with following information (Sinkkonen et al. 2002):

- The meaning of the test is to measure product, not his or her skills
- The supervisor of the test is an objective person. The tester has a great possibility to send feedback to developers. They have a possibility to comment freely.
- Test is confidential and confidential is mutual.
- Test is voluntary and it is possible to end whenever he or she feels like.

- Test is recorded by video camera and needs to be approved by the task performer.
- Underline how important the tester is for the product usability.

Testers will be selected according to their know how towards DTM, process and device. First group will be consisting of user who has knowledge of DTMs in general. From them the most important measuring attribute is effectiveness and satisfaction. Second group will be users who have a knowhow of device and DTMs but no commissioning itself. This group will be mainly testers for effectiveness and efficiency. The last group will be professionals who have done commissioning duties so they have a know how to all tested values. From them the efficiency and satisfaction are the most important test attributes.

7.3 Why benchmarking tests were done?

Benchmarking tests were done for the biggest competitors of CX devices. This was done for the need to know where the Company X device is at the moment comparing to other 3rd party devices. Benchmarking tests were unique because there haven't been made similar tests in CX. That was one reason why this kind of benchmark was ordered. Despite, the most important reason for benchmarking tests were the usability study. The scope of the master thesis is to improve the usability of CX DTM and that is reached not only by usability studies but also by benchmarking the competitors. By this approach was meant to reach the best practices from all competitors and the unique look and feel of CX. Basically to have a look and feel of CX but make it more usable by mixing usability theory and benchmarking know how.

7.4 What were measured in the tests and why?

The main focuses were the efficiency, effectiveness and satisfaction. These three attributes have come out in usability studies as the most important factors for good usability. The most important attribute is effectiveness, to make software so usable that needed thinking and miss clicks would be minimalized to zero. This will be measured by needed help and faults during the task performing. Next monitored attribute was efficiency which is measured by time and clicks. The last measured attribute was satisfaction which is reach by task performer's talk during the test and after, plus an application with satisfaction questions. (Appendix 4)

8 Practical conclusions

Clarified user types and their requirements combined to benchmarking results

User types and their goals have been clarified. Also the user needs are found out. Now the practical benchmarking tests are behind so it is possible to connect all these information to one package by using in theory mentioned Kano model's requirements: Must-be-, expected- and attractive requirements.

This master thesis was practical and the results are based on practical test which was created by the knowhow of usability study, done from the latest researches. Anyway, it is possible to share these Kano model's requirements from practical perspective. Must-be requirements are basically the different user types tasks. For example, operator will and need to see variables. Expected requirements came up while asking user types goals. For example maintenance staff wants the tool to improve his or her performance to do the commissioning. Attractive requirements are again those which came out from the benchmarking tests as surprising features. In figure 12 will be the information gather to one figure.

		Must-be requirements	Expected requirements	Attractive requirements
Operator		• Measured variables is possible to read • Information in a case of failure	• Measured variables are available as simply and fast as possible • Health status information	• Intuitive look
Maintenance staff	**Novice**	• Commissioning is possible to perform • The detailed information is available (in a case of problem)	• Commissioning is easy and fast with the tool • **Commissioning is guided**	• **Informative user interface** • Fast and intuitive user interface • (wizard)
	Regular		• Commissioning is easy and fast with the tool • **Advanced setup** is available for high sophisticated process	• **Easy access to task parameters -> "one page view"** • Modern visual look with information in it
Expert		• All needed variables possible to configurate	• Possibility to do precise configurations • Easy (and uniform) access specific parameters	• Easy access to specific parameter -> "one page view"

Fig. 12. The output of user clarification and benchmarking results

The most interesting parts for this master thesis are maintenance staff- and expert requirements. In the figure 12 it is possible to see how maintenance staff is divided into two groups based on their experience. The basic tasks are for both the same but in expected requirements come the differences. Novice users are expected to be guided. On the other hand regular users for DTMs are demanding more from it and want to access more detailed tuning possibilities. From the benchmarking tests came out that novice maintenance staff would want informative user interface as an attractive requirement. Regular maintenance staff otherwise sees the fastness to get handle the needed data more important. The view of all parameters in the same page is liked among the experienced users. They don’t need guidance towards variables, so for them it is enough to offer just the names, fast but ugly. The interesting point from the tests is that regular maintenance staff was keener on visual look but they also liked to have information available as fast as possible. One solution for this dilemma of different user type needs, could be a wizard for commissioning to fulfill novice maintenance staff need and modify the expert look to more task oriented and just the needed information included. Not forgetting that experts are normally functional oriented, still categorizing the variables by tasks wouldn’t harm the expert users` work either. By improving the look and feel of current DTM setup look with better topology structure and figures, would on the other hand offer the needed visual outlook for regular maintenance staff. By these improvements could probably the satisfaction get better.

9 Conclusions

From the result figures (not available) it is possible to see that many improvements are needed for CX DTM. Efficiency, effectiveness and satisfaction, these all has a space for improvements according to accomplished tests.

Tests have shown that we are way behind in the efficiency and also in the satisfaction towards competitors. In usability satisfaction we are competing against Company M from the last place when Company V and Company E are fighting of the first place. In the efficiency CX were competing of the last place when Company M and Company E were almost twice faster. Plus in the effectiveness CX was the only one who had faults otherwise in the need of help CX were in the third place, just Company M was behind CX.

First major improvement is for the ***tree structure***. At the moment it is too messed up with huge amount of information. There is no sign of “cause and effect” feeling for user. More simple and clear structure is required. The task workflow is mandatory to be understandable for user. At the moment just the surface has been simplified by different categorized tasks for different user types. Inside the folders can be found a jungle of different parameters with no actual connections to each other. Naming issue is also a part of tree structure understanding. Currently there are many parameters where is no real connection to the real value. This is probably an influence of CX huge need to make all devices and platforms to look and feel uniform. This way many parameter names have lost its real meaning. Some are even misleading.

Next important place for improvement is the ***figures*** inside of the DTM. Present figures are messed up with information and that makes the provided information unclear for user. It is not an advance for anyone to ruin figures with too much information. The main idea of figures should be simplifying and that is only possible to reach by making figures simple. Point being - what is shown in figure is helpful, not try to put all information in the figure, just the basic principle.

Third improvement is the ***wizard***. The results have shown that the novice users especially are expected and wanted to be guided. This is measured to be a solution to make for example commissioning task more efficient to perform. Plus knowing that approximately 85% of commissioning is done by basic configuration, it is a fact that wizard could be an effective tool to make commissioning fast for almost all cases. In the rest 15% of the cases more advanced setup are needed.

10 Critical evaluation of research

The tests came out to be successful. Results were reflecting mostly the facts which were clarified in the theory. Even some interesting indifferences were found, for example commissioning for 3rd party devices took longer for expert users to execute. Anyway the most important fact was revealed. The usability of CX device has much space for improvements. The fighting of the last position is definitely not enough for such a company as Company X. For a company which wants to be a pioneer in automation industry. CX device is at the moment providing enormous amount of different parameters. Comparing to competitors, the CX device is totally alone with huge number of parameters. Anyway, these other devices are doing the demanded tasks as well as CX device, even with fewer faults. Questions come to mind, that is the direction right to provide more and more parameters, and have a pole position in functionalities. Or simplify the product and reduce the parameters to essential ones, and provide a tool for customer needs? These are the questions which should take in consideration. Despite of reducing much of parameters, there is a possibility to make huge improvements to usability. The results and theory has shown that earlier introduced improvements should make the usability better, even without significant parameter reduction. In master thesis proposed way the customers have heard and provide solutions for novice and expert users.

This study was done inside the Company X -company with the CX workers. That is why the results would look different if the tests were done by external persons who are not involved with CX. It is known that in development issues, the workers are much more critical against own product than others. So possibility is high that provided test on outside of the company wouldn't be so clearly showing the lack of CX DTM usability. Other interesting point would be to have experts from 3rd party devices as well. This would give really valuable information how the different competitors stands next to each other.

Analyze of the graphs results were done by one man with the influences of usability theory. For example the improvement of the wizard for novice users was also figured out from the graph. Actually wizard was also liked among expert users. These facts clarify that there can be holes in the conclusions. It can be also a coincidence that master thesis had a group of tested people who really liked to be guided and it wasn't really depended on the experience. On the other hand for example visual look is what expert users want. For sure, both users liked more the visual look than the basic style, but are the look really more important for expert users than for novice? If you think that novice users need more help and that is the number one thing, on the other hand experts are more free to think other things like visual appearance. This still doesn't confirm which one is the more after the visual look but at least there is a direction. It is sure that a nice look isn't an issue for neither.

All proposed usability improvements are based on the tests and theory. Still suggested proposals are just a view of one man, influenced by different sources, theory and results. To proof that proposed improvements are really improving the DTM usability, must retest to be done. After the retest, the comparison to previous results of novice-expert ratio for CX device and the new results, will tell the direction. At the moment, experienced users are doing the commissioning tasks half faster than novice users. The scope for the improvements are to have this difference vanished. Also it is important to mention that the tests were kept by two men. So it wouldn’t be the same to use other test keepers, because the role of the test keeper is really important and you will have to be involved to tests time to time. The results would look different with other people, because in the end we are just human beings and even the same testers would not always act the same but the influence is smaller.

11 Future plans

Future plans should focus to making the proposed improvements implemented and then test what kind of influence these changes has on DTM usage satisfaction. These improvements for CX device would be an example how to improve usability for other CX DTMs also. With these results and improved DTM it would be easier to go for other CX departments and clarify how many changes are needed for DTMs. In the end, CX would have a uniform DTM look and feel with major improvements mentioned in the master thesis, but modified to different CX products. Modified version means to make all DTMs look like same but specialties in necessary product variables are unique for all measurement discipline and these are important to take in consideration when implementing new DTMs.

This research was also concentrating mostly on commissioning. In the future it would be a good idea to make similar evaluation for troubleshooting. At least there is a demand among the service technicians to make the “diagnosis” –folder more simple. There can be also see the common CX problem, too many parameters. This demand is based on the experience of couple maintenance workers with approximately 10-years’ experience with the device. Probably the conclusions of the modern tree structure would be critically simplified from the look what CX has at the moment.

It is important to keep in mind that CX want to be number one in the automation field devices. So it is important to start to develop a product which has future look and feel. One example of future look was provided in the master thesis chapter “Future GUI look and feel”. By this way the CX could keep their position as a pioneer in the automation world.

12 Summary

The master thesis results showed that research was needed. Clearly Company X is behind of the competitors in the perspective of DTM usability. The lack of structure and complexity of DTM makes the whole its usability too complex. Even the usability issues are seen in the efficiency. The performance of CX device is actually pretty good, and the measuring efficiency is definitely one of the best in the market, but the usability problems and overload of parameters makes even the efficiency look bad. Anyway, problems at the moment aren't so huge and it is possible to make huge improvements.

The test showed that from current 4 user type categories actually only three is needed. These three are operator, maintenance staff and experts. The maintenance staff group is important to share by usage to novice and regular groups. For these three user types the master thesis made evaluation of their needs and goals. Benchmarking tests revealed requirements for all user types, from must-be- to attractive user requirements. The commissioning was the focus of the thesis and that is why especially maintenance group's needs, goals and requirements were in the main focus.

Research showed that there is a place for improvements in the usability of CX DTM. The proposed improvements in the master thesis are focusing on tree topology, figures and "cause and effect"-reaction, believing that following improvements would increase the satisfaction, efficiency and effectiveness. The master thesis has an approach to improve the usability at the moment but also the appearance of upcoming look and feel of DTMs. First, by improving the current usability with small changes that it can compete with other 3rd party devices of the pole position and then start to focus on the future, how the development should start progress. This would be the easiest way for company to build up better usability for today's product and then for the future. If the CX would want to really offer a product for the end customers, even from the usability point of view, then the direction should be on less parameters and more structured interface with visual 21st century look, also not forgetting novice user guidance. These are the facts which are customer demands and should take in serious consideration.

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Appendices

Appendix 1

General information

Gender	Male ☐		Female ☐		
Age	18-25 ☐	26-32 ☐	33-40 ☐	41-50 ☐	≥50 ☐

Job title ________________________________

Experience information

DTM experience	0-1 (years) ☐	1-2 ☐	2-5 ☐	5-10 ☐	≥10 ☐
How often you use DTMs?	Daily ☐	Couple of times in a week ☐	Couple of times in a month ☐	Less than once in a month ☐	Never ☐
CX device Experience	0-1 (years) ☐	1-2 ☐	2-5 ☐	5-10 ☐	≥10 ☐
Is CX device DTM Familiar for you?	Yes, I use it daily ☐	Yes, I use it weekly ☐	Yes, I use it monthly ☐	I use it less than once a month ☐	No ☐
Company V device Experience	No ☐	Yes ☐	If Yes, then how often used? (daily, weekly monthly)? ____________		
Company M device Experience	No ☐	Yes ☐	If Yes, then how often used? (daily, weekly monthly)? ____________		
Company E device Experience	No ☐	Yes ☐	If Yes, then how often used? (daily, weekly monthly)? ____________		
Commissioning Experience	0-1 (years) ☐	1-2 ☐	2-5 ☐	5-10 ☐	≥10 ☐

Appendix 2

Commissioning

“You are working as a commissioning engineer for CX Finland. You are the lucky one which has been sent to Las Vegas (USA) for commissioning duty. What you should also keep in mind while setting up measurement units. This trip means one week trip to paradise of casinos and the land of gallons and feet’s. Before you can try to reach the biggest jackpot of the casino, you are meant to do your duty.

At the moment you are standing right next to this tank which is made for storing the money of casino. Your duty is to make commission for the CX device with coaxial probe to measure the level of money in the tank. Because of your importance, the company has already prepared the mounting of the device and the software for the basic configuration is already running. Now you are expected to make the connection between the device and the software for start commissioning. Before anything, the first task is to reset the device to factory settings and change the device tag to your own name. After resetting and changing the tag you notice a paper next to the device. There is a message of your partner for you. It says, the empty calibration for the level device is 5-feet from the top of the tank and full calibration is 3-feet from the top of the tank. Empty calibration makes you laugh cause you just realize now how carefully casinos are not to let too much money go away from the casino. You also have made your own study for commissioning and found out that the diaelectric constant of money is 9.

After the needed setting for the device you check that your configuration is successfully done by going through the values of level and distance. For the last thing, you confirm the distance. After all this you are done commissioning duty with the device.”

Just to reminder, all the talk during testing is allowed, even recommended.
+ test is measuring ONLY product usability, not user performance.

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Needed guidance to complete

Task performer

Company X -device

	Without Help	Problems/ without help	Need help
Operating mode			
Distance unit			
Tank type			
Medium group (DC)			
Empty calibration			
Full calibration			
*Level	xxxxxxx	xxxxxxx	xxxxxxx
*Distance	xxxxxxx	xxxxxxx	xxxxxxx
*Signal quality	xxxxxxx	xxxxxxx	xxxxxxx
Mapping→Confirm distance			

* Values which is just not possible and needed to change. Just visible.

Deviation from optimal path/Spatial accuracy

Steps

	Faults[1]:	Setup order
Operating mode		
Distance unit		
Tank type		
Medium group (DC)		
Empty calibration		
Full calibration		
*Level	xxxxxxx	Xxxxxxx
*Distance	xxxxxxx	Xxxxxxx
*Signal quality	xxxxxxx	Xxxxxxx
Mapping→ Confirm distance		

1) U=Understanding of concept issue
T=Trust issue/user was not sure of actions
W=Workflow issue
M=Mispath

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Action while testing

1. Mentioned things while testing

2. Noticed things while test? (Some repeating mistakes/misunderstood etc.)

3. Given hints how to improve the product

After the test

1. Mentioned things

2. After the commissioning, was the tester sure that he succeeded with the commissioning?

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Usability Benchmarking

Task performer:

Connection, starting up time: _______min_______s ______clicks

Time after resetting: ______min_____s ________clicks
Changing the device tag: ______min_____s ________clicks

Completed tasks:	**Clicks:**	**Used time:**
Distance unit		______min_______s
Operating mode		______min_______s
Tank type		______min_______s
Medium group (DC)		______min_______s
Empty calibration		______min_______s
Full calibration		______min_______s
*Level		______min_______s
*Distance		______min_______s
*Signal quality		______min_______s
Mapping→ Confirm distance		______min_______s

Complete time: ______min_____s

Time, when tester knew that he has succeeded with the commissioning _______min_______s

*Values which is just not possible and needed to change. Just visible

Appendices 4
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Questions after the test

Task performer:

My interaction with the technology is clear and understandable?
(1=strongly disagree, 2=moderately disagree, 3=somewhat disagree, 4=neutral, 5= somewhat agree, 6=moderately agree, 7=strongly agree)

1	2	3	4	5	6	7
☐	☐	☐	☐	☐	☐	☐

Technology's interface is user-friendly to use?

1	2	3	4	5	6	7
☐	☐	☐	☐	☐	☐	☐

Interacting with the technology does not require a lot of my mental effort?

1	2	3	4	5	6	7
☐	☐	☐	☐	☐	☐	☐

I find the technology to be easy to use?

1	2	3	4	5	6	7
☐	☐	☐	☐	☐	☐	☐

I find it easy to get the technology to do what I want to do?

1	2	3	4	5	6	7
☐	☐	☐	☐	☐	☐	☐

I find the technology to be flexible to interact with?

1	2	3	4	5	6	7
☐	☐	☐	☐	☐	☐	☐

Learning how to perform tasks using the technology was easy?

1	2	3	4	5	6	7
☐	☐	☐	☐	☐	☐	☐

The technology has good functionality (features)?

1	2	3	4	5	6	7
☐	☐	☐	☐	☐	☐	☐

I feel I have an intuitive sense on how to operate the technology?

1	2	3	4	5	6	7
☐	☐	☐	☐	☐	☐	☐

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I find it easy to remember how to perform tasks using the technology?
(1=strongly disagree, 2=moderately disagree, 3=somewhat disagree, 4=neutral, 5=somewhat agree, 6=moderately agree, 7=strongly agree)

1 2 3 4 5 6 7

☐ ☐ ☐ ☐ ☐ ☐ ☐

Using the technology improves my performance in my job?

1 2 3 4 5 6 7

☐ ☐ ☐ ☐ ☐ ☐ ☐

Using the technology in my job increases my productivity?

1 2 3 4 5 6 7

☐ ☐ ☐ ☐ ☐ ☐ ☐

Using the technology enhances my effectiveness in my job?

1 2 3 4 5 6 7

☐ ☐ ☐ ☐ ☐ ☐ ☐

I find the technology to be useful in my job?

1 2 3 4 5 6 7

☐ ☐ ☐ ☐ ☐ ☐ ☐

In my duty, usage of this technology is relevant?

1 2 3 4 5 6 7

☐ ☐ ☐ ☐ ☐ ☐ ☐

I have no problem with the quality of the technology’s output?

1 2 3 4 5 6 7

☐ ☐ ☐ ☐ ☐ ☐ ☐

How likely are you to recommend technology for others?

1 2 3 4 5 6 7

☐ ☐ ☐ ☐ ☐ ☐ ☐

Overall, are you satisfied with the performance of technology?

1 2 3 4 5 6 7

☐ ☐ ☐ ☐ ☐ ☐ ☐