



Remote assistance for service technicians

Juho Silmukari

2019 Laurea



Laurea University of Applied Sciences

Remote assistance for service technicians

Juho Silmukari
Degree Programme in Service
Innovation and Design
Master's Thesis
May 2019

Silmukari, Juho Reijo

Remote assistance for service technicians

Year	2019	Pages	88
------	------	-------	----

Industrial maintenance work is changing rapidly due to the ongoing digitization. The new communication technologies involving video and augmented reality enhance the way two persons can communicate during troubleshooting situations. By utilizing the common mobile communication devices, it is possible to create more interactive and informative support concepts for remote support.

The purpose of this thesis is to research the next generation's remote assistance concept for service technicians in industrial maintenance and validate its benefits by conducting a case study with the commercial remote assistance tool. The objective of this study is to understand the user's requirements of the next generation's remote assistance concept and to generate accurate insights to support future decision-making in the client company.

The knowledge base of the thesis was built on the theories related to communication and interaction between people. The theories explain the practical application of different communication principles in the context of the modern remote assistance channel. Service design disciplines were applied extensively during the research project. The creative problem-solving model was used as the main body of the process. Qualitative research methods were used extensively in the thesis, including in-depth interviews, user experience study and usability testing.

The results of the project indicated that the tested remote assistance tool provides some benefits in troubleshooting situations compared to the current process. The results of the field pilot indicated that the service technicians found the audiovisual channel as a suitable and informative tool when explaining the fault situation to a support person. The results of the project can be used in the further planning and implementation of the next generation's remote assistance concept for the industrial maintenance situations.

Keywords: Service design, Remote assistance, Usability study, User experience

Silmukari, Juho Reijo

Seuraavan sukupolven etätukikonsepti huoltoteknikoille

Vuosi 2019 Sivumäärä 88

Teollisuuden kunnossapidon huoltotyöt muuttuvat nopeasti käynnissä olevan digitalisaation vuoksi. Uudet viestintäteknikat joissa sovelletaan videokuvaa sekä lisättyä todellisuutta, mahdollistavat entistä tehokkaamman viestinnän. Yleisesti käytössä olevien mobiililaitteiden avulla on mahdollista luoda entistä interaktiivisempia ja informatiivisempia vianmäärityskokemuksia etätukitilanteissa.

Tämän opinnäytetyön tarkoituksena on tutkia seuraavan sukupolven etätukikonseptin soveltuvuutta huoltoteknikoille teollisen kunnossapidon ympäristössä. Opinnäytetyön tehtävänantona on selvittää uudelle etätukityökalulle parhaiten soveltuvin paikka vianmääritysprosessin arvoketjussa, tunnistaa etätukityökalun käyttäjävaatimukset sekä validoida etäyhteyden tuoma lisäarvo vikatilanteen ratkaisemisessa. Opinnäytetyön tutkimusprojektissa validoidaan yhden kaupallisen etätukityökalun soveltuvuus sekä hyödyt.

Työssä käytetty tietopohja koostuu ihmisten välisen viestinnän ja vuorovaikutuksen tulkintaan liittyvistä teorioista. Käytetyt teoriat selittävät eri viestintäperiaatteiden käytännön soveltamista nykyaikaisen etätukikanavan yhteydessä. Palvelumuotoilun teoriaa sovelletaan laajasti opinnäytetyön tutkimusprojektin aikana. Prosessimallina työssä käytettiin havaintojen keräämiseen keskittyvää luovaa ongelmanratkaisumenetelmää. Opinnäytetyön tiedonkeruussa käytettiin laadullisia tutkimusmenetelmiä, joihin sisältyi haastatteluita, käyttäjäkokemuksen tutkimusta sekä käytettävyyden testausta.

Tutkimusprojektin tulokset osoittivat, että seuraavan sukupolven etätukityökalu tarjoaa tiettyjä etuja vianmääritystilanteissa verrattuna nykyiseen prosessiin. Kenttäpilotin tulosten perusteella kaksisuuntaisen audio-visuaalisen kanavan hyödyntäminen lisää tehokkuutta ja informatiivisuutta vikatilanteissa, joissa ongelmanratkaisu tapahtuu etätuen avulla. Projektin tuloksia voidaan soveltaa seuraavan sukupolven etätukityökalun suunnittelussa sekä käyttöönotossa.

Keywords: Palvelumuotoilu, Etätuki, Käyttäjätutkimus, Käyttäjäkokemus

Table of Contents

1	Introduction	7
1.1	The purpose and objectives of the research project	8
1.2	Limitations	11
2	Theoretical background	12
2.1	Previous studies of remote assistance systems	12
2.2	Grounding in conversation.....	14
2.3	P.O.A paradigm.....	17
2.4	Symmetries in communication.....	18
2.5	References in communication	19
2.6	Communication theories applied in the remote assistance concept.....	20
3	Service design.....	23
3.1	Service design process	23
3.2	User experience study	25
3.3	Usability testing	27
3.4	User interviews	29
3.5	Personas	33
3.6	Service blueprint.....	34
4	Research project	35
4.1	Objective finding.....	38
4.2	Fact finding	41
4.2.1	Field guides	42
4.2.2	Finding informants.....	43
4.2.3	Themes in tier 1 and 3 interviews	44
4.2.4	Themes in tier 2 short interviews	45
4.2.5	Service days-event and small group discussions	46
4.3	Problem finding	47
4.3.1	Analyzing the data from small group discussion during the Service days ...	49
4.3.2	Analyzing the data from tier 1 and 3 interviews	50
4.3.3	Analyzing the data from tier 2 short interviews.....	51
4.3.4	Creating insights from the interview data.....	52
4.4	Idea finding	55
4.4.1	Planning of the pilot.....	56
4.4.2	Conducting the pilot.....	58
4.5	Solution finding.....	60
4.5.1	In-depth interviews after the field pilot	60
4.6	Acceptance finding	63

4.6.1	Introducing the results to the client of the project	63
5	Findings and results	65
5.1	Conclusions	66
5.2	Summary of the research project	66
5.3	Value of the research project	67
5.4	Opportunities for further research development	69
	References	70
	Figures	73
	Appendices	74

1 Introduction

Industrial maintenance is moving towards the new era. Not only equipment base in industrial maintenance has become more complex, but also the variance in devices and technologies in maintenance base require an excessive experience from the technicians who are conducting the maintenance tasks. At the same time network infrastructure, audio-visual tools and advanced software algorithms have made it possible for service professionals to collaborate with each other. In the past when the fault occurred during the fieldwork, a technician could either utilize possible manuals available or to phone for support (Bottecchia, Cieutat & Jessel 2010, 2). What is also apparent in industrial maintenance, is that there are increasing amount of cases where technicians lack the basic knowledge involving the maintenance tasks due to a large number of devices in the service base (Bottecchia et al. 2010, 2).

In addition to lack of knowledge and resources in difficult situations during the fieldwork, the expert capable of solving the issue can be inhibited for traveling on site to provide assistance. This leads to possibility to utilize telecommunication methods to solve the problems from the distance by providing instructions for the technician present at the site. The same issue has been recognized by Fussell, Setlock, Yang, Ou and Mauer (2004) stating that because experts in modern industries have a global operating field, they are not necessarily available in needed location, which in turn requires remote assistance solutions (Fussell et al. 2004, 5). However, remote assistance in industrial maintenance demand effective tools to enable the shared situational awareness between different parties (Domova, Vartiainen & Englund 2014, 1). What should be also noted is the aspect of information confidentiality related to situations where data, concerned as a core competence of industrial service, are transferred over third-party servers. Despite that there are many existing services that are providing tools for transmitting audio-visual signal between dislocated parties, the confidentiality of the data should be re-garded as an important attribute for any company planning to utilize remote assistance channel (Domova, Vartiainen & Englund 2014, 2)

This increased requirement of performance in industrial maintenance has been recognized by the service providers. Competition in the industry is driving companies to seek new communication technologies to support professionals in their work (Bottecchia et al. 2010, 2). However, it has been recognized that the development pace of such systems has been much slower than need of industries providing industrial services (Fussell et al. 2004, 5). The telecommunication system should enable quick and reliable channel for troubleshooting with an ability to point the wanted objects (Domova, Vartiainen & Englund 2014, 1) Further challenges of using digital remote assistance are also addressed by Rice, Ma, Tay, Kaliappan, Koh, Tan and Ng (2018, 5). They argue that when such system is used in troubleshooting, it needs to be able to indicate awareness and attention of users to create effective interaction through the cameras.

The typical form of collaborative repair work is to complete tasks which includes one or more objects which are combined with other parts or changed during the repair by using various tools (Fussell, Kraut and Siegel 2000, 4) The same definition for collaborative repair work gives also Fussell et al. (2004, 5) by addressing it as an event where at least two people co-work on determining tasks in the real world.

Yet when turned to remote collaboration, Fussell et al. (2000, 4-5) continue by defining the concept of remote assistance, which is described as a process where normally two persons, worker with the help of a remotely located expert, ground themselves in repair situation, determine the best course of action and by cooperation complete the task successfully. With the development of bandwidth and the internet infrastructure, remote assistance as a concept has now been matured to the level where it allows seamless collaboration between the professionals. The true value of this progress comes from the possibility to create shared view remotely, thus allowing industries to improve the quality of their service (Bottecchia et al. 2010, 2).

1.1 The purpose and objectives of the research project

The introduction chapter revealed the latest progress happened in the industrial maintenance business. Based on the findings from various studies from recent years, it is apparent that world of industrial maintenance is rapidly adapting the remote collaboration technologies to answer to increased competition in the business. The increasing interest of companies towards this technology can be also understood as an attempt to preserve the quality delivered while at the same time being competent to offer services for increasing complex equipment. Remote assistance as a concept is not new, but only during the recent years, it has reached the technological maturity capable of changing the very paradigms of service quality and processes.

The progress explained above has not left unnoticed in the case company regarding the thesis, operating globally in the field of machinery and metals. The concept of remote assistance has been discussed many years in the case company. This is because the company is also a global scale service provider in the industrial maintenance business. The concept of next generation remote assistance was originally part of the larger ongoing project concentrating on digitalization of tools utilized in service operations. Hence, when considered as suitable topic as the thesis work, it was detached as an individual project to systematically validate the feasibility and possible benefits of remote assistance for service technicians.

The client of the thesis work was the head of technical support. The possibility of doing my thesis work from remote assistance topic was first introduced to the client in early 2018 and

we were quickly able to create mutual understanding about the need behind the remote assistance development. Thus, soon after this we set up a kick-off meeting to outline the thesis work objectives and goals.

In the kick-off meeting the background of the assignment was introduced. The situation was that there was a strong need identified for improving the current technical support process. It was outlined that modern remote assistance technology possesses an unrealized potential for the case company service organization. The need for improvements regarding the technical support comes from the increased complexity of technology and variance used in equipment, and for distribution of expertise in the service organization. This phenomenon has been identified as important to solve, but no measures were taken yet to find the solution. The case company being a technology leader of its own industry possessed a strong internal motivation and adequate resources to initiate the project to upgrade the technical support for service technicians. A master's thesis was therefore seen as a fine opportunity and the first-of-a-kind study in the case company organization to research remote assistance.

Based on the assignment addressed above, the following research questions for the thesis were created with the client:

1. Recognize the most valuable section in the troubleshooting value chain which would benefit most from using remote assistance concept and define who are the key user groups involved.
2. What are the requirements of different parties for remote assistance channel located in an identified section of the value chain?
3. What is the added value of using remote assistance channel for identified user group?

The broad purpose of next generation remote assistance concept is to create more interactive and informative remote assistance experience for situations when peer-support is required. Benefits seen in this new concept is the opportunity to reduce customer downtime during fault situations, increase work efficiency and ability to collect the content from different service situations more systematically to create data-based models for future service concepts.

There are four key concepts which are used extensively in the thesis. These concepts are introduced in the following chapter.

Remote assistance

Remote assistance as a concept can be utilized in any occasions where two or more persons located at different physical location are using an audio-visual channel with any appropriate

devices for troubleshooting purposes. In the context of this thesis the remote assistance refers to a situation where the service technician or technical support expert establish an audiovisual connection by using a specific remote assistance application with mobile devices or laptop computer. Remote assistance in industrial maintenance applies in the situations where the technician faces a situation where he requires assistance or guidance from another person (support) during the fieldwork. By using remote assistance system, two persons can create shared visual awareness about the situation and exchange the information and knowledge between each other to overcome the issue.

User experience research

Studying of the user experience was essential method in the development project of this thesis. This was because given assignment involved validation of the new digital tool for service technicians, which required deep understanding about the preferences and requirements of the user group to form accurate insights. User experience research was the leading philosophy in this thesis which included methods of deep interviews, creating personas and a service blueprint to create a holistic picture about troubleshooting process and feasibility of the remote assistance applied in it.

User Interviews

User interviews had the most important role in this thesis work what comes to utilized research methods. The interviews were chosen because the research questions required in identifying the most important stakeholder groups regarding the remote assistance channel and to find out their expectations when utilizing it. User interviews used in this thesis work concentrated on finding accurate insights within focus groups. Insights from interviews were used to validate the research questions and hypotheses which were outlined in the beginning of the development project.

Service design

Service design was the core discipline in this thesis. Hence, the development project was planned and executed by the principles of service design, which emphasize the user-centered approach during every stage of the project. The design aspect was used to determine the methods and the process used when the ideas and solutions were created.

Structure of the thesis

The structure of this thesis is divided into five chapters. The first chapter introduces the thesis topic and background of giving objectives. It explains the need behind the thesis, key concepts used in the work and word about the limitations the work possesses. Second part of the

work is about theories related to the remote assistance concept. Theories regarding communication between people, cognitive framework information processing, remote collaboration constraints and symmetries, referencing of expertise and elements of telemaintenance are introduced. Third chapter concentrates on a service design aspect of the thesis work. There are explained different research methods and the creative problem-solving model used in the development project in this thesis. In the fourth chapter the development project is reported. Last chapter presents the summary of the thesis work and the conclusions made from the results.

1.2 Limitations

Remote assistance can be applied any occasion where two or more physically dislocated persons are utilizing audio-visual channel with some communication devices for troubleshooting purposes. Hence, the possible use cases for remote assistance imaginable are endless. The results derived in this thesis must be interpreted from the viewpoint of the service organization of the case company in Finland area. Hence, project outcome indicates solely very limited aspect of remote assistance concentrating on lifting device maintenance. In addition, due to time restrictions, arranged a field test of remote assistance concept in development project provides only narrow understanding about the topic, thus cannot be used in making any universal assumptions about the benefits of remote assistance.

Furthermore, when looking the results of the thesis work it must be noted that conducted field pilot concentrated solely on Finland. Thus, the reported troubleshooting cases where remote assistance was applied represents service situations with local equipment base. Hypothetically, if the field test should have been conducted on different country, the reported use cases would have probably been differed from the realized results.

The thesis work presented here concentrates strictly on reporting the results about the usability of remote assistance channel in a chosen environment. Hence, the work does not emphasize the ideation or the content of the remote assistance channel itself, but instead reports its benefits from the perspective of the focus group. The decision not to extend the work on creating new content for the remote assistance channel is because of two arguments: first, the assignment given by the client was to study the feasibility of the remote assistance channel for the chosen user group and to report the results.

A second reason for not to include an ideation stage for the work scope was that the maturity of the technology used in remote assistance concepts is high. This means that remote collaboration over the internet has already become very common in the terms of available solutions and the selection of features. What was found out during the early stages of the thesis work, was that there are a high number of established system providers of remote assistance services. This fact, combined with mature level of technology results that there is already an

abundance of customizable features for remote assistance channel available. Hence, I decided not to expand the work scope on ideation to better focus on main objectives.

2 Theoretical background

Different theories used in the thesis are introduced in the following chapter. Theoretical background of the thesis consists established scientific framework used in interpreting the communication and interaction between people. In addition to this, there is a specific paradigm for explaining interactions between the persons in remote troubleshooting situations via audiovisual channel. The chapter is concluded in the summary section where the practical application of different theories in the modern remote assistance channel is introduced.

2.1 Previous studies of remote assistance systems

Remote assistance systems have been studied extensively during the past years. The studies have been concentrated on defining different tools and features needed in remote collaboration. The basic research setup in these studies has included two persons, usually names as a worker and the helper, collaborating with each other to solve the given tasks by using remote assistance system. Hardware used in these testing setups has varied from wearable augmented reality helmets to laptop interface and to mobile devices with different combinations between them.

The studies have shown that there are various external factors which are preventing accurate predictions when testing the remote assistance in the field situation. Thus, as the remote assistance system requires the events where collaboration is needed to be studied accurately, the results may vary depending on the occasion (Domova et al. 2014, 7).

Rice et al. (2018, 1) tested the remote assistance system which they titled as a remote assistance platform. The basic setting in this system for troubleshooting was a combination of different devices, mobile phone, wearable augmented reality helmet and/or PC desktop, enabling an audiovisual transmission between the devices over the internet connection. In addition, the system included functions for experts to assess instructions over the established channel. The feasibility of the remote assistance system was tested in a controlled situation where pairs were formed between the participants with different tasks given requiring collaboration to be solved.

Similar studies for their self-built and determined remote assistance channel has been made by Domova et al. (2014, 3). Their goal was to test and validate the efficiency of such system in industrial environment. Like most of the conducted field tests, there was also an artificial scenario created where two persons, local worker and remote expert, located at distance with each other were instructed to collaborate to solve different technical support tasks.

Based on the research made on remote assistance systems, several requirements related to content, features or usability of the audiovisual channel for troubleshooting has been identified. Domova et al. (2014, 3) identified that in troubleshooting situations where efficient interaction is required, it is desirable that both field worker and remote expert have an equal ability to create annotations over a video stream. This is because possible fault situations may be so complicated that input from both parties greatly enhance the troubleshooting ability.

Rice et al. (2018, 1) in turn identified the importance of focusing on human aspect when developing the remote assistance system. This is because they saw that emphasis of such a system should be recognized and to consider different behavior models during a one-on-one collaboration situation to ensure that channel is optimized for technical troubleshooting.

The other interesting result from testing the remote assistance channel was the requirement of audio beside the annotations when solving the most complicated tasks like assembling of complex objects. The test participants were able to solve the given task much quicker when using verbal communication instead of making drawing on the screen. The results indicated that utilization of voice as a communication method is still an elemental feature in remote collaboration to ensure the effective outcome (Spitzer, Nanic & Ebner 2018, 13).

Previously conducted research on remote assistance has been concentrated on the technical feasibility of remote connection, but also on the content of the system examined from a user perspective. Spitzer et al. (2018, 13) have researched both aspects with research questions considering the usability of live annotations (arrows, rectangles) placed in video stream to support persons doing the troubleshooting. Their research concentrated on studying the usability of different pointing methods with the remote assistance prototype for further validation.

There is also a notion concerning the interaction dynamics in the remote assistance channel. The requirement of two-way interaction during the remote troubleshooting was identified by Fussell et al. (2000, 4) in their study. Based on their findings, it is important that remote expert can infer the local worker focus of attention by adjusting the ongoing repair task accordingly. The very same functionality applied also to the local worker side. Thus, remote assistance channel should possess the tools for making quick deictic expression, which refers to pointing the specific components which are visible on the screen.

The recognized challenges in remote collaboration were identified also by Bottecchia et al. (2010, 6) in their study. Different from a face-to-face situation, the remote support system must be able to replace different pointing gestures which are made normally by hand movements. There was three distinctive dimensions identified, the pointing device, ability to indicate object or location, and function to show the connection of the previous two by using dedicated action symbols. The testing of pointer device integrated in the remote assistance

system during the same study indicated that pointer is cost-efficient and feasible solution to improve the communication between parties in troubleshooting. Results from various studies concerning the effectiveness of the remote assistance system indicate that there are multiple benefits when utilized in troubleshooting. Domova et al. (2014, 7) witnessed very positive results indicating that remote assistance systems biggest benefit is ability to convey the spatial information between the parties instead of using the audio channel solely. There were also convincing results in the improvement of communication overall with shared visual awareness about the situation at hand. Rice et al. (2018, 5) shared the same results as above, reporting results about positive impact on work efficiency from the possibility of making annotations and clear symbols on top of the video stream. There was also another discovery made by Spitzer et al. (2018, 16) in their study about remote assistance channel alike, where results indicated that with high-resolution image quality, the remote assistance channel will become particularly efficient when working with electrical components as they require seeing details and colors alike. Similar results were found also by Henderson and Feiner (2009, 9) in their research on remote assistance system where mechanics reported that using augmented reality with the audio-visual channel is beneficial when working with electrical systems.

There were also similar results reported by Fussell et al. (2004, 30, 36) in their study where pointing feature was tested as a communication tool in remote assistance channel demo. In this study the participants were able to do also representational gestures with the pointer which was reported as beneficial addition what comes to usability and enhanced informative. Participants in the study find pointer easy to indicate different angles of the objects and direction of movements by creating arrows. Same study addresses the benefits of drawing tool combined with pointer to increase the efficiency in troubleshooting considerably. The ability to draw different shapes and lines incorporate with faster success in troubleshooting as it can indicate objects and locations in shared view almost as efficiently as having participants co-located. The efficiency was even better when drawing tool annotations are automatically erased in seconds after drawing, the results indicated.

The decrease of the errors made during the maintenance task when using audiovisual remote assistance system was noted by Henderson and Feiner (2009, 7-9). They pointed out that mechanics had better success with remote experts informing them through the augmented reality display during the maintenance tasks. The system also provided an enhanced capability to locate the faults, which speedup the overall repair process. Also, the participants found different annotations useful during the communication.

2.2 Grounding in conversation

Clark and Brennan (1991, 1) identify two separate aspects in grounding during communication. First, there is a purpose which includes what are the goals of the people having the communication, and second is the medium of communication which means the techniques

available for reaching the purpose with the effort it comprises. When brought together, having purpose and medium of communication creates a grounding criterion, which means that people participating in conversation reach the mutual collective understanding about the subject.

When person is contributing in conversation with another person, he will first make a statement on what he wants to address. After this, the other person either signals back have he understood the statement what was just made. This process of contributing in conversation is divided into two phases: first is the presentation phase where the person making the initial statement in conversation with a belief that partner will understand his message. Second is the acceptance phase where another person gives some type of evidence that he has understood the message received. Again, this person assumes that first person can understand the given signal of acceptance (Clark & Brennan 1991, 3) There is a great chance for misunderstandings during the presentation phase because expressions and terms might contain signals that are not familiar to the person receiving them. The actual grounding takes place in acceptance phase when there are four different alternatives which can take place after the presentation has been made. In terms of grounding efficiency, the worst case is that person don't even notice the given message. The adjacent state can be that person notified the presentation attempt without understanding the content nor purpose of the message. The second-best state would be that person correctly understood the message itself but not the content, thus grounding was not established. The best state and the goal in conversation is that the person understood the message and its content, thus leading to successful grounding.

People require also some evidence during the conversation to acknowledge that another person has either understood or not their signal. This is divided into negative evidence and positive evidence. Positive evidence has many forms. For example, with simple acknowledgment the person clarifies that he has understood the message content. With positive evidence there is also a chance for respondent to use relevant next turns, which are types of confirmations and adjacent question in the same to clarify the first statement. The third positive evidence type is called the continued attention, which indicates to non-disrupted connection between the people having the conversation. Hence, the person making the presentation is constantly observing to have confirmation that his message was received (Clark & Brennan 1991, 4).

Theory of grounding in communication includes also the principle of least collaborative effort in conversational grounding. By the definition this means that people participating in conversation will try to minimize the collaborative effort needed from own side to reach the level where mutual understanding of the situation has been established. In practice this means that during the conversation participants aim is to form most compressed utterance possible with the information and mediums they possess (Clark & Brennan 1991, 5) Principle of least collaborative effort has also been notified by Fussell et al. (2000, 10) in their study. The results

from testing indicated that persons participating in collaborative repair task are utilizing the video connection if it is available. This can be explained so that in troubleshooting using video is a significantly more informative medium of communication than audio.

Grounding changes depending on the medium used. There are several constraints which might prevent grounding to happen and which should be taken into consideration when communication is made over the different mediums. For example, when using the audiovisual channel as a conversation medium, the following constraints must be considered: co-presence is something that brings communication constraint due to persons do not share the same physical space. Visibility becomes also at least partially constrained when using audiovisual channel if the visual field is depending on the position of transmitting camera. Third, there is a matter of sequentiality which refers to the possible pre-defined turns in the conversation between the participants. In audiovisual channel, this is a possible constraint as all participants can interfere and add presentations to conversation over each other. Last, there is a possible constraint coming from revisability, which refers to the possibility of making any adjustments or corrections to the message before sending it to respond. When having direct line with another person, the unclear message may disrupt the mutual grounding (Clark & Brennan 1991, 8).

In addition to common constraints in grounding process, Clark and Brennan (1991, 9) identify eleven cost types which are all apparent in the grounding process. Different cost types are present in co-existed way, meaning that they have strong causality with each other. The cost types can be perceived so that in an ideal situation the cost of certain types is zero, whereas when cost value increase the more effort it requires from the participants to reach the grounding.

The following cost types should be considered with the remote assistance channel:

First, it requires certain costs from speaker to formulate the message, referring to the level of complexity of the utterance to be sent. Production costs mean the effort required to process the actual message. When using audiovisual as a medium, the overall cost of these two types is relatively low due to a high informative level of video format when sharing the situation with another person. Reception and understanding costs are costs that are paid by the message receiver. These are referring to chances of receiving the utterance made in most understandable form as possible. In audiovisual format any possible disruption in the picture or audio feed creates more costs (Clark & Brennan 1991, 9)

The rest of the cost types related to remote assistance channel are the ones that consider both the speaker and the receiver. The delay costs are referring to any possible delay occurring in the communication medium, causing information travel longer between the parties. Display costs in grounding are probably the most relevant out of all cost types regarding the

remote assistance channel. Display costs are tied to the possibility of making gestures and annotations between the participants. The more difficult it is to point and indicate the objects on the screen, the more there are display costs. (Clark & Brennan 1991, 10)

The benefits of grounding theory have been addressed also by Kraut, Gergle and Fussell (2002, 11) in their study. According to them, creating a shared visual space between people doing collaboration using remote assistance channel enhances the grounding effect and communication especially in a more visually complex situation. Furthermore, the grounding between the worker and the expert become more efficient when using the audio-visual channel. This was because of the shared view on the ongoing task as the expert was able to follow all the actions in real time and correct the worker when required. More evidence about the benefits of shared visual space was also found in a study made by Fussell et al. (2000, 11). Their results from the collaborative repair field test showed that using video channel during the repair task can significantly speed the grounding process between the participants.

2.3 P.O.A paradigm

There is a recently established paradigm for collaboration with remote assistance system. The paradigm refers on three adjacent basic functions that replicate the gestures that would be used to support during co-located collaboration: picking, outlining and adding. The P.O.A paradigm by Bottecchia, Cieutat, Merlo and Jessel (2009, 4-6) was formed after the testing of the remote assistance system in maintenance tasks. The paradigm gives the basic framework for any collaborative system utilizing audiovisual channel for creating shared visual space. With three defined functions the helper can pick a wanted object from the screen (picking), specify what to do and why with the pointed object (outline), and last show what type of action is required (adding).

When examining the three steps more deeply there are the following aspects included:

Picking refers to the physical pointing to the object. Symbol for picking can be anything that associates with pointing like arrow for example. The purpose of pointing is that remote expert can quickly augment different places, objects and directions over the video stream to help worker locating the point of action. Outlining is meant to work like sketching. By outlining, the expert can draw shapes around the components or to highlight the silhouettes of the certain parts to indicate the required actions for the worker. Outlining is supporting the verbal explanation and it can include also the making of notes with typed characters to support the message. Adding is the last step in P.O.A paradigm and it refers to miming of different actions which are pointed and outlined over the video stream. Adding can be done by either with readily available symbols integrated in the system tools or with more elaborated animations which provide information to worker for example on how to combine two components together or how to turn a pointed part (Bottecchia et al. 2009, 5).

P.O.A paradigm was tested and validated by Bottecchia et al. (2010, 6) in a way that it was compared to other systems without structured collaboration paradigm. The results indicated that remote assistance system by utilizing the framework of three actions resulted in better efficiency and success rate in troubleshooting and provided more synchronized interaction possibilities for dislocated persons than systems without P.O.A paradigm.

2.4 Symmetries in communication

There is the dedicated model about communication asymmetries when using different interfaces or devices for collaborative tasks. The symmetries are caused from the variance of the capabilities included in different devices. For example, desktop interface may differ from mobile device interface, as well as there might be built-in differences between expert user and common user interfaces of the remote assistance system. Also differences in communicating performed tasks may possess asymmetry in information. When pointing to equal chances between two interfaces, the symmetry can be considered as a status quo. However, asymmetries emerge when there are notable differences between the interfaces (Billinghurst, Bee, Bowskill & Kato 1999, 1).

The model of communication asymmetries includes the following possible states between the interfaces. Functional symmetry can be reached if both users have the similar abilities to share information during the collaboration over the audiovisual channel. Differences in the abilities cause the functional asymmetry (Billinghurst et al. 1999, 2).

Implementation asymmetry is apparent when both parties have same physical interface properties like resolution of the interface they utilize. Similarly, the implementation asymmetry results from having, for example, large and small resolution used to share the same situation (Billinghurst et al. 1999, 2).

Social symmetries can be reached by having same conversational cues for both parties. This refers to the ability to provide participants personality, for example, by indicating name or photo to used stream. However, the asymmetry is a more prevalent social state if one participant is using solely audio stream of communication with video stream user (Billinghurst et al. 1999, 2).

Having equal role for both party's inability to access on information and participate in collaborative tasks, this makes possible of having task symmetry and information symmetry. On the contrary, in cases when other participant is having less knowledge about the task to be solved, compared to co-worker, there is information asymmetry in place. Similarly, if the participants do not share the equal real-life view of the problem to be solved, task asymmetry occurs (Billinghurst et al. 1999, 2).

What comes to the practical aspect of asymmetries in communication, the importance of taking the possible information asymmetry situations into consideration already during the design phase of the remote assistance system becomes elemental. Interfaces between experts and common users should be designed in a way that when dislocated with each other, both parties are able to send and receive symmetrical information in any environment. In addition, user interface design requires special attention to ensure that, for example an expert using mobile phone interface can communicate without asymmetries with another mobile device user over the audio-visual channel (Billinghurst et al. 1999, 8).

2.5 References in communication

Clark and Wilkes-Gibbs (1986) have constructed a theoretical model in making references in communication. The model is based on the phenomenon where two people possess different amount of knowledge about the topic they are discussing with each other. This is particularly apparent in the situations where an expert and the novice of some field of expertise are communicating and try to reach a common goal through collaboration. In practice, difficulties in referring might occur in the context of terms and locations (Clark & Wilkes-Gibbs 1986, 1). It is proposed that to make it possible for these two persons make their references mutually understood, they must first discover the current amount of information they possess and try to establish their future reference to commonly shared amount of knowledge on the issue. This proposition is based on framework of two hypotheses. First, persons knowledge about the topic sets limits on how specific information one can address at the moment. Second hypothesis is that if persons possess equal amounts of expertise about the topic, with circumstances they will offer own information to the discussion to intensify their message (Clark & Wilkes-Gibbs 1986, 10)

The theoretical model for references in communication proposes that to create a shared understanding on references made, the participants need three adjacent steps. Three steps are identified as assessing, supplying and acquiring. During the assessing phase, two persons having the conversation need to establish a common understanding about each other's expertise about the topic. The purpose of assessing is to strive to understand the partners level of understanding so that oneself can adjust own diction in an understandable way. This is done via targeted questions made back and forth between participants (Clark & Wilkes-Gibbs 1986, 2). The second step in reducing the conflicts between the references is in supplying expertise. After the assessing phase, it is often that party which now acknowledged to possess more expertise on the issue, must supply his own expertise to another person to ensure that they are able to continue the discussion. In practice, the expert in this phase explains the meaning of the terms to less knowing party or alternatively he can try to propose the suitable noun to create a common ground between the participants (Clark & Wilkes-Gibbs 1986, 2).

Acquiring expertise is the last phase in establishing references between two persons. After the supplying phase, it is normal that the novice person will mutually thrive to supplement his own understanding about the topic. This can happen either actively when a novice person shows questions to an expert person to fill the missing details, or so that the novice person will engage in conversation after listening what an expert person has addressed about the topic, thus bringing newly adapted knowledge into the discussion (Clark & Wilkes-Gibbs 1986, 2)

Theory of grounding in communication with three-step model makes it possible for participants to reach the mutual understanding of references used successfully. The benefits of using the model for referencing are that it makes the definition of terms quicker, which again contributes to any possible communication process which takes place between the persons (Clark & Wilkes-Gibbs 1986, 11)

2.6 Communication theories applied in the remote assistance concept

Theories introduced in the previous chapter concerned different phenomena's occurring in the situations where two or more persons are changing information with each other. It can be argued that when considering remote assistance concept for any industrial maintenance, there are certain elements of communication principles and human-cognitive functions that are present even though the interaction happens via audiovisual channel.

Theories introduced in previous chapters are comprised in the following diagram. The diagram about communication theories applied in the context of remote assistance gives an overall layout about relations that takes place during the troubleshooting. Different colors in rectangles indicate the field of theory the term belongs to.

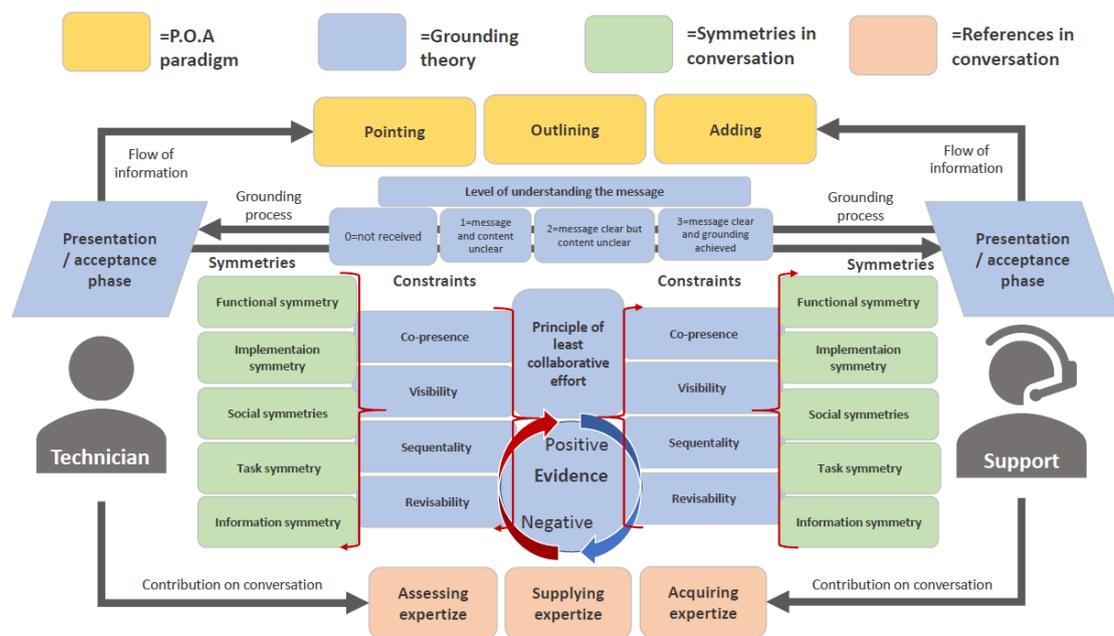


Figure 1 The diagram of communication theories applied in the context of remote assistance.

As it can be read from the diagram, the overall aim in any conversation is to establish a perfect grounding between the parties regarding the topic. During the attempt of achieving the grounding there are several identified principles which apply in any conversation between the people. There are two grounding principles at the center all communication. First, people are thriving towards the least collaborative effort when attempting to bring their references in conversation, and secondly, there is a constant process of finding evidence for having their opponent acquired the message (Clark and Brennan 1991). When establishing an audiovisual communication, a technician making the statement must formulate his presentation by using all the means available in used remote assistance channel. When establishing an audiovisual communication, a technician making the statement must formulate his presentation by using all the means available in used remote assistance channel. There are several symmetries which may either support or hamper in creating a successful grounding. These symmetries are determined by the used conversation medium, and they can be affected by the overall design of the remote assistance system (Billinghurst et al. 1999)

Exchanging information via remotely by audiovisual channel includes several constraints which sawn as partially mandatory obstacles between the ideal exchanging of information between the parties can be (Clark and Brennan 1991). Although cannot be avoided completely due to characteristics of choosing communication medium, constraints can be also minimized by valid design, like with finding the sustaining symmetries in conversation. For example, it is possible to minimize the effects of constraints involving co-presence and visibility with proper technical solutions.

After the technician has conveyed his presentation at the beginning of the grounding, different symmetries and constraints along with technician's own competence will largely determine on how the expert is able to formulate the acceptance phase. As stated in the grounding theory, there are three possible states which can be used to determine the level of comprehension person takes during the acceptance phase. To be completely grounded on the topic, the expert must be able to reach level three. Any other possible outcome, the expert must assess himself in the presentation phase to inquire additional information on the topic.

If the grounding attempt is not successful with first presentation-acceptance cycle, the technician and expert need to start another cycle in communication, this time starting from the presentation phase made by the expert person.

Whether the grounding has been achieved or not, there are ongoing sub-processes during the communication which affects to creating of shared situational view. One is that the technician and an expert might possess an unequal amount of expertise about the topic they are discussing. This situation is pointed in the theory of forming references in conversation which is about finding common terminology and the level of expertise by which both parties can understand the situation mutually (Clark & Wilkes-Gibbs 1986). There is an important aspect of this theory connected to using remote assistance channel. Particularly in troubleshooting the situation is often that technician making the support call lacks the expertise about the topic he is seeking assistance. Thus, it is apparent that theory of references in conversation is applied between the technician and the expert. This means the remote assistance system itself can be used to support the referencing process, for example by using tools to create annotations on top of the video stream.

P.O.A paradigm is a proposed framework by Bottecchia et al. (2009) which remarks the most basic functions that are required for sharing the information in two ways when using the remote assistance in troubleshooting. By using pointing, outlining and adding participants can refer to wanted objects or places in the screen shared with each other. As a final element in theory regarding the communication in remote assistance concept, the P.O.A paradigm can be considered as a layout for practical aspect, standing on top of the principles of enabling of expertise referral and the continuous attempt of grounding.

Each of the theories introduced above are complementing the overall context of the modern remote assistance channel between the technician and the expert for troubleshooting situations. The diagram of communication theories applied in the context of remote assistance as seen in the figure 1 can be used to estimate the communication process between the professionals in remote collaborative cases. By considering the principles and valuating them correctly when planning the remote assistance channel, it is possible to avoid the possible pain points occurring during the communication.

3 Service design

In the following chapter introduce the research methods used in the research project of the thesis.

3.1 Service design process

Service design is considered as a multi-faceted method which borrows from various fields of academic disciplines to create user-driven solutions to needs and challenges identified in business. In addition, service design tends to avoid clear definitions of the characteristics it includes which makes it constant difference based on the applied field (Stickdorn & Schneider 2011, 29)

According to Stickdorn and Schneider (2011) there are five distinct principles in service design and thinking philosophy it possesses. First, service design is strongly characterized by being user-centered approach. This means that all the actions in the service design process are oriented by users or customer's perspective, thus it is identified as a common language among designers. The second aspect in service design is the co-creative approach. Co-creation is about collaboration between the stakeholders and experts. The co-creativity's aim is to lower the silos inside the organizations and to reach common understanding of design process participants. Service design is also sequencing by its nature. Sequencing is about focusing on every possible detail and touchpoints that users or customers experience when interacting with any company representative. The purpose of this is to gain deep understanding about every stage in the service process to find user-centered solutions.

Being evidencing is the fourth characteristic of the service design. In practice this means that every design process is conducted by creating as much as tangible evidences about the studied phenomena. The evidences created and applied in the actual service activity is a key point in creating more valuable customer experiences. The fifth principle of service design is the holistic view it holds over any activity. This thriving towards the holistic view is about seeing interactions and effects taking place between the organizations, employees, customers and any stakeholders involved in the value-creation chain. Overall, there is a strong emphasis towards co-operation by which it is possible to maximize the value in each value chain (Stickdorn & Schneider 2011, 36-45).

Service design process should always be considered as an iterative which means that there can be various stepbacks taken during each stage. This non-linearity in process is a typical characteristic in any service design activity. When using any process model, the practitioner should be aware not to follow the theory part too strictly. This is because of the huge variance between the starting situations and the array of possibilities when planning the path to a solution. However, the framework of the existing process model will tend to give more value

and ability for outcome reflection of service design process outcome (Stickdorn & Schneider 2011, 123-124).

Service design process model used in this thesis is based on the creative problem-solving model by Parnes (1967a). The original model consists of six adjacent stages concentrating around finding. Six stages in the model are named as objective finding (identify the goal of the project), fact finding (gathering information about the identified goal), problem finding (clarify the actual problem behind the identified goal), idea finding (mapping of possible solution for the problem found), solution finding (validating of selected solution) and acceptance finding (analyzing the results and planning the future implementation). Specialty of creative problem-solving model is that there are divergent-convergent thinking phases included in each of the six steps. The purpose of this is to make it possible to designers to generate new ideas through the whole process as well as evaluate them during each stage (Parnes 1967a, NA)



Figure 2 Creative problem-solving process map with six stages (Creativity Web 2005)

A renewed version of creative problem-solving model was introduced by Puccio, Mance, Murdock, Miller, Vehar, Firestien, Thurber & Nielsen (2011) which has four main stages with six explicit steps in the process. First is the clarifying stage where the steps go through identifying the goal, gathering of data and formulating of challenge. The Next stage is concerning the ideation which involves on finding proper ideas to solve the identified problem. A third stage is about developing by formulating solutions to validate the best ones. Last is the implantation stage where key purpose is to find acceptance and make plans for implementation of the results.

The difference between the original creative problem-solving model by Parnes (1967a) and the renewed version Puccio et al. (2011) is that latter version of the model has more holistic approach of the development project in the first half of the process, meaning that stages of identifying the goal all the way to the definition of the problem are handled inside the clarifying stage. The only practical difference between these two models is that when using the original model, it enables for designers to have more detailed results from the first half of the process due to additional divergence-convergence phases compared to four-stage model.

Based on the specifications given above, different service design processes have similar structure and purpose. Basically, process maps are for taking the selected development, research or study from start to finish through a specific set of stages. Stages (or phases) in the design

process include determining actions which must be completed before moving to the next phase with the deliverables gained during the previous stage. Thus, processes nature is to carry the deliverables (knowledge, discoveries or contribution) from one stage to another after the requirements are met.

One of the differentiating factors in service design models is whether they concentrate on either on abstractions or details in deliverables. This variation depends on what model is intended for, whether they seek clearly detailed results or more wider interpretations. Hence, the combination of these two factors enables processes that can be used independently on a wide range of different products and design purposes, but details of the result is reduced in the same (Gericke & Blessing 2012, 178-179).

Different service design process models can be distributed, whether they emphasize the actual user need or design problem or instead management-oriented approach. Another distribution in service design process models can be seen on are they focused on product life-cycle thinking, referring to whether the process is considered as complete after the implementation phase or does the model also focus on the after-design period of the product. In addition, different service design models can be categorized as stage-based models versus activity-based models, solution-oriented models versus problem-oriented models, and even design focused models versus project focused models (Gericke & Blessing 2012, 174).

There are also service design process models which are specifically tailored for delivering results which are more tangible for designers to analyse and turn them into actual business. One such model is introduced by Yu (2017) where the focus is on outcome-oriented result delivery when conducting service design practices. The purpose of this approach is to move service design process framework focus from activity-centred descriptions to be more outcome-centric deliverables. This includes all the centrepieces of the process like design perspective, approach and activities. According to this model, the focus should be on creating active communication between the goals of the designer and the goals of the organization. Thus, the results of the different process phases can be analysed by both sides to create a more detailed overall situational awareness (Yu 2017, 34-37).

3.2 User experience study

According to Lang and Howell (2017, 18) research is about finding approval of the current state of topics which are studied now. Furthermore, when it comes to user-centered design, the main purpose of the research is in understanding the needs of the user to gain better results when developing services. They highlight the meaning of empathy and respect towards the user, to see beneath the surface of a group of users and recognize the individual nature and motivations of the persons among the user group.

Engagement is an important aspect when conducting the research. The focus should not be solely on delivering documents but to engage the decision makers with insights gained from the design process so that they can get familiar with the users. This helps them to recognize users as real persons which in turn assist designers when planning of services (Lang & Howell, 2017, 17).

User experience researcher must have multi-faceted approach on a given task to get all the demands and limits given by the client. Furthermore, the user experience of research can be shown as a skill to go into details of a connection of a product and its user and study the topic from this perspective. The information gained by user experience research is to create clarity and flow through the development process (Kuniavsky 2003, 52-53).

The formal research plan for user experience helps you in many occasions during the project. It is recognized that using a formal research plan instead of informal (non-structured helps to organize the goals and schedules for project for better utilization of resources, rate of guaranteed results increases and there is a smaller chance of choosing the wrong research path (Kuniavsky 2003, 57).

When the research plan has well pondered structure, it also helps other stakeholders to follow your schedule and timetable, working as a communication medium. Hence, when applied in the user research project, clear research plan enables stakeholders to contribute in project easier (Kuniavsky 2003, 57).

There are three major parts identified in a research plan: the goal (the purpose of the research, the schedule (how the plan is employed) and available budget (the available resources). Based on these main parts, it is easier to divide the plan into even smaller sections. The work prior doing the research plan should consist identifying two aspects: what is the purpose of the research project (client/problem owner expectations), and what will be the usage of the results you have to deliver (seeking most purposeful targets for final product). The purpose and deliverables of the project will thus help you to outline the most relevant research questions (Kuniavsky 2003, 58).

When considering the user experience research even further, it is apparent that in the beginning there are no barriers or stepping stones set for the project. Thus, the relevant orientation point should be taken from the most important features of the service or product to be researched in the project, whereas they mean the lineaments that are valuable from a company perspective (Kuniavsky 2003, 58). It should be also noted that no matter what type of user research project will be, it will always have a certain effect on service or product and in the same time it needs to take different aspects in consideration. To fulfill this dual-task, there are three step list, which to use when identifying the most relevant features of the service.

First step in identifying the most important feature(s) is to collect the possible issues and present them as goals. The first step starts by recognizing the stakeholders which have most of the influence on service which is to be researched. After identifying the most relevant stakeholders for the service, it is essential to get in acquaintance with them and to discuss about the possible hidden issues or unsaid expectations regarding the service (Kuniavsky 2003, 59-60). When completing this step, it should be also noted that there might be lots of tacit information around the organization which might have significant benefit when doing the research plan. This type of hidden information might originate from previously conducted surveys, marketing studies, customer interviews etc. (Kuniavsky 2003, 61)

After the issues has been identified and goals of the research project clarified, the second step is to prioritize these goals to form questions which are valid in user experience study. The goals be formed so that they stakeholders view them as most important in the context of the research service. There should be couple of larger goals, emphasizing the topic, and several smaller goals deepen the details (Kuniavsky 2003, 62).

The purpose of the formed goals is to work as a foundation for questions to be used in user research. This is the last step in finding the most relevant features in research topic. Goals are rewritten as questions to be answered based on their scale and topic. It is advised that questions should be simple as possible to be effective in user research, but if needed, the scale of the questions can be also make broader (Kuniavsky 2003, 63).

After these three steps identified issues can be formed as goals and further refined as questions to be asked in the context of user research project.

3.3 Usability testing

Rubin & Chisnell (2008, 21) defines usability testing as a process with a specified test group conducting given tasks to validate the usability of a service or product as surrogates of real end users. It is considered as an umbrella term for various techniques which are feasible in determining service, product or a system, specifically requiring users to be key participants in the process.

A modern form of usability testing suitable for business environment has been refined and established over the years. Apart from its classical form, which included the pre-scheduled test period with specifically formulated hypothesis conducted in controlled test environments to document every causality as clearly as possible, the modern version of usability testing focuses on doing preliminary designed fast-iteration rounds to gain as much information as possible to be used in refining and adjusting the research topic (Rubin & Chisnell 2008, 23-25).

Aim in usability testing is to create information and insights to be shared with design. By connecting usability testing with design, it becomes possible to identify possible pain points in

service or product before taking it to the markets. The goal in combining usability testing with design is to create services or products that possess high value to the customers in terms of user-friendliness, problem solving, desirability and usability (Rubin & Chisnell 2008, 22).

Usability testing originates from classical experimental methodology, where the number and the scale of the tests and participants alike can vary considerably. Also, the nature of testing approach holds the significance of resources and time required (Kuniavsky 2003, 259).

Usability testing is argued to be the fastest and easiest method to validate the specific prototype, service or process. The effectiveness of the tool is because of an instant feedback it provides to the researcher, revealing possible flaws and difficulties by repeating several iterations rounds before implementation of the service (Kuniavsky 2003, 259).

To accompany this, Rubin & Chisnell (2008, 26) has similar views about the benefits of usability testing. A well-timed, paced, focused and iteratively conducted usability test as a research method can reveal potential problems in service almost certainly. Thus, it should always be included in research plans if seen appropriate in the context. The focus of a usability test is in structured process where different tasks are completed by the focus group or a person. The researcher is conducting the process and is responsible for documenting the results accordingly (Kuniavsky 2003, 259).

Kuniavsky (2003, 259) points out that usability test should be used excessively from early to middle parts of the development process to gain full benefits from the research process. This is because instant feedback received from usability tests early in the process provides valuable information as it makes possible for researchers to find confirmation, create new ideas or to re-evaluate the concept during the process.

In practice the focus of usability testing should be validating the possible problems and misunderstandings concerning the service. This approach, compared to mapping of entire user experience, is more useful what comes to gaining valuable insights. Hence, the usability test should focus on the details of how features are presented to the user and what is a user reaction on pointed features. When focusing on specifically identified features, there should be no more than five individual features tested during one iteration round (Kuniavsky 2003, 260).

The usability test should be carried out after the identification of relevant focus group, which usually takes place after the interviews and stakeholder identification. Usability test results should be considered as an instant material for refining the service, which means that there should be allocated time to react to the findings before the end of the development process (Kuniavsky 2003, 260).

What should be also taken into consideration in the research plan, is that usability test results may also indicate some major problems in the studied topic that it requires significant redefining of the targets from researchers. Thus, when conducted properly, usability testing is iterative, ranging from beginning to the end of the development process and will cover all the main aspects of the service, providing insights and new understanding from the focus group (Kuniavsky 2003, 260).

3.4 User interviews

Portigal (2013, 9) identifies interviewing techniques in general to be derived from the ability of asking questions. He sees that interviewing valuable method to identify the possibilities for development projects, or either to refine already structured design hypotheses (Portigal 2013, 5-6).

Lang & Howell (2017, 136) describes research interviews as synthetic social events between the researcher and the interviewee where they give information back and forth. Interviews may pose a lot of negative anticipation on interviewees, concerning information privacy and expectations on how to behave to name a few. Thus, interviewees might reflect their expectations on the interview situation, making in unintentionally difficult to conduct.

Doing user research by conducting interviews aims to collect information about users which is turned into the insights to enable solid framework for research when new services are developed. Key steps in the interviewing process are gaining deep understanding about people in their own context, map the reasons for different behavior, to come up tangible data and insights which are usable in advancing on the research path (Portigal 2013, 3).

Interviews as a research method differs from, for example from conducting surveys in a way that it emphasizes purely quality of the data over many samples. As interviews cannot reach the quantity, each sample should be considered as unique in a way that it represents expressions of a single person, thus avoiding objectivity as such (Portigal 2013, 27).

Conducting interviews with users or other stakeholders are deeply connected to the concept of qualitative data. Qualitative questions revolve around forms like with, why, how and what, aiming to map out impressions, explanations and feelings (Lang & Howell 2017, 42). The qualitative information requires that analysis will be made from the perspective of the focus group. Kuniavsky (2003, 240) continues that qualitative research techniques can specifically reveal that what is the reason that customers or users use some specific product or service in a way they do. The restriction in qualitative research is that it is not able to make specific distinctions between the characteristics of customers and non-customers. This is the separation of quantitative research which can give exact numbers about a topic which is researched.

Further, qualitative research can describe what are the basic qualities of your customers (Kuniavsky 2003, 303).

In addition to collecting qualitative data and creating insights from it, interviewing is a particularly powerful method for reforming the initial problems which are defined in research questions. This is because of when making deep interviews with stakeholders at the different phases of development process, there is a chance to reveal previously unrealized possibilities (Portigal 2013, 5 - 6).

Interviewing as a method requires some special skills from the interviewer. The interviewer should be able to position oneself outside of the theory involved in the subject to strive for objectivity. In the same, the interviewer needs a capability to create shared experiences with different stakeholders, starting from the interviewee. This connects to the skill of empathy with the focus groups, which is needed to understand their experience and emotions to be able to reach the complex realities (Portigal 2013, 10).

The interview includes a lot of elements of observing, but the main emphasis should be asking questions. However, questions should follow the preliminary planned and standardized structure (Kuniavsky 2003, 117).

There are several usable methods to create a structure for the interview, which to use as a guide for conversation. Lang and Howell (2017, 83) names this as a discussion guide with certain standard elements. In this form, discussion guide includes different topics which will be separated into different phases. Their distribution of phases are introduced of session and participants, setting up four main topics, entering main topic, exploring the details, comparisons of different versions, and finally summing up the discussion.

Kuniavsky (2003, 118) defines the hourglass shape interview structure in five different steps. First, there should be an introduction between the persons who are participating in the interview situation. In the introduction it is important to specify the purpose of the interview and what are the roles of interviewees. This will often make participants more comfortable with the situation and gets them more oriented to the situation. The second step is warm-up, which purpose is to take respondents more oriented on the topic at hand and start to steer them in upcoming questions. Third phase includes so called general issues related to service or product. This phase purpose is to map out different expectations and experiences that respondents have towards the service. It is advised that there no deeper details about the service itself don't mention at this stage. Following fourth stage is the deep focus, which is to introduce the service itself. Deep focus aims to clarify what is the purpose of the service and what are respondents initial expressions of it. Last is the retrospective stage where interview returns to the wider scale of the topic. This means making general evaluation about the expressions raised during the previous stage.

There is a concept of tipping point which should be the objective in every interview. The tipping point is the situation where questions and answers are exchanged in a rapid pace between interviewer and respondent. The tipping point is valuable because most informative richest stories are located during that period (Portigal 2013, 24). Lang & Howell (2017, 87) also identifies this point where the respondent is in the most natural state what comes to providing information about the discussed topic. He names this as the heart of the interview, and from the researcher perspective, it is the most valuable time in the interview to focus the questions on valid subjects. Thus, when this most fruitful point is reached, the questions should be arranged so that they will reveal most insights depending on the subject.

From an Interviewer's perspective, the interview is more about listening and not so much about talking. It is important to avoid any unwanted interruptions after the conversation has been established with the respondent. This is where the interviewer must keep focusing on listening and to wait for all possible information that is about to arrive (Portigal 2013, 24).

There are several basic established guidelines for making the interview to ensure that data can be considered as objective and as valid as possible. Kuniavsky (2003, 119) notifies that interview must be nondirected. This refers to avoiding the leading questions which might either affect to respondent answers or to interpretations of the answers itself. Hence, the questions should be presented without bias and responses should be received unconditionally.

When asking questions during the interview, it is also important to ask them in a nonjudgmental manner. This is particularly important when interview considers the preferences of respondent that interviewer does not create any expectations about correct answers for a given question. Open ended questions are preferred when doing deep interviews. The limited amount of choices may narrow respondent's perspective on the subject. When respondent needs to form their answer totally in their own words the information is much more objective (Kuniavsky 2003, 121).

When doing the interview, any possibility for misunderstandings with terms and their meaning should be minimized. Kuniavsky (2003, 122) points out that definition of different terms is critical for respondents to understand the paradigm in which the conversation takes place. Definition of the words, for example, technical concepts, should be clarified in the very beginning of the interview.

A valid technique to delve into the respondent's viewpoints and to clarify the terminology at the same time is to restate the answers. When restating the answers, the interviewer uses the respondent own words to verify that they both understood the given answer in a way that it also gives respondent the chance to adjust the information. Restating answers work well in the situations when there are lots of unfamiliar terminology used and when given answers might require more detailed information (Kuniavsky 2003, 123).

When selecting the focus groups for interviews and usability study, there are two criteria for this. First is concerning the validity, which means that selected focus group represents as well as possible the overall user base of the researched service. The validity of the focus group, when indicating to a usability study, can be ensured during the user interview rounds by arranging the carefully with relevant questions included to gain accurate data for making insights. Second criteria when selecting focus groups are considering the level of achievability. The achievability points to overall willingness and reachability that people in the selected focus group has, affecting their ability to successfully participate in research projects. The achievability of the focus group should be ensured already when making initial screening for usability study participants (Lang & Howell, 2017, 58).

After there are enough data collected from interviews, the material will be analyzed with a structured process. The analysis part can be extended to any development cycle in a way that there is an opportunity for valid analysis during the different stages of the process. The main purpose of well-outlined analysis process is to ensure that the findings are still in line with the project goals. Lang and Howell (2017, 157) identifies five stages in the analysis, which out of three considered as mandatory. The analysis starts by creating a plan which includes the analysis points scheduled through the development process.

Absorbing the data is the next phase which takes place when the fieldwork is completed. When absorbing the data, every possible nuance and detail of the collected material will be organized so that they are ready for the next phase. Depending on the recording format used, absorbing the data should be made with adequate time and with current stakeholders involved. The outcome should be arranged in a format that is informative and easy to follow (Lang & Howell 2017, 157).

Third phase involves finding patterns from the assorted data. Patterns found are the basis of the insights, the concrete discoveries about the topic. When finding patterns, the focus should be on constructing larger blocks of information from the individual observations. The rule for finding patterns is to locate the red line or repeating occurrences (Lang & Howell 2017, 165).

Lang and Howell (2017, 152, 176) gives also two optional phases which utilize in analysis stage. One is that researcher in certain circumstances might need to reconfigure the patterns found to form new ideas. If creating new is essential for the chosen research project, using insights at this stage should be considered as a good solution. When creating ideas sometimes it might be also beneficial to return to finding patterns because fresh ideas can require new associations made from collected data. Other optional phase is to create narrations or stories from the insights. This can be considered as an alternative for creating ideas and should be

utilized in the projects where you deliver inputs for other stakeholders to back-up their decision making. The narrative should have clear and logical structure, so it can connect the most important findings together.

3.5 Personas

The persona is an imaginary and an abstracted collection of a user needs put together for research purposes (Lang & Howell 2017, 194). Personas should be understood as design methods which are to create prioritization and a conversation between the designers. This is because personas cannot include every aspect of a real user or a customer but only a fraction of it, thus forcing to make decisions and form insights. Personas should be updated continuously along the development project when new insights are found. (Lang & Howell 2017, 197). Hence, they work to make comparisons between the ideal user and real world (Kuniavsky 2003, 130)

The only way persona becomes effective is that they are created by the same persons who use them. Creating personas demands discussion between the people upon deciding which of them depicting the users in the most valid way. In other words, personas require prioritization to be effective research method. When organized well, they possess the ability to build empathy between the different worldviews because the commitment they need from very people using them (Lang & Howell 2017, 194-196). Kuniavsky (2003, 130) titles the personas as a summary of the material collected, making them as surrogates of the users which designers should be able to spend time with along the project, thus making them entity-like objects despite being fictional.

The persons should be a compressed out of the research material. This means that they should be brief and comprehensible collages focusing on those aspects of the project that are relevant to the outcome. It should be also considered who is the audience for the personas created because based on their background different stakeholders have different expectations from personas (Kuniavsky 2003, 151)

Stickdorn et al. (2011, 177) identifies personas as a compressed image of any group of people constructed from the qualitative research material. Personas function is to make people or a group of people it presents more alive and tangible for researchers by putting different layers of emotions and insights of them in the same page to be seen. Thus, they make first seemingly homogenous group of people into the recognizable individuals which ideation and concept building can be based upon. Personas can be either fact-based or fictional, depending on the availability of information. Personas can include different components depending on use case, so basically there is no standard model for constructing personas, and they must be adapted and adjusted case by case. The more elaborated the personas are, the more precise knowledge they deliver to later phases of the process.

The most obvious way to construct personas is to conduct interviews with target groups. Data from the interviews is written in understandable form, assessed by the topics and included with the persona cards to relevant topics (general info, special info, highlights, etc.), the good number of personas are somewhere between 5-7. Having more may easily result in a situation where any additional personas delivers zero new information about the researched topic (Stickdorn 2018).

3.6 Service blueprint

Service blueprints are widely used tool for sequencing a detailed description of service process. Blueprints are shown as an effective and adaptable tool to be used in various fields like service innovation, customer experience design or strategic adaptations (Bitner, Ostrom & Morgan 2007, 3). The strength of the service blueprint comes from its multi-level usage as it offers the ability to analyze both the very detailed level of individual steps during the service process, and to deliver the large picture of service process as a whole (Bitner et al. 2007, 4). Blueprints makes also possible to make comparisons between the wanted service and the existing one, thus enabling special type of dual-process to identify possible quality gaps (Bitner et al. 2007, 20).

The purpose of the service blueprint is to show what is happening to whom, how and when it occurs. As the happenings are constructed in sequenced manner, blueprint, when made appropriately, enables to see the critical areas from a service provider point of view. In addition, one of the benefits of the tool is that it shows the interdependencies of the organization in a way that interlinking roles is easy to be aware of. Blueprint is meant as "living" object, meaning that it is started at the beginning of the project, iterated and completed along with newly acquainted research data and insights, and taken as proof documents when delivering the final version of the new service product (Bitner et al. 2007, 18).

The structure of service blueprint is built on separate layers on top of each other's, each depicting the process lane which takes place in a sequenced manner. These layers represent the different views to service process stakeholders from customers to system providers. To create a comprehensive blueprint, active collaboration between the stakeholders is preferred. This offers a twofold benefit; first, it engages people from different parts of the organization to contribute to blueprint creation, making them feel part of the owners of the subject. The second reason is to make sure that every aspect and viewpoints added in the service blueprint are valid when moving forward on the project, as it can be considered also as an implementation plan for a product launch (Bitner et. al 2007, 5).

Finding the point of focus is important when building a blueprint. It is essential to clarify the specific customers its focus on and what are the relevant layers for the blueprint. Blue-print

also needs a proper starting and ending points which will provide a suitable framework for the project (Bitner et. al 2007, 7).

Commonly used version of the service blueprint includes five following components. Customer actions component is the main driver of service blueprint which gives the basic outline and reason for all charts. Put simply, this line involves all the participations from customer side. Onstage/visible contact employee actions are the actual contact points of employees with the customers. This line also includes the “moments of truth” happenings meaning the experiences that the customer receives from the service, whether it is positive or negative. Back-stage/invisible contact employee actions are the happenings that takes place during the employee contacts and are autonomically in relationship with them but remain invisible to customers. Support processes include all the sub-processes inside the organization that makes it possible for customer contact employees to deliver the services successfully. Physical evidences are placed on top of the blueprint and they indicate everything that is concrete to the customer during the service process, and which may cause them to like or dislike the experience (Bitner et. al 2007, 6-7).

4 Research project

The following chapter presents the research project made for the thesis work. The research project was based on creative problem-solving model. The project is divided into six adjacent stages, each concentrating on documenting new findings. Each stage is divided into theory and research parts wherein first part is to describe related theory and latter part to report the research work and results.

The reason why creative problem-solving model (CPS) was chosen as a foundation of re-search project in the thesis was because of the distribution of different stages. In CPS model the first the first half of the process is concentrating solely on defining the challenge (objective finding, fact finding, problem finding). This was shown as most-suitable approach in the thesis topic because the research framework requires that the problem is clearly identified before finding solutions. Also, the CPS model applied well in the thesis because after the solution and idea finding stages, there is a dedicated stage for defining the acceptance of the project results.

Case study as a method

This strategic approach in this research project was a single case study. Case study can be defined as a method used to understand the dynamic present state in certain environments. When conducting a case study, it is normal that several data collection methods are used together to find either qualitative or quantitative data. Case studies are valid approach when there are no existing theories which could be used to back-up the research project. This can

be apparent if the researched phenomena are totally new. Thus, it is possible to create a completely new theory base with the case study without need to apply it to existing theory. In addition, case studies should be utilized on early stages in the research process as it enables to create new findings and discoveries from the topic (Eisenhardt 1989, 4-6).

The main benefit of the case study is that it allows researchers to move quickly between the collection of data and creating a novel theory base during the same project. Another key aspect of the case study is that when conducted properly, case studies often create new theories. This is because case studies can bring out evidence or data that involve contradictions, which require fresh thinking to be interpreted. Yet another benefit of the case study is that it allows researcher to test and validate the found hypotheses quickly. This is because case studies involve measurable constructs which are generated already during the research. In addition, one benefit in case studies is that whatever the theory is generated, it is probably also valid. This is because of the close relationship of data collection and theory created during the same process (Eisenhardt 1989, 16-18).

Data gathering methods in the research project

The data gathering in this research project followed the interview-field pilot-interview structure. The data gathering for the project took place between March and September 2018. The purpose of this was to find accurate insights about the current troubleshooting process in the case company organization. First part consisted conducting both deep and short interviews with the stakeholders involved in the process. In addition to the interviews, data were gathered from eight small group conversations during the case company internal annual meeting in Finland. Overall during the first round there were totally 25 interviews made. After the first round of interviews the field pilot was arranged where one commercially available remote assistance tool was tested with the focus groups identified based on the results gathered from the first round of interviews. Field pilot lasted approximately two months and there were overall 17 participants who were instructed to use remote assistance tool during the pilot phase. After the field pilot the second round of deep interviews was conducted with the field pilot participants where the purpose was to map their experience with the tested tool. On the second interview round there were four in-depth interviews made. The process of data gathering is pictured in the following diagram.

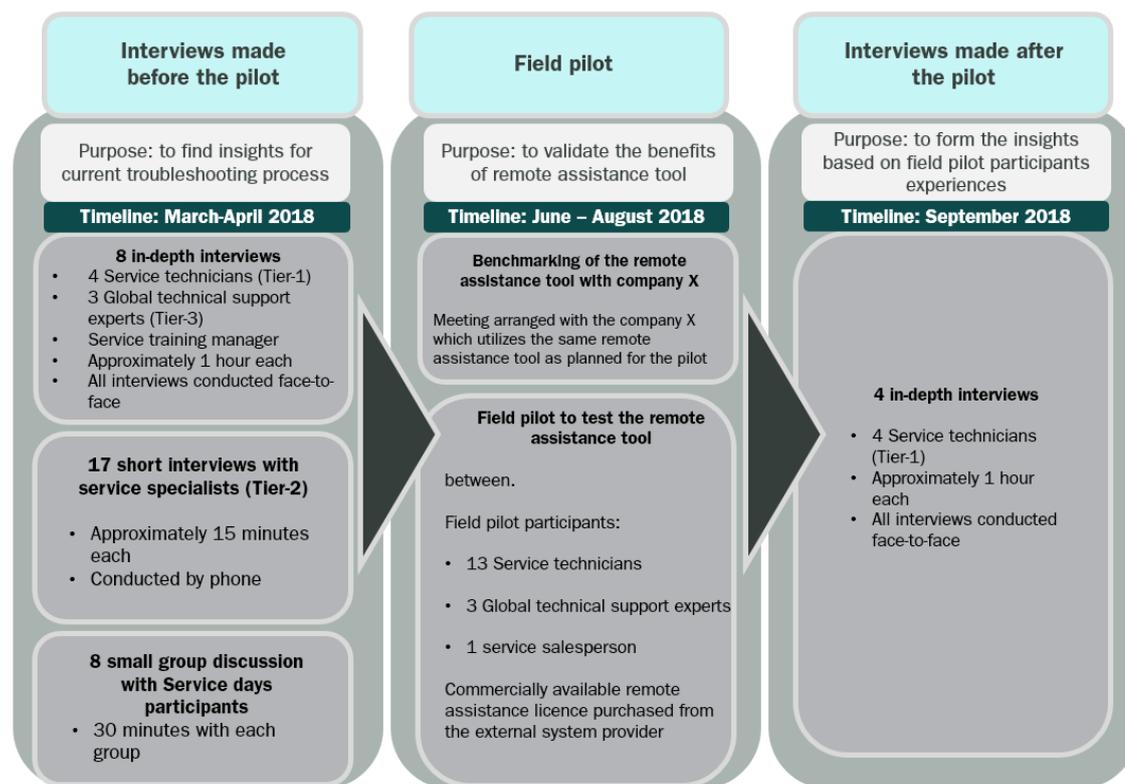


Figure 3: Data collection process in the research project with interviews-field pilot-interviews-structure.

Qualitative research

The qualitative research approach was used extensively during the research project in the thesis. Saldana (2001, 4) identifies qualitative research as top-term for various methods which are used to find data from natural social life. The purpose of the qualitative research is to interpret and analyze the collected data to create a synthesis of it, which is to produce deep understanding and insights from complex interactions between the people. Qualitative data are most commonly non-quantitative, which means that it must be interpreted from the viewpoint of human experiences instead of numbers or volumes. Furthermore, qualitative questions involve impressions, explanations and feelings. Interviews in general are considered as the main method for qualitative research.

Qualitative research in the context of making interviews can be understood basically as interaction between people by asking questions and answering them. Brinkmann (2013, 16) divides this interaction into separate phases of presenting of the question, negotiations of meaning of the question asked, description or answer made by the respondent, interviewer attempt to understand the given answer, after which the interaction cycle starts over again. During the phases, both participants will undergo the exchange of information which will allow the interviewer to form qualitative research data.

There are aspects that are deeply rooted with qualitative research methods. Brinkmann (2013, 21-23) identifies these as the following. Having purpose is one of the characteristics of the qualitative interviewing as opposed to the casual conversation with another person, the interview always seeks to find information or to fulfill goals. Interviews have also sought a description by asking questions from the respondents with the aim to receive descriptions about the certain phenomena. Thus, descriptions are best obtained by asking questions like why and how. It is also noted that in qualitative research it is essential to interpret the meanings, which means that data received from the interviewee must be filtered somehow to get a comprehensible insight which to study. This is because people tend to understand concepts differently, thus when conducting qualitative research, these meanings must be interpreted by the interviewer.

There are different forms for conducting qualitative research interviews. The classes for them are based on how structured the field guide used in the interviews is. Brinkmann (2013, 18-21) describes the different forms as follow. In structured form of the interview there are always a certain type of structure found in the interview made in the qualitative manner. Having some structured form in the interview also means that it is necessary to use leading-questions at least to some degree due to preliminary planning. In semi-structured interviews it is possible to give respondent more free space to bring out different stories while the conversation. the purpose of the semi-structure is that non-planned insights can be found among the conversation when the strict field guide is not followed. Non-structured interview does not have any structure, and it is meant as mostly a free conversation between interviewer and interviewee. The purpose of this form is to let the interviewee produce most of the story after the interviewer has provided some initial theme from which to continue. It is important that interviewer steer the conversation when needed.

4.1 Objective finding

Remote assistance for service technicians-research project started in February 2018 when the kick-off meeting was held with the key stakeholders of the project. Both were employees of the case company. The participants were the vice president of technical support, who acted as a main client for the thesis work, and the project manager of digitization project who acted also as a main consultant of the remote assistance project. The purpose of the kick-off meeting was to discuss about the background of the case and create research questions for the project.

According to the client, the need for next generation remote assistance tool comes from the non-realized possibility to utilize the latest communication technology in troubleshooting situations. The case company being a technology leader in its own industry, scouting and validating new technologies to improve the work efficiency and customer satisfaction is consid-

ered as an important value. The progress of the remote assistance technology has been already followed by the service organization for some time, but no development projects were yet started. The expected benefits of implementing the next generation of remote assistance in maintenance are opportunities to reduce downtime, increase work efficiency and to systematically collect data from different fault situations.

The present situation in case the company is that troubleshooting situation which requires remote support are handled by using mobile phones. In practice this means that service technician needs to make the call to the local service specialist, who can provide verbal guidance to solve the issue. If the service specialist is unable to provide the solution to the issue, the next step for him is to contact a technical support expert in global technical support center who has constant access to the all documentation in the database to find the solution to the issue. After the fault has been identified and a solution found, global technical support expert provides the instructions back either to the specialist who contacted him or alternatively sending it directly to the service technician in the very beginning of the troubleshooting chain.

Previously described troubleshooting process follows the official guidelines in the case companies' service policy. Hence, there are three levels in troubleshooting hierarchy, named as tiers. Tier 1 consists of service technicians who are usually a local person responsible for making scheduled inspections and on-call maintenance tasks at customer site. The overall number of technicians involved in the tier 1 level are considered in thousands. Tier 2 are country-based group of technicians specialized in providing technical support to tier 1 technicians with their own language. Technical support can be provided remotely or by traveling on-site. The global number of specialists are calculated in tens. Tier 3 is a global technical support, or GTS, and it is the highest point of contact for technical support in the case company. Global technical support consists three support centers with about a dozen experts, offering problem solving and troubleshooting internal services to help reduce unplanned downtime. Global technical support can also establish a remote connection with the devices that are connected to the internet.

According to an official guide for troubleshooting situations, when a field technician faces an issue he cannot solve by himself, he must seek assistance from a local service specialist. If the further assistance is required to solve the issue, service specialist must contact global technical support and brief the GTS expert about the issue. Then, it is the global technical support expert who either contacts directly to the service technician and guide him to solve the issue, or alternatively expert can brief the service specialist how to solve the issue who in turn contacts the technician according to instructions given by the expert. This is called the troubleshooting value chain between the tier levels 1 to 3.

During the conversation with the client of the project, client, it was suggested that when considering the future scenario, the focus on the next generation remote assistance channel design should be on tier 1 service technicians. This is because the majority of the service personnel is service technicians, thus it is most probable that most troubleshooting calls are made from the tier 1 level or inside of it. However, it was also acknowledged by the client that, troubleshooting process might differ from the official guidelines. In practice this means that the first point of contact for service technicians in troubleshooting situations can be someone else than tier 2 specialists. There were no existing data available about the real situation, thus it was considered essential to study and document the reality considering troubleshooting process before making any further plans about the re-mote assistance.

With given specifications the main goals of the project were established during the conversation to meet the expectations of the client. Eventually it was decided that the purpose of the thesis work is to plan, test and validate the basic concept of future remote assistance channel for service technicians which enables a peer-support from other experts when required during the field work. Research questions formed for the project was to study the current situation of troubleshooting process and find out the main issues involved, identify key stakeholders in the troubleshooting value chain who would benefit the most from renewed remote assistance, and to validate the possible benefits of the concept. The expected outcome of the research project was to create a proposal about the content and requirements of next generation remote assistance experience for the situations when peer-support is required.

Based on the kick-off meeting with the key stakeholders the project goals were established. The following chart was constructed based on the research questions outlined during the discussions with the client and the consultant of the project. The chart visualizes the initial situational awareness regarding the troubleshooting process. Hence, the function of the chart is to indicate the unknown areas of the project scope, and to update them as the new data and insights are gathered during the study.

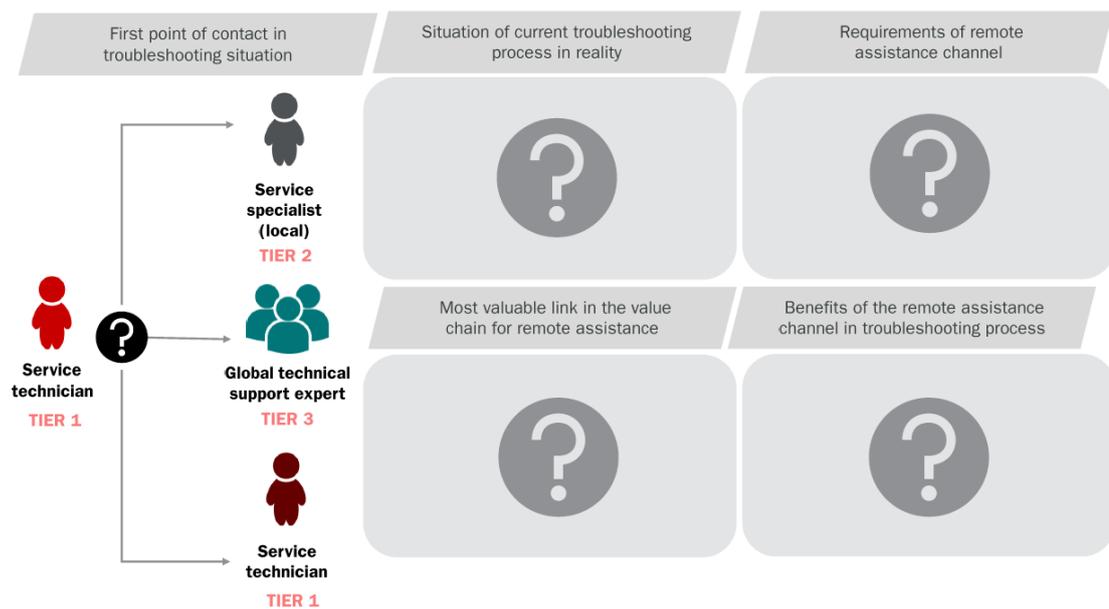


Figure 4 Development project progression map - objective finding.

4.2 Fact finding

After the objectives of the research project were established, the next stage in the process focused on fact finding. During the fact-finding stage, the purpose is about finding information and data about the current situation regarding the troubleshooting process in the case company. As it was outlined during the objective finding-stage, the chosen research method was to use qualitative research to gain as accurate insights as possible. Interviews with different tier level representatives were chosen as a data collection method.

Theme interviews

The most commonly used forms used in the qualitative interviews is the semi-structured, which allows the interviewer to conduct the interview based on selected themes, but which provides room for conversation to move aside from the actual questions (Brinkmann 2013, 18). Theme interviews are based on semi-or non-structured interviews. Both enable the interviewer to use some pre-determined topics, phenomena's or issues as a framework during the conversation. These can be considered as themes by which the participants can approach the conversation. Compared to completely structured interviews, including themes will give more freedom to expand the conversation beyond the questions in the field guide. The benefits of using themes are the increased flexibility in communication and the possibility to discover broader perspectives (Edwards & Holland 2013, 3).

When the researcher needs to create themes for the interview, they should be marked as topics in the field guide beforehand as a side note which enable for the interviewer to follow the progress more accurately. Themes can involve certain aspects of the research or the context

of the individual questions. How and when to handle the themes in the context of the interview should be evaluated according to the situation to make them support the pace of conversation better (Edwards & Holland 2013, 29).

Data collection

Saldana (2011, 32) identifies various methods to be used in data collection. The researcher can collect data by writing, listening, recording or observing when using different methods. Interviewing is considered as the most common method to collect data. There are various benefits of this method as it enables researchers to gain deep insights from the respondent's experiences. With proper field guide and carefully selected participants, interviewing is an effective way to collect data.

Another popular method to collect data is to observe participants. The purpose of this method is to observe and document different actions that people do and what they experience in their normal life or work. The observation should be continued for extended periods to ensure the validity of the data. The benefit of the observation is that it enables researchers to witness more natural behavior of focus group because observing is less artificial situation compared to interviews. The nature of observation is determined also by the degree of what is the researcher position compared to research subjects. Researcher position can influence the data collected as it can make observed persons to change their behavior. Observations require also a well-determined location and the properly made fieldnotes to ensure the efficient data collection (Saldana 2011, 46-50).

With these methods it is possible to effectively document the respondents' experiences and thoughts regarding the studied topic. The collection methods enable to transfer the perspectives and values of the focus group, which are essential in qualitative research. Utilizing semi-structured interview plan makes it possible to expand the conversational topics to gain more viewpoints to the material (Saldana 2011, 32).

It is important to justify the data collection methods based on the research questions formed earlier. Depending on the studied topic, the most suitable data collection methods should be selected when obtaining the data. The researcher should validate whether the data collection happens by listening, talking or watching to name a few possibilities. Also, determine whether is it mandatory to utilize several different data collection methods or only one is important before starting the activity (Saldana 2011, 76).

4.2.1 Field guides

As it was addressed during the project kick-off meeting, many open questions were involved in understanding the present situation of the troubleshooting process. Thus, it was decided that the most suitable approach to collect more information is to use qualitative research

methods with the main stakeholders involved in the troubleshooting process. Based on the discussion with the client and the consultant, the following aspects were identified as important to find out when researching the tier levels: the annual volumes in the troubleshooting on a global level, the content of the calls made indicating what are the most common reasons for troubleshooting, what is the common troubleshooting process and who are involved, and finally what are the experiences of different stakeholders regarding the current process in remote support. Based on these topics, it was decided to arrange a series of interviews to gain understanding about the current troubleshooting situation and the cases involved in it.

Conducting of interviews in a structured manner requires a specific field guide which includes the series of questions to be asked. Based on the questions outlined during the kick-off meeting, there were three different field guides formed. Because each of the groups has a different position in the tier hierarchy with certain unique characteristics, it was required that some of the questions in the field guides must be tier-level specific. The difference in the questions comes from the assumption that first point of contact and tasks for each tier level group is probably different from each other. Part of the questions in field guide was same, disregarding the tier-level. Complete field guides for each group can be found from the appendix of the thesis.

4.2.2 Finding informants

To obtain information about the troubleshooting situations happening in the maintenance work, it was decided that suitable approach is to interview stakeholders from every tier-level in technical support organization. This was because there were no data available about the precise nature of the troubleshooting cases happening between the persons involved. In addition, what was seen as an important to find out, were the annual volume of calls happening between among tier-levels. With even rough estimation about the annual volumes available, it would help to determine the business benefits of remote assistance tool. None of this type of data was systematically collected before which caused that there was no existing information available. Hence, interviewing every tier-level groups was seen as a valid starting point to gain better awareness about the situation.

Interviews with tier 1 service technicians were arranged in Finland on the timeline during April to May 2018. The interviewees were selected during the meeting with the Finland service area manager. The agenda of the meeting was to provide details and specifications of the research project and to identify the suitable persons together. In the meeting it was decided that interviewees should be selected from Southern Finland area to simplify the communication and handling of practicalities with them. Also, it was shown that service technicians in the Finland service organization would offer expertise from multiple areas of maintenance, making them a suitable group as interviewees to study the troubleshooting situations

in the field. Thus, based on their individual background and work situation, for service technicians were identified during the meeting as interviewees. Each of them was contacted by phone soon after to schedule the suitable time to conduct the interview.

Arranging of interviews with tier 2 service specialist required a different approach. This was due to their distributed location in tens of different countries and that they did not work under single branch. The contact list of tier 2 specialist was arranged by the case company service organization which was used to arrange the interviews with each of the interviewees. As it was not possible to arrange face-to-face interviews with tier 2 specialists due to the distance, it was decided to do interviews by phone. The interviews were booked by using email. The approximate duration of the interviews with tier 2 specialist was 15 minutes. Shorter duration of tier 2 interviews was because of the more comprised field guide used than in tier 1 and tier 3 interviews.

Like tier 1 interviewees, also tier 3 expert interviewees were all located in Finland. Recruiting of them was also conducted by having a meeting with the global technical support manager and introducing the purpose of the research project to him. Based on his recommendation, three tier 3 global technical experts were chosen as interviewees. They were also contacted by phone soon after and suitable meeting times for interviews were booked.

The details of each interviewed group are summarized in the following table.

Group of interviewee	Number of interviews made	Time of interview(s) held	Approximate duration	Location	Scope of work
Service technician (Tier 1)	4	April-may 2018	1 hour	Face-to-face	Person specialized in doing basic scheduled inspections and on-call visits on customer site.
Service specialist (Tier 2)	17	April-may 2018	15 minutes	By phone	Country specific specialist who is able to provide support to the technicians with their own language. Trained and specialized to handle sudden device breakdowns.
Global technical support expert (Tier 3)	3	April-may 2018	1 hour	Face-to-face	Crane expert located in the office with an access to factory files, equipment data and documents. Available 24/7 to offer remote problem solving and troubleshooting to help reduce unplanned downtime.
Service training manager	1	May 2018	1 hour	Face-to-face	Person responsible for providing up-to-date training to service technicians and specialists globally.

Figure 5 Table of interviews conducted before the pilot

4.2.3 Themes in tier 1 and 3 interviews

The interviews with tier 1 and tier 3 experts were conducted in interleaved order at Hyvinkää, Finland. They were all arranged in face-to-face situation and their length was approximately one hour each. The method used was an in-depth interview concentrating on creating qualitative insights from both group situations regarding the troubleshooting process.

The structure of in-depth interviews followed the field guide with three separate sections with specific themes involved. Field guides used in interviews with tier 1 and 3 persons included similar themes with each other. Themes handled with these two groups concentrated on finding data about the current troubleshooting process and experiences. The questions involved in topics like how the respondent handles the fault situation now when he requires remote support, and how does the overall process go from the beginning until then when fault is solved. Additionally, questions in the interviews concentrated on what the most typical fault types are that respondents face in troubleshooting situations, and how often they require the assistance from another person to solve them. Field guide concentrated also on finding the most common pain points involved in the troubleshooting. All interviews were documented by using pen and paper by sketching respondent's answers quickly to the paper. The paper sketches were transcribed into the electrical text form after each of the interview sessions. Based on the data the separate memo was created from each interview.

The memos made from the interview data were analysed and turned into persona cards. The persona cards consisted same themes that were also apparent in the field guides used during the interviews. They were about experiences, pain points in troubleshooting, possible tensions or surprises emerged, and summary of the key insights found. Persona cards made from each in-depth interview concentrated on respondent experiences about the troubleshooting instead of their future expectations of possible solutions. This approach was taken because the clear problem definition regarding the research project was not yet formed, and it was foreseen more suitable to concentrate on present situation instead of possible future remote assistance concepts. The persona cards made can be found from the appendix section of the thesis.

4.2.4 Themes in tier 2 short interviews

Interviews with tier 2 specialists were conducted during the same period as tier 1 and 3 in-depth interviews. There were totally 17 short interviews made with tier 2 specialists. Duration of interviews with tier 2 specialists was approximately 15 minutes each and they were handled by phone. This was because service specialists are in several different countries and thus also interviews were needed to do remotely. Field guide used with tier 2 specialist short interviews was different from the one used with in-depth interviews. Themes handled with tier 2 specialists focused on finding facts about the content of the troubleshooting call they receive, who are the persons contacting them and what is the number of calls they receive annually. The responses of tier 2 specialists were written down by using pen and paper during the conversation. After each interview the data were transcribed in the electrical form for further analysis.

4.3 Problem finding

The purpose of the problem finding stage is to clarify the actual problem involved in project scope. This was made by analysing the data gathered during the previous stage and by forming the insights to clarify the questions that were specified in the first stage of the project with the client. The following chapter will introduce the analysis of the data gathered from the interviews with different tier level groups and insights that were formed based on the analysis.

Analysing the data

The purpose of the data analysis is to deliver the insights and findings in an understandable format which can reveal the essential from the research made. Data analysis can be factual, conceptual or interpretive. In addition, analysis can be presented in descriptive or more emerging manner, depending on the level of details included or research goals. It is important to adjust the wanted outcome of the analysis to its purpose (Saldana 2011, 89-90).

After enough data are collected by interviewing people, the material will be analyzed with a structured process. The analysis part can be extended to any development cycle in a way that there is an opportunity for valid analysis during the different stages of the process. The main purpose of well-outlined analysis process is to ensure that the findings are still in line with the project goals. There are five stages in the analysis, from which three are considered as a mandatory (Lang and Howell 2017, 152).

The analysis starts by creating a plan which includes the analysis points scheduled through the development process. the purpose of the planning is to make it possible for the researchers to gain data as much as possible during the project by using the most suitable methods. During the planning it is important to clarify what is the expected outcome of the project, what are the resources and double-check the data types to be collected and how it made (Lang & Howell 2017, 157).

Absorbing the data is the next phase which takes place when the fieldwork is completed. When absorbing the data, every possible nuance and detail of the collected material will be organized so that they are ready for the next phase. Depending on the recording format used, absorbing the data should be made with adequate time and with current stakeholders involved. The outcome should be arranged in a format that is informative and easy to follow (Lang & Howell 2017, 157).

After the data has been collected, it should be noted that some prioritizing actions should be done when analyzing the material. Prioritizing can be made by rating each interview, according to how beneficial the content is from a quick review. This way it is possible to allocate more time on more beneficial content. Prioritizing can be also made by dividing the material

into groups, whether they are clear, confusing or unhelpful for the project outcome (Lang & Howell 2017, 162).

Third phase involves finding patterns from the assorted data. Patterns found are the basis of the insights, the concrete discoveries about the topic. The purpose in finding patterns is to process the large amount of data into more general categories. When finding patterns, the focus should be on constructing larger blocks of information from the individual observations. The rule for finding patterns is to locate the red line or repeating occurrences (Lang & Howell 2017, 164-165).

Conceptual diagrams are effective tools when trying to assess and understand the data. The visualization of the data into diagrams is helpful in understanding of relationships between the different concepts. Diagrams used can be anything from timelines to matrixes depending on the data type to be analyzed (Lang & Howell 2017, 168).

Lang and Howell (2017, 152, 176) gives also two optional phases which utilize in analysis stage. One is that researcher in certain circumstances might need to reconfigure the patterns found to form new ideas. If creating new is essential for the chosen research project, using insights at this stage should be considered as a good solution. When creating ideas sometimes it might be also beneficial to return to finding patterns because fresh ideas can require new associations made from collected data. Other optional phase is to create narrations or stories from the insights. This can be considered as an alternative for creating ideas and should be utilized in the projects where you deliver inputs for other stakeholders to back-up their decision making. The narrative should have clear and logical structure, so it can connect the most important findings together.

Saldana (2011, 91) describes the importance of identifying of patterns from the data to be analyzed. He continues that when doing the systematic analysis of the data collected from various sources, the researcher should utilize the coding method to reach proper insights. Coding is described as a method of discovery for gaining meanings out of certain portions of the data. Code can be understood as a word or a short phrase which summarize the most essential meaning of the source text or material. The purpose of the codes is to provide classifications to the data, so it can be interpreted more efficiently (Saldana 2011, 96).

When moving from coding of the data to further analysis, the making of analytic memos is considered as a valid approach. Analytic memos are the form of document in which research can form based on data to create reflections, narratives and interpretations. They help researcher to position oneself to the experiences of the interviewee or studied topic. After the coding has been made to the data, analytic memos are proper way to guide the thinking process to create larger structures from the material. Thus, memos give more coherent output for the coding. The analytic memos should be updated along the project and the content of

the memos should have different categories which are important for the studied topic and the quotes from the possible interview respondents (Saldana 2011, 98).

After the data have been coded and analytic memos created to create larger structures from the material, the last phase in constructing the proper analysis is to utilize grounded theory to summarize the data further. The principle of grounded theory is to move from the ground up, to work small units into larger units. In grounded theory the purpose is to handle and compare small data units to unify them into more general classes. In practice grounded theory in data handling means that by analyzing small details and categorizing them into relevant category, researchers can form a central category which can be considered as the main topic of the research topic. After finding the central category it is possible to lead various major categories which works as a foundation when forming an understanding about observations. Furthermore, analytic memo is considered as an essential tool when creating classifications from the data with grounded theory by using coded terms. The memos can work as a connective medium for all the other created analysis (Saldana 2011, 116-119).

4.3.1 Analyzing the data from small group discussion during the Service days

Small group discussions during the Service days were beneficial in gathering background information about the troubleshooting process happening in the field. The data from the small group discussions was collected by writing the participants' responses to sticky notes and placing them onto the wall. Afterwards the notes were collected, and data were transcribed into electrical form. The data were further analysed, and the following insights were formed.

First question involved the first point of contact for service technicians in troubleshooting situations. The respondents commonly agreed that when facing an issue during the fieldwork, which requires troubleshooting, service technicians first point of contact is another technician inside their own service branch. This was brought out frequently during the discussion with every group. Thus, it provided a strong signal about the contact behavior.

Another valuable insight which was formed based on the groups discussions was the practice of utilizing silent knowledge. By this the participants referred to the common practice among the service technicians where they utilize their own colleagues inside the same service branch to find information and assistance when troubleshooting is needed. Utilizing of silent knowledge was totally new finding in the project. It was specified by the participants that in practice it usually means that every service technician possess some type of special knowledge about some specific area, like electrics, motors, gears etc. and they know how to utilize their colleague's expertise when required. This can be also interpreted that service technicians can in some situations refrain of contacting to upper tier levels in troubleshooting situations.

When discussed about the most common problems involving the troubleshooting situations, the following aspects were raised out most frequently: it is a common problem that service technicians face lack of proper information or documentation available when attempting to solve different faults. Connected to the previous problem, it was also seen difficult to share documents and materials quickly with the colleagues. This means that during the troubleshooting there are no proper channels to share information. What was also apparent in troubleshooting cases was that many times service technicians are having difficulties to provide support due to inability to share the view concerning the fault situation. This insight is connected to current practice where technicians are required to utilize solely an audio channel when interacting with other tier levels during the troubleshooting cases.

4.3.2 Analyzing the data from tier 1 and 3 interviews

The data from the in-depth interviews with tier 1 and tier 3 persons was transcribed from physical form into the electrical form after each interview session. After transcribed into electrical form the data were analyzed by sorting the similar terms and experiences to the larger categories. After the categories were made, persona cards were created from each interview. The persona cards made can be found from the appendix section of the thesis. Based on the data analyzed and persona cards the following insights were formulated.

When asked about the first point of contact during the troubleshooting cases, all the respondents expressed that based on their knowledge the first point of contact for service technicians is another service technician inside their own service branch. When asked further about possible reasons for this practice, the common view among the respondents was that it is the most convenient way of solving the issues faced while in the field. In addition, based on the responses it was shown that service technicians tend to seek support from the same place they have found it successfully last time.

What was also highlighted in the answers was already previously discovered phenomena of service technicians utilizing the silent knowledge of other technician colleagues. Based on respondents, the reason for this was that service technicians have usually labeled each other based on their expertise involving different areas like motors or electrics. This gives further confirmation to the discoveries made during small group discussion in Service days.

When asked about the most common fault type in troubleshooting situations, the respondents' answers highlighted two fault categories which were seen generally as biggest causes for troubleshooting calls. When inquired further, reasons for this by the respondents was because of lack of documentation available, an inability to access proper documents when needed or in some cases when the technician does not have an earlier experience about the fault type.

Based on the respondents, the average time spend on troubleshooting cases is approximately 2 hours. The time spent differs considerably based on the fault type whereas easier faults are identified and solved in approximately 30 minutes, but in most difficult faults cases repair process may take several hours to find a solution.

The most common pain points in current troubleshooting addressed by the interviewees were the difficulty to share the fault situation with the support person. What comes to identify pain points according to respondents, it was also noted by most that service technicians have difficulties to identify the correct support person on who to call. There is a somewhat contradiction in this insight to the practice of utilizing the silent knowledge. It could be seen that reason for this is because service technicians do not possess any tools which they could use to check the suitable support persons for specific issues. Hence, they are obligated to use personal memos or act according by own memory. In addition to difficulties in troubleshooting, it was also brought out that common phenomena involved in these situations is the service technician requirement to have confirmation about the fault from the support person. Based on the respondents the reason for this seems to be that in most cases service technicians can conclude the reason for the fault correctly by themselves, but they want to have a colleague's opinion before doing the actual repair.

Pain points expressed by global technical support experts indicated that in their position the biggest difficulty the lack of information about the fault case when the support request call is established between different tier levels. The missing information such as what is the actual location and possible previous repair history of the device makes the troubleshooting time consuming in some of the cases.

4.3.3 Analyzing the data from tier 2 short interviews

Interviews with tier 2 service specialists were conducted by phone and questionnaire used in their case was shorter and concentrated on only a few specific areas considering the troubleshooting in their position. The questions to tier 2 people involved the most common fault types in troubleshooting calls, the amount of calls on annual level, the duration of troubleshooting calls and what is the share of the cases where they need to request support from tier 3 level expert to solve the case. The full field guide used with tier 2 specialist interviews can be found from the appendix section of the thesis.

Tier 2 interviews were also highly beneficial when forming the overall picture of the troubleshooting process current situation. The results from tier 2 interviews were able to confirm that it is most apparent that most traffic in the troubleshooting value chain is in tier 1 level between the technicians. What makes this possible to deduct was that the overall number of annual calls coming from tier 1 level reported by the specialists exceeded by far the calls happening between tier 2 specialists and tier 3 experts. Thus, this was the final confirmation

to the question regarding the most trafficked link in the troubleshooting value chain. Leading from the previous insight, second valuable information gained from tier 2 interviews concerned the amount of troubleshooting calls on an annual level. By taking the answers of 17 tier 2 specialists, it was possible to construct a relatively accurate number of annual calls received by specialists in the case company service organization. Last insight made from the data was the further confirmation to most common fault types regarding the troubleshooting calls. Answers of tier 2 specialists also highlighted that two categories that were identified also during in-depth interviews were the most common reason why service technicians require support.

4.3.4 Creating insights from the interview data

The data collected from the interviews with maintenance and technical support organization was used in formation of insights which were working as a foundation when an overall understanding about troubleshooting process was created. In addition to interviews, the material from small group discussions collected on Service days-event provided valuable insights about the situation. In the beginning of the research project, there was no accurate understanding about the actual troubleshooting process happening in the field maintenance. The open questions concerned about the first point of contact for service technicians in troubleshooting situation, number of troubleshooting cases annually in the case company and in which part of the troubleshooting value chain they are located at, and how the troubleshooting cases are solved. All these questions were considered as an important because the specifications of the remote assistance tool would have to be planned according to the facts found.

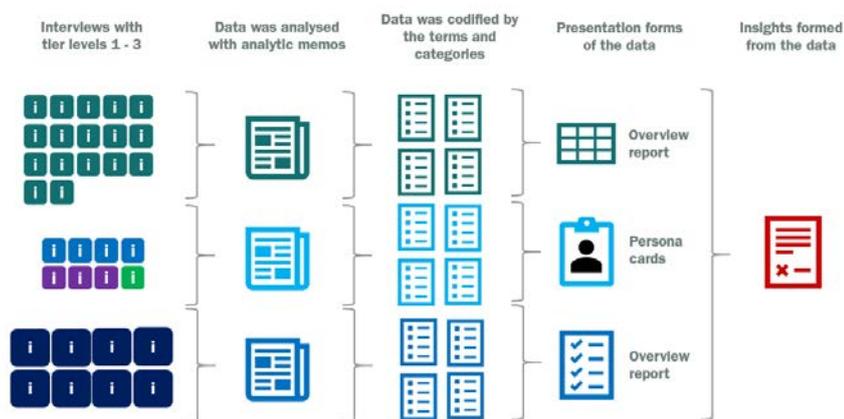


Figure 7 The process map depicting the collection of the data and different analysing steps

As an answer to research question 1. which was to recognize the most valuable link in the troubleshooting value chain suitable for remote assistance tool and to identify the key user groups involved in the recognized link, based on the material it was strongly apparent that the most valuable section in troubleshooting value chain for the remote assistance concept is

located between the technicians at the tier 1 level. Findings advocate this proposal are that based on the research data collected from the interviews and discussions, the troubleshooting happens most frequently between the service technicians. This conclusion is supported by the estimation of annual number of troubleshooting calls on a global level in the case company lead by the overall results of the interviews and small-group discussions.

Second finding to support this conclusion is that according to the data from interviews technicians already utilize each other's competence in field work. Thus, as technicians already do troubleshooting between each other, remote assistance channel could be used to increase the efficiency of the fault solving process. Third finding which supports this conclusion is that according to respondent's lack of shared view in troubleshooting situation is considered problematic. Thus, possibility to utilize the audiovisual channel like in planned remote assistance concept in troubleshooting situations can provide significantly better understanding situation awareness.

The question concerning the most typical fault types in troubleshooting situations provided a fourth main argument for the chosen conclusion. According to respondents there were two fault categories which were most commonly involved in troubleshooting cases. Similar results regarding the fault types were also recognized in earlier studies made by Spitzer et al. (2018) and Henderson and Feiner (2009), where the results indicated that remote assistance channel is beneficial when dealing with the issues.

Troubleshooting process visualized in the service blueprint

Based on the interviews with different stakeholders, the service blueprint process map was created to further visualize the troubleshooting situation. The blueprint was made from the perspective of service technician in tier 1 level and it includes the troubleshooting situation from receiving of the on-call to customer site to the closing of the case. The creation process of service blueprint was not typical in that sense as it was worked together based on the insights formed from the interview data. Thus, instead of creating the blueprint with the stakeholders, the stages, sub-stages and channels were added to the blueprint based on interviewees description regarding the normal troubleshooting process. After that, corresponding touchpoints with each stage were added according to the interview material.

With the service blueprint it was possible to identify the section where remote assistance tool is most feasible to use in the troubleshooting process. Based on the interviews, it was apparent that service technicians commonly try to solve the fault themselves before calling support. This involves attempting to understand the fault and acquiring relevant information to solve it. During these two stages in the process, it would be possible to utilize the remote assistance tool to retrieve information from any specific database including the fault history of

similar cases. However, to create such an option would require significant data system development which is not in the scope of this research project. This is still a valid insight which can be utilized in future development work.

The second identified section in the troubleshooting process is the stages where the service technician needs to make a call for support. Based on the interviews description of the common troubleshooting process, during these stages person de-scribes the fault to support person and the stage where communication and creation of common situational awareness are established. Channels utilized during this stage are the phone and related documents when available. Thus, as the technicians uses the phone in this section of the process already, it would be the most suitable occasion for service technicians to utilize the remote assistance tool also.

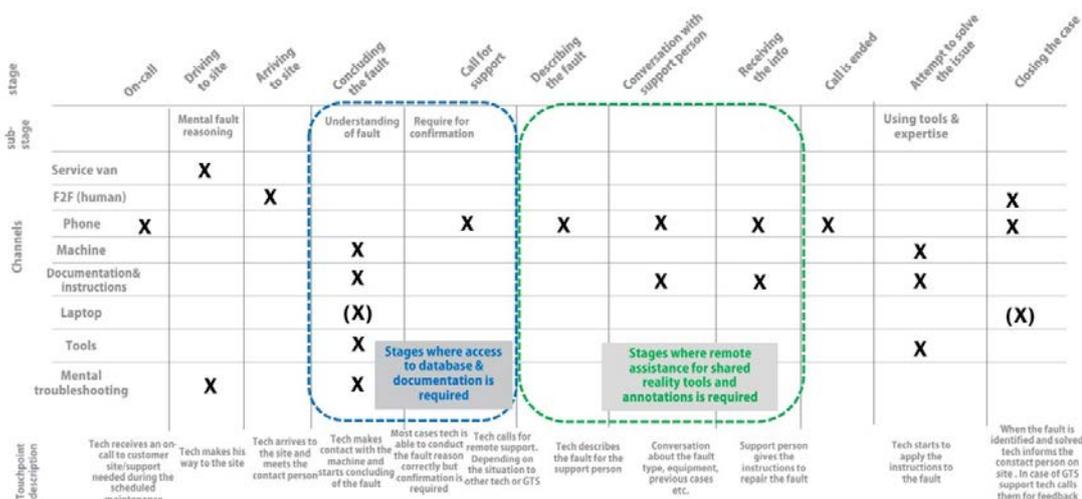


Figure 8 Service blueprint of troubleshooting process from the perspective of service technician with touchpoints and feasible section for remote assistance tool.

With the interview data analyzed and formed insights placed on the chart depicting of unknown areas in the current troubleshooting process, the results are the following: first, the data gave the confirmation that most traffic in troubleshooting situations takes place in tier 1 level between service technicians. Secondly, the results confirmed that technicians consider the lack of visual awareness about the fault cases as a major constraint when providing the support. In addition, the results revealed that service technicians are utilizing each other silent knowledge in troubleshooting. When combined, these results provided strong support to move into the next stage of the research project and to arrange the field pilot to test remote

assistance concept in practice.

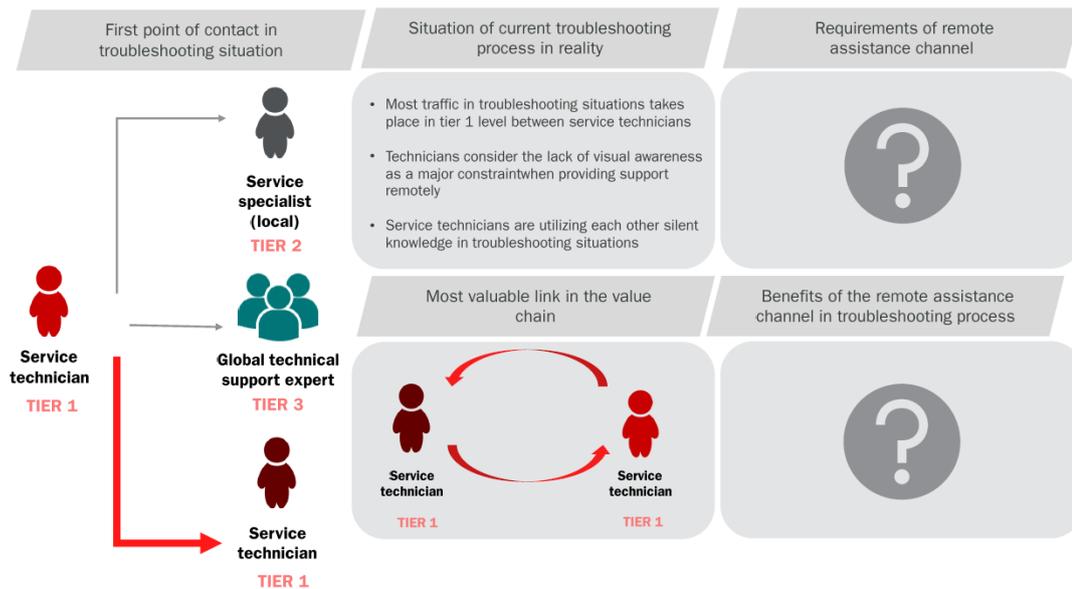


Figure 9 Development project progression map - problem finding.

4.4 Idea finding

In problem finding stage the open questions in research topic were identified by collecting data systematically from the interviews and forming the solid understanding about the real situation in the troubleshooting process. The next stage in the process concentrated on finding ideas. In this research project this stage of the process should be considered as suitability finding instead of finding new ideas. This is because the purpose of this research project is in validating the benefits instead of creating new solutions. After the 1. research question was resolved, it was apparent that to find answers to questions 2. and 3., the remote assistance concept would have to be tested. As concluded in the previous stage, the most interesting test group for the remote assistance were service technicians in tier 1 level. Therefore, it was decided that a properly planned and conducted field pilot was the most suitable method to resolve the remaining two research questions.

Usability study

According to Kuniavsky (2003) arranging of usability testing with well-defined goals is the suitable method to validate the feasibility of specific topics. Rubin and Chisnell (2008, 26) continues that modern form of usability testing conducted with fast-iteration rounds and efficient data gathering is valid method to be used in a research project where new service or products are studied. The purpose of the usability testing is to validate on how the studied concept suits in the real user environments in terms of user-friendliness, problem solving, desirability and usability (Rubin & Chisnell 2008, 22). Furthermore, usability testing is argued to be the

fastest and the easiest method what comes to validating of new service or product (Kuniavsky 2003, 259).

Usability testing in the research project should be arranged during the early or middle part after the interviews and identifying of the focus group. In practice usability testing involves the identified focus group or person completing different tasks and researcher to study their experiences by collecting and analyzing the data. The aim of usability testing is to identify the benefits, open questions or pain points related to service of product to support to later decision making (Kuniavsky 2003, 259-260).

4.4.1 Planning of the pilot

The first step in arranging of the field pilot to test remote assistance was to find a suitable testing platform. Two possible approaches were identified here, either the case company would create totally new remote assistance tool as an internal project, or such tool would be bought from some commercial provider. As it was concluded in the chapter about the earlier studies regarding remote assistance concept for maintenance tasks, there are a large number of similar systems tested and technology has been found feasible for the remote support purposes. With the quick search over the internet, it was apparent that there are a large number of existing commercial remote assistance system providers. Furthermore, there have been even small-scale tests conducted by a couple of different commercially available remote assistance tools in the case company. Thus, there were existing contacts of commercial companies offering the remote assistance system for enterprise users. By utilizing these contacts with the project consultant, the potential candidate for remote assistance tool to field pilot was identified.

Benchmarking meeting with company X

Before arranging a pilot phase with the company providing remote assistance system, it was decided to do benchmarking of the system with the other company that was known for using the similar remote assistance system as their official tool for remote troubleshooting. The benchmark company, which was also involved in business providing service and maintenance of the devices, was contacted and the meeting was arranged with them. The agenda for the meeting was to benchmark their experiences about the remote assistance tool to have confirmation about the feasibility of the tool.

The meeting with the benchmarking company provided good insights for planning of the field pilot in development project. Based on the discussions with their representative the overall experience with remote assistance tool was considered as positive. According to them the tool offers a compact package with all necessary features included which are needed in remote assistance, performing well in professional use.

According to benchmarking company remote assistance tool has certain benefits. More specifically its biggest benefit was reported from reducing the cases where a technical support person requires to travel at customer locations to solve the issue. In practice, these are the situations that are impossible to handle through the phone and are traditionally solved by assigning a person travel to site. There were also apparent similarities between the case company and benchmarking company in the technical support structure, although in their case the remote assistance was used only between technicians and support experts. Hence, the meeting provided strong arguments on behalf of using the planned system provider when arranging the field test for remote assistance.

Remote assistance tool used in the research project

The remote assistance tool used in the field test was the application made by the unnamed Finnish company. The application is referred as the tool or the application from here on. The selected tool is the remote assistance application for professional-use and it is compatible with mobile platforms like iOS, Android and personal computer Windows platforms. The testing license of the application was purchased from the system provider by the case company to be utilized during the development project. The introduction of the application was made by each user individually and after installing the user profile was registered via system provider. After that the application was ready to be used.

There were some strong arguments which supported the selection of the application. One of the arguments was the positive references received from the company X in the benchmarking meeting. Based on the experiences by them, the application suits well to be used in the industrial maintenance environment. Second argument were the features of the tool. The tool includes the basic tools for remote assistance between two persons. These are the sharing of audiovisual stream between participants, making annotations over the video image and sharing of the screenshots taken from the view. Annotations in the application included different lines and symbols in magnification options. The tool also makes it possible to swap the source of video stream between the participants and ability to freeze the screen while making annotations. In addition, the application includes the distributed contact list, which enables users to find other persons using the application.

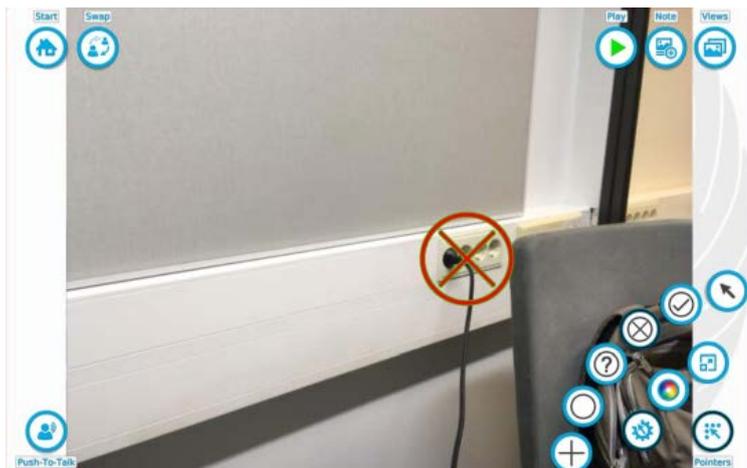


Figure 10 User interface of the remote assistance application used in the field pilot.

4.4.2 Conducting the pilot

The field pilot for service assistance tool was planned in early June 2018. The framework and the goals of the pilot was discussed with the project consult. The expected results of field pilot were determined in four dedicated questions. First, does remote assistance channel bring extra value in troubleshooting situations from a user perspective, second, are there any time savings gained from using remote assistance compared to current, and if there are, how much. Third, what are the features that service technicians find useful and what type of additional features are needed, and fourthly, what are the possible difficulties in using the remote assistance tool. These four topics were lead from the two remaining unsolved research questions, involving the requirements of the tool and the additional value it brings to the users.

During the meeting it was decided to include also tier 3 global technical support experts to maximize the amount of pilot participants and to bring different user group focus into the testing phase. There were two reasons which backed up this decision. First was that even that it was indicated by the data that service technicians utilize primary each other's knowledge during the troubleshooting, in some cases they require the assistance from tier 3 experts to solve the faults. Thus, it was seen as a valid opportunity to study the troubleshooting communication between tier 1 and tier 3. Second reason was the opportunity further introduce the new remote assistance tool for tier 3 experts alike.

The length of the testing period was set to two and a half months, from the first half of June until the beginning of September. During this period, the field pilot participants were free to utilize the remote assistance tool installed on their mobile phones in any suitable situation in the field work. The situations might involve unexpected faults found during the scheduled inspections, emergency calls, inquiring information to certain work task to name a few. The

purpose of the field pilot was to introduce the remote assistance tool to focus group and collect the data from them afterwards by in-depth interviews.

The focus group of remote assistance field pilot was formed from the service technicians located in southern Finland. The initial discussions about the possibility to arrange a field pilot was made by Finland service managers. In the meeting arranged with them, they were introduced to the project purpose and the goals of the planned field pilot. In addition, service managers were inquired to name suitable participants for the field pilot. After the meeting there were totally 14 persons enlisted to the field pilot. 13 of them were service technicians from tier 1 level, and one person from the service sales organization. In addition to tier 1 group, eventually three global technical support experts from Finland participated in the field test.

The briefing session with field pilot participants were arranged in mid-June 2018. In the meeting participants were briefed to the pilot purpose and introduced to the application. All participants installed the remote assistance application during the meeting and several test calls and tryouts were conducted during the meeting. There were no strict instructions given on how to utilize the application. The test group was encouraged to experiment and test the application on any situation they see fit like in troubleshooting, information sharing or training. The only formal request of the field pilot participants was that they should utilize the remote assistance tool as active as possible during the testing phase. At the end of the meeting the participants were informed about the upcoming round of in-depth interviews to be conducted with them after the pilot.

Documented failure incident during the field pilot

During the field pilot, one troubleshooting case was documented by the service technician and a global technical support expert. This was done after the special request given for certain field pilot participants to document some suitable cases during the pilot for study purposes. The troubleshooting case involved an inspection of an electric cabin. The situation took place in Hyvinkää and it involved service technician and an expert solving the issue that was found during the field work.

During the regular inspection the technician noticed that certain component located inside the electrical cabin indicated an alarm. The technician was not familiar with the fault and acquired more information on how to solve the situation. Thus, the technician made the call to the global technical support expert and described the situation to him. They agreed to establish connection with the remote assistance application.

After the connection was established, global technical support expert used remote assistance application screen annotations to guide the technician to first check correct components and

their status. After identifying the most probable cause for fault, the expert guided the technician to operate the device by pressing a correct button. By doing this, the technician was able to solve the issue successfully.

After the inspection was continued, the technician noticed that also and the panel of other de-vice indicated an error message. Hence, the two agreed to use remote assistance application again to take a screenshot from the panel. Technician zoomed the device front panel with the application, after which the expert used screen annotations to guide the technician to solve the issue. To highlight the root cause of the error, the expert used own PC to browse correct manual for the issue and shared the view in his desktop with a technician's phone with the remote assistance application sharing feature.

The documented troubleshooting case of field pilot indicated that remote assistance tool is feasible solution what comes to faults related to electrical components. Afterwards, during the informal discussion with the service technician who participated in documenting the case, the feedback was highly positive. Based on the technician, using the remote assistance tool suited well to describe the fault to the technical support expert and the situation was solved more efficiently than using only audio by phone.

4.5 Solution finding

The purpose of the solution finding stage is to converge the validations found during the previous stage. The aim of finding the solutions is to determine what is the overall feasibility of the results from the research scope perspective. The feasibility of the findings can be determined in terms of probable acceptance, cost competence and technical suitability. The solution finding stage in this research project is to collect and analyze the data from the field pilot. The objectives in this stage were to systematically gather data by conducting interviews with pilot participants and to form insights to be delivered to the final stage of the project. The data which was gathered after the field pilot by conducting the interviews was analyzed with similar methods that were utilized in the first round of interviews.

4.5.1 In-depth interviews after the field pilot

Field pilot arranged to test remote assistance tool with service technicians and global technical support experts in Finland lasted from mid-June to end of September. During the field pilot the participants, 17 persons overall, were free to use the remote assistance tool with their smart phones and laptops in any situation which they saw as feasible. The activity in using the remote assistance tool in troubleshooting was intermediate. Based on the statistics received from the remote assistance system provider, the overall calls made during the testing period were 65, and application was installed 21 times. The duration of the calls was generally short, 43 lasting between one to five minutes and 22 with over 5-minute duration.

Small activity during the field test can be partially explained by the overlapping holiday season, which resulted that some of the participants were having an annual leave during part of the testing phase.

After the field pilot, the focus of the project was to collect the experiences of field pilot participants by conducting second series of in-depth interviews with them. The process of arranging and conducting the interviews after the pilot followed the same plan as in the previous interview round. The field pilot participants were contacted and totally four persons were selected based on their schedule for face-to-face interviews. All the interviews were conducted in Hyvinkää, each lasting approximately one hour. After the each interview a memo and persona cards were formed based on the data collected. The field guide used in the conversation, and the persona cards made indicating pilot participants experiences can be found from the appendix section of the thesis. Reported insights from the interviews are documented below.

Interviews made after the field pilot	Number of interviews made	Time of interview(s) held	Location	Scope of work
Service technician (Tier 1)	4	September 2018	Finland	Person specialized in doing basic scheduled inspections and on-call visits on customer site.

Figure 11 Table of interviews conducted after the pilot

The themes involved in in-depth interviews with field pilot participants concentrated on what type of situations the respondents have been using the remote assistance tool and on what type of fault cases were handled. The questions covered also the overall experience when using the tool when handling the work tasks. Positive and negative experiences were asked alike. Third theme involved in the field guide was the estimated time savings when utilizing the remote assistance tool in fault cases, and the possible overall need of using the tool in own work.

When asked of the field pilot participants that does the remote assistance tool bring extra value in troubleshooting situations from a user perspective, the findings were the following. Participants answers indicated that overall experience about the remote assistance tool was carefully positive. The common experience was that despite the certain flaws in the tool, the participants found audiovisual channel somewhat beneficial in their own work. Furthermore, the feedback from interviewees indicated that participants appreciated the video stream feature because it clarifies the situation much better in certain situations when peer-support is required.

When asked what the features of remote assistance tool were that service technicians find useful, the possibility of two-way video stream was considered generally positive. According to respondents, video, link brings an extra value in the troubleshooting situations in terms of explaining and understanding the situation with the remote co-worker in troubleshooting situations. This was seen particularly valuable when introducing beginner to new situations occurred in the field. When asked about the usability of the annotations made on top of the video stream, the participants did not feel this feature too beneficial in bringing any value in troubleshooting situations. Except for the individually documented troubleshooting case by one of the field pilot participant explained above, the respondents did not utilize the documents sharing through the application almost at all, thus the benefits of this feature were not reported. In addition, there were non-of direct negative feedback about the features included in the application.

When inquired about the type of fault situations where respondents had used the remote assistance tool, the following cases were mentioned. During the pilot the respondents reported two different fault types which were most commonly involved in the contacts made. Based on the respondents the main reason for this was that audiovisual channel was considered most beneficial in fault types that are difficult to describe verbally, alias the control panels indicating some type of error message. Second fault type mentioned were wiring issues. During this situation the respondents required assistance on how to replace electrical wirings correctly. Based on the responses, remote assistance tool is beneficial when dealing electricians and wirings because it enables both parties to see the colors and positions of wires more easily.

Other types of faults where remote assistance tool was used were identifying of different components, confirmation of the working principle of certain part and acquiring guidance from the expert to make adjustments to brake.

The negative aspects of remote assistance tool reported by the field test participants were revealing. It was addressed by all respondents that audio levels when using the application was very weak. This resulted that even the slightest background noise during the call made it impossible to hear what another person was saying. This was seen as discouraging flaw in the application because according to respondents this prevented by using the tool in certain situations during the pilot. Another negative aspect reported was the high usage of battery when using the remote assistance tool in smart phone and that application did not indicate when someone was trying to establish a call via application directly. In addition, it was reported problematic in some situations when it is required to have one hand holding the phone during the troubleshooting, leaving only one hand to perform the actual repair tasks.

During the interviews, the respondents estimated that they would use application about one to two times per month primarily in cases which are difficult to handle in other way. When asked about a possible reduction in need to contact upper tier levels in troubleshooting situations, the respondents estimated that using remote assistance tool would reduce the need approximately 5 to 10 %. Interviewees estimated that using remote assistance tool would bring 5 to 10 minutes time savings per troubleshooting in average cases, but estimated also that time savings could be even more what comes to more difficult cases. It was also noted that sometimes solving the case requires multiple calls, and with video stream it is possible to find a solution with a single call. This should be considered also as potential time savings when utilizing the tool.

4.6 Acceptance finding

After the second interview round was concluded and the results analyzed, the development project of remote assistance for service technicians was concluded in the acceptance finding stage. Acceptance finding stage focus on possible ways to implement the solution found during the project. In this thesis, the stage purpose is to summarize the results and generate business specific insights out of the findings to be used as a decision-making material regarding the remote assistance tool in case company.

4.6.1 Introducing the results to the client of the project

After the field pilot was concluded and the insights from the collected data were formed, the results of the project were introduced to the client. The summary meeting was arranged at November 2018 in Hyvinkää. Participants in the meeting were the client of the project and the manager of digitalization who acted as a consultant on the research project. The following summary and the analysis of the results were presented and discussed in the meeting.

The insights comprised based on the material from the interviews indicated that overall experience about the remote assistance tool was carefully positive. The participants estimated the feasibility of the tool as positive what comes to solving of troubleshooting situations in the field situations. The overall conclusion was that participants estimated an audiovisual channel as somewhat beneficial in their work. Estimated usage of the tool was approximately 1-2 times per month per technician. This result could be interpreted that in Finland service technicians possess a high level of competence what comes to solving issues during the field work. In other regions the usage could be estimated higher.

The interviews suggest that using remote assistance tool would reduce the time used in troubleshooting by 5 to 10 minutes per case. This should be interpreted as quite a moderate saving when taken in proportion of the total amount of service technicians in case company. Thus, there would could be potentially saved annually in work time globally. The results also indicated that using audiovisual channels in troubleshooting would reduce the need to call

higher tier levels by five to ten percent. These results should also be interpreted as a chance for potential annual savings in possibility to focus technical support in the most urgent cases.

Based on the field pilot results the remote assistance was considered beneficial when dealing with faults related to two device categories. The common understanding between the field pilot participants was also that audiovisual channel is most usable in fault types that are difficult to describe verbally. The negative feedback regarding the tested remote assistance tool concerned the problems with extremely weak audio levels during the calls. This was causing that participants were unable to hear each other's speech when there was even slight background noise at present. This was considered as a serious flaw by the participants because having proper audio is considered essential when interacting with other persons and in exchanging the information efficiently. The problem with audio levels was most probably due to the software used in the remote assistance tool. Thus, it should be considered as an error in software design, and not as deficiency involved in a hardware like smart phone used by the participants. In overall, the discovery regarding the common background noise occurring in customer sites should be considered as valuable insight as it is possible to anticipate the requirements of future remote assistance tools used in the case company.

At the end of the development project with conclusions made from the insights, the last two of the unknown areas in the chart were filled. The first aspect of the requirements needed in the remote assistance channel was clarified based on the field pilot participants' feedback. Based on the studies the remote assistance tool must be suitable for mobile devices and laptops alike. This is because of the technical support process with many tier levels where stakeholders in tier 1 and 2 are usually having mobile devices used in troubleshooting, whereas tier 3 global technical experts are utilizing laptops. Thus, the requirement for a tool supporting multiple platform is valid.

Second, somewhat surprising results from the field test was that service technicians did not consider annotations-feature too usable during troubleshooting situations. Thus, when the possible future remote assistance tool is planned to be implemented in the case company, the annotations-feature may not be a necessary function included. This result might be explained partially by the fault cases occurred in field pilot, thus more excessive study may be needed to confirm this argument. Third, the insight about the sufficient audio level needed during the troubleshooting call in noisy environment was valuable finding. The problem of hearing what other person in taking when using remote assistance tool was also a surprising discovery as it was not mentioned in any of the previous studies or benchmarking company which was using the same tool in remote support. The field test revealed that the working environment in case the company is apparently often noisy, and this fact must be taken into consideration when implementation of a remote assistance tool is planned.

The last of the unknown areas in the chart depicted the possible benefits of the remote assistance tool in troubleshooting. There were three main findings: the results indicated that service technicians found the tool usable with certain fault types, in general this means the faults which are difficult to describe verbally. This benefit is due more efficient sharing of the ongoing situation with a support person by using video stream. The second benefit is also the direct outcome of better visualization. The time needed to solve the faults is decreased along with technicians need to inquire support from higher tier levels, creating savings in work time. Overall, when considering the benefits from user experience side, the remote assistance was considered as carefully positive experience by field pilot participants. This indicates that, if integrated as an official support tool, service technicians would probably accept the remote assistance to be used in their work.

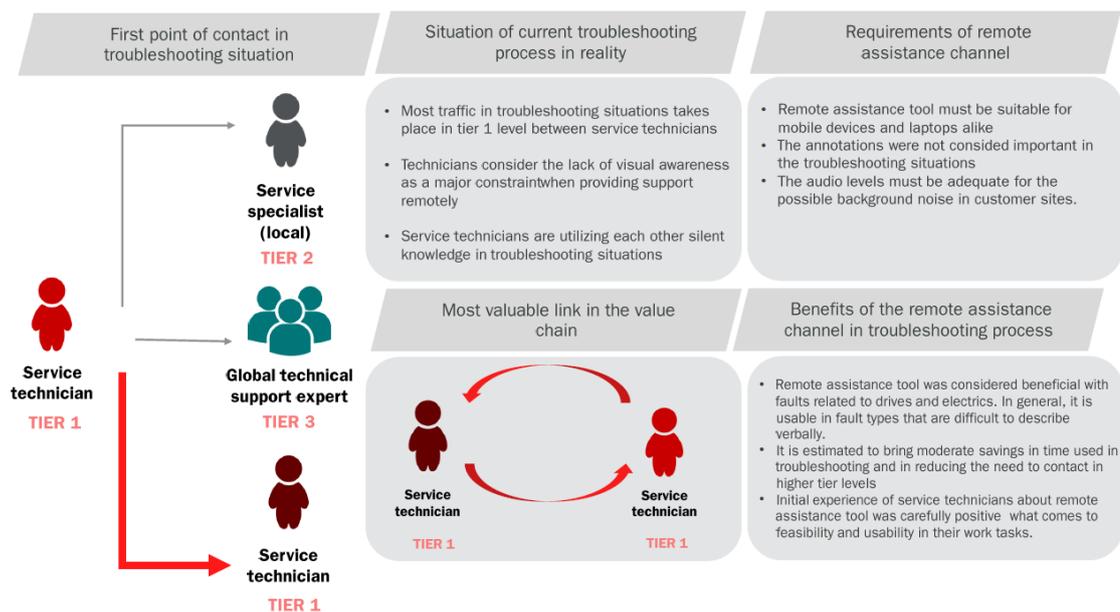


Figure 12 Development project progression map - acceptance finding.

5 Findings and results

In the next chapter are introduced the findings and results of the research project in the thesis work. First are reported the conclusions of the project with all the main findings based on the research made. Next there is a summary of the research project where the goals and the used knowledge base are introduced. Third is the value of the research where further analysis of the main findings is made from the perspective of industrial maintenance business. In the end there are contemplations made about the possible future research opportunities based on the results.

5.1 Conclusions

The results of the research project were in line with the previously reported findings from other studies regarding the remote assistance systems used to support repair tasks. First, field test participants in this research project reported that using audio-visual channels in troubleshooting decrease the time required to solve the issue. This was reported also by Henderson and Feiner (2009). Secondly, it was reported that remote assistance is suitable for fault situations which would be difficult to describe only verbally. Field test participants saw this as a big benefit in using video stream. When compared to using only audio channel of communication when a person receives or provides the assistance remotely, the capabilities of audio-visual stream in creating situational awareness for both parties clearly improve the user experience in the troubleshooting process. Similar results were reported by Domova et al. (2014). One of the differences found with previous test results was the feasibility of the annotations used to mark objects on top of the video stream (Spitzer, Nanic & Ebner 2018). Field pilot participants did not find any value on using annotations in troubleshooting cases, and video image was felt sufficient when explaining the situation to the support person. This was one of the surprising elements among the findings, which might indicate that it is industry-specific whether the annotations bring any extra-value in troubleshooting. The most important insight from the project results was concerning the requirements of the remote assistance tool. The field pilot participants commonly reported that audio-levels of the remote assistance tool were too low to be used in the factory environment. This was totally unexpected finding because the tool was promoted to be suitable for professional use, but apparently there are large variations in background noise levels depending on the industry which was not foreseen. The insight about the lack of audio levels was extremely valuable in the sense that it helps to avoid possible errors when planning the remote assistance concept in the future.

5.2 Summary of the research project

The thesis work reported the research project concerning the remote assistance for service technicians. The scope of work concerned with validating the feasibility of the remote assistance tool in troubleshooting situations in industrial maintenance. This included studying of current situation of troubleshooting in maintenance work in the case company, discovering of most suitable link in the troubleshooting value chain and to test the concept in real use and report the findings. The client of the project represented the technical support department in the case company and there was an existing need to validate the possibilities of the next generation remote assistance tool for maintenance. Thus, the thesis work had an important purpose in this manner. The work process followed the creative problem-solving model by Parnes (1967a) with six development stages. The scope in each stage was on making findings during the process, eventually clarifying the status quo and creating insights based on research which were refined as a test framework for the tool.

The theory framework in the thesis work was built on communication theory with different aspects on changing information between two persons. The theory on grounding in communication by Clark and Brennan (1991) was used excessively to create a core for a model explaining the communication during remote assistance. The process for creating a successful grounding between the parties was essential information with various types of constraints identified in the theory. When taken together with the principles of symmetries in communication by Billingham et al. (1999), it was possible to create a chart for identifying the crucial parts of the communication process. Symmetries occurring in communication can be either supportive or negative what comes to the functionalities of chosen communication medium. These two theories outlined the basic communication process which was enhanced with the principle of making references in communication by Clark and Wilkes-Gibbs (1986). Explaining of how references are made is important part of the theory map because it explains what is required in addition to the grounding when two persons are finding the mutual understanding about the terms and expertise needed to solve the task. P.O.A paradigm by Bottecchia et al. (2009) offered the framework for actions needed to feasible remote assistance tool. Pointing, outlining and adding functions are the basic elements required to efficiently communicate via video stream.

Most important research methods used in the development project were the interviews made with different stakeholders and usability testing with service technicians and technical support experts. These two methods were selected in this project because it was important to gain an understanding of the initial situation and form insights about the expectations of the remote assistance tool users. Furthermore, usability testing in the form of field test was conducted because it was essential to find and map the experiences of service technicians from real troubleshooting situations (Kuniavsky 2003).

5.3 Value of the research project

The research questions determined at the beginning of the project were answered successfully. With the systematic research work made concentrating on clarifying the current situation in the troubleshooting process in the case company, and by conducting careful analysis of the data after each stage, eventually leading to well determine interpretations and insights formed, the overall understanding of the benefits and the requirements regarding the remote assistance concept was dramatically increased. When comparing the initial situation with multiple open questions involving the feasibility and the acceptance of next generation remote assistance to the status after the concluded project, the amount of information regarding the topic is substantial.

The deliveries of the research project can be considered as a pioneering work in two ways for the case company. Primarily, it was the first project arranged in the history of the case com-

pany which focused on validating and testing the remote assistance concept among the service technicians. The results gained from the field test can be considered as the first proof about a systems feasibility in troubleshooting situations. The results from field tests confirms the suitability of the remote assistance system in the industrial maintenance business.

Second, pioneering aspect of the thesis concerns the business case of the remote assistance concept. The business case in this context is lead from the estimated expenses occurred from using remote assistance system compared to the estimated savings gained from utilizing the tool. The data for calculating the business case was collected from the research made during the fact-finding stage of the project where the goal was to identify the most suitable link in the troubleshooting value chain to test the remote assistance tool. With the excessive number of interviews conducted with tier 2 service specialists, it was possible to estimate the number of troubleshooting calls located in the middle section of the technical support tier hierarchy. When combined with previously recorded data involving the number of troubleshooting calls made to tier 3 level, it became possible to deduce the number of annual troubleshooting calls happening on the lowest tier level, between the service technicians. With the estimation of the overall annual troubleshooting volumes in the case company, combined with the field pilot results about estimated time savings gained, it was possible to form an initial result about remote assistance business potential. This was the first time in the history of the case company when the amount of annual troubleshooting cases between different tier levels was identified by using research methods. The value of the business case results is that it enriches the findings from the field pilot by indicating the feasible cost structure of a remote assistance tool in the context of the case company. In the preliminary business case it becomes possible to ponder the benefits versus costs of such system.

The value of the research made during the project comes from the insights delivered regarding the troubleshooting process. This was done by identifying systematically the different stakeholders involved in the process and the factors they experience during the troubleshooting. With the results delivered in this report, it is possible to determine the benefits of the remote assistance tool in industrial maintenance in the context of the case company, and furthermore to estimate the business case based on the calculations made from the interview data. The results clearly indicate that service technicians felt next generation remote assistance tool utilized with smart phones as a positive improvement regarding their work. In addition, the results indicated that the working environment in the case company business is often too loud for the remote assistance tool used by smart phone's speakers. As such, the findings of the thesis can be utilized in planning and executing the possible second development project of the remote assistance concept in the future.

The knowledge base used in the thesis work was used to create the diagram of communication theories applied in the context of remote assistance. This diagram can be considered as a

novel contribution to the field of research concentrating on remote assistance in maintenance. It indicates the relationship between the established communication theories and the modern remote assistance concept. The diagram can be utilized as a chart which enable the system designers to consider the different key features and human-cognitive functions which are taking place between the two persons exchanging information during the troubleshooting. The value of the diagram is that it makes the information exchanging process during the troubleshooting visible with symmetries, constraints, references and the level of grounding that are all occurring during the conversation. Thus, the diagram of communication theories applied in the context of remote assistance helps either when completely new remote assistance channel is created and designed, or when existing remote assistance solutions are benchmarked and validated to be used in the maintenance environment.

5.4 Opportunities for further research development

The digitization of work methods used in the industrial maintenance is already an ongoing trend, changing the traditional working environment into more dynamic and data-oriented. The next generation of remote assistance concept utilizing latest communication technologies with mobile devices is one of the movements in this direction. As the overall acceptance towards the tested tool was carefully positive among the field pilot participants, in addition to other benefits found during the project, there is a valid opportunity for the case company to continue the research on the remote assistance concept. Technologically the concept of audio-visual support channel is mature and there is lot of previous research done in the field of remote assistance which can be used to support the future planning as well.

Like the results reported here, the benefits of remote assistance concept in making repair tasks faster and easier to solve has been validated also by Domova et al. (2014) in study concentrating on related industry. The results found in the thesis acted as a valid proof about the suitability of the remote assistance concept utilized by organized technical support personnel. The proposals for the possible future development work for the remote assistance are the following. First, to validate the usability of the support tool in more demanding use environment, it is necessary to arrange a larger international field pilot. This should be made with sufficient number of participants covering the technical support organization of the region to ensure the sufficient data. The reason for this is that despite the encouraging results of the first pilot, the scale of the pilot was small, thus reducing the accuracy of the data and the reported user experiences. Another aspect that should be recognized in the possible upcoming development is the suitability of the remote assistance tool selected for the field pilot. The features included in the tool should correspond the professional level of the focus group and the expected troubleshooting cases to be solved.

References

Billinghurst, M. Bee, S. Bowskill, J. Kato H. 1999. Asymmetries in Collaborative Wearable Interfaces. Human Interface Technology Laboratory. University of Washington. Seattle, US.

Bottecchia, S. Cieutat J-M, Merlo, C. Jessel, J-P. 2009. A New AR Interaction Paradigm for Collaborative TeleAssistance system: The P.O.A. IRIT, Univ. Paul Sabatier, 31062 Toulouse, France.

Bottecchia, S. Cieutat, J-M. Jessel, J-P. 2010. T.A.C: Augmented Reality System for Collaborative Tele-Assistance in the Field of Maintenance through Internet. AH'2010 (Augmented Human), France.

Brinkmann, S. 2013. Qualitative interviewing. Oxford University Press.

Clark, H & Brennan, S. 1991. Grounding in conversation. Perspectives on socially shared cognition. American psychological association. Washington, DC

Clark, H & Wilkes-Gibbs, D. 1986. Referring as a collaborative process. Stanford University, US

Creativity Web. 2005. Accessed 10 March 2019. <http://members.op-tusnet.com.au/charles57/Creative/Brain/cps.htm>

Domova, V. Vartiainen, E & Englund, M. Designing a Remote Video Collaboration System for Industrial Settings. 2014. ABB Corporate Research. ITS 2014 In the World.

- Yun, E. 2016. A Reflection on and Suggestion of Service Design Processes: from Activity-Centered Descriptions toward Outcome-Oriented Demonstrations. Lancaster University, UK.
- Edwards, R & Holland, J. 2013. What is qualitative interviewing? Bloomsbury Academic, UK.
- Eisenhardt, K. 1989. Building theories from case study research. *The Academy of Management Review*, Vol. 14, No. 4 (Oct. 1989), pp. 532-550
- Fussell, S, Kraut, R & Siegel, J. 2000. Coordination of Communication: Effects of Shared Visual Context on Collaborative Work. Human Computer Interaction Institute Carnegie Mellon University. Pittsburgh, US.
- Fussell, S, Setlock, L, Yang, J, Ou, J & Mauer, E. 2004. Gestures Over Video Streams to Support Remote Collaboration on Physical Tasks. *Human-computer interaction*, 2004, Volume 19, pp. 273-309.
- Clark, H & Brennan, S. 1991. Grounding in conversation -perspectives on socially shared cognition. American psychological association. Washington, DC
- Henderson, S & Feiner, S. 2009. Evaluating the Benefits of Augmented Reality for Task Localization in Maintenance of an Armored Personnel Carrier Turret. *IEEE International Symposium on Mixed and Augmented Reality. Science and Technology Proceedings*. 19 -22 October, Orlando, Florida, USA
- Gericke, K & Blessing, L. 2012. An analysis of design process models Across disciplines. *International design conference - design 2012*. Dubrovnik, Croatia.
- Kraut, R, Gergle, D & Fussell, S. 2002. The Use of Visual Information in Shared Visual Spaces: Informing the Development of Virtual Co-Presence. *CSCW'02*, November 16–20, 2002, New Orleans, Louisiana, USA.
- Kuniavsky, M. 2003. *Observing the User Experience A Practitioner's Guide to User Research*. Morgan Kaufmann Publishers an Imprint of Elsevier Science San Francisco, CA.
- Lang, J & Howell, E. 2017. *Researching UX: User Research*. SitePoint Pty, Limited
- Bitner, M, Ostrom, A. & Morgan, F. 2007. *Service Blueprinting: A Practical Technique for Service Innovation*. Center for Services Leadership, Arizona State University
- Stickdorn, M & Schneider, J. 2011. *This is service design thinking*. John Wiley & sons, Inc, Hoboken, New Jersey.

Miller, B., Vehar, J., Firestien, Thurber, S & Nielsen, D. 2011. Creativity unbound: An introduction to creative process. Evanston, IL: FourSight.

Osborn, A.F. 1953. Applied imagination: Principles and procedures of creative problem-solving. New York: Scribner

Parnes, S. J. Creative behavior guidebook. 1967. New York, Scribners.

Portigal, S. 2013. Interviewing Users - How to Uncover Compelling Insights. Rosenfeld Media, 1st edition.

Puccio, G.J. Mance, M & Murdock, M. C. 2011. Creative leadership: Skills that drive change. Thousand Oaks, CA: California

Rice, M. Ma, K-T. Tay, H-H. Kaliappan, J. Koh, W-L. Tan, W-P & Ng, J. Evaluating an Augmented Remote Assistance Platform to Support Industrial Applications. 2018. Institute for Infocomm Research, A*STAR.

Rubin, J & Chisnell, D. 2008. Handbook of Usability Testing, Second Edition: How to Plan, Design, and Conduct Effective Tests. Wiley Publishing.

Saldaña, J. 2011. Fundamentals of qualitative research. Oxford University Press.

Spitzer, M. Nanic, I & Ebner M. 2018. Distance Learning and Assistance Using Smart Glasses. Virtual Vehicle Research Center, Austria.

Stickdorn, M. 2018. Service Design Process and Methods. Held on 3 February. Laurea University of Applied Sciences.

Koltay, Z. & Tancheva, K. 2008. Personas and a user-centered visioning process. Cornell University, Ithaca, New York, USA

Figures

Figure 1 The diagram of communication theories applied in the context of remote assistance.	21
Figure 2 Creative problem-solving process map with six stages (Creativity Web 2005)	24
Figure 3: Data collection process in the research project with interviews-field pilot-interviews-structure.	37
Figure 4 Development project progression map - objective finding.	41
Figure 5 Table of interviews conducted before the pilot	44
Figure 6 Sticky note-collage made based on small group discussion during the Service days-event	46
Figure 7 The process map depicting the collection of the data and different analysing steps	52
Figure 8 Service blueprint of troubleshooting process from the perspective of service technician with touchpoints and feasible section for remote assistance tool.	54
Figure 9 Development project progression map - problem finding.	55
Figure 10 User interface of the remote assistance application used in the field pilot.	58
Figure 11 Table of interviews conducted after the pilot	61

Figure 12 Development project progression map - acceptance finding.	65
--	----

Appendices

Appendix 2: First interview round field guide for tier 2 interviewees	76
Appendix 3: First interview round field guide for tier 3 interviewees	77
Appendix 4: Second interview round field guide for field pilot participants.....	78
Appendix 5: First interview round, Persona A	79
Appendix 6: First interview round, Persona B	80
Appendix 7: First interview round, Persona C	81
Appendix 8: First interview round, Persona D	82
Appendix 9: First interview round, Persona E	83
Appendix 10: First interview round, Persona F	84
Appendix 11: Second interview round persona A.....	85
Appendix 12: Second interview round persona B.....	86
Appendix 13: Second interview round persona C.....	87
Appendix 14: Second interview round persona D	88

Appendix 1: First interview round field guide for tier 1 interviewees

- How often do you need support/assistance in maintenance?
- Who is the first contact to who you contact when you require support/assistance
- Can you name any common issue or fault when do you normally need assistance?
- What is the typical troubleshooting process? Please describe it from start to finish as detailed as possible.
 - How long does it typically take?
- How do you describe the situation for your peer-support? Do you use any supporting devices or communication tools?
- What is the most difficult part/component to deal with when having assistance now? Why is that?
- What type of database do you have in use when providing support, or where do you search for info?
 - Are the cases documented somehow? How do you create ticket or record about solved support/assistance cases?
- What are the biggest challenges in the troubleshooting process?

Appendix 2: First interview round field guide for tier 2 interviewees

- What are the most common device types troubleshooting calls involve?
- What type of faults the troubleshooting calls are related to?
- How many troubleshooting cases do you receive weekly?
- How long does the average phone call last?
- What is your estimation, how many percentage of calls do you re-direct to tier 3?

Appendix 3: First interview round field guide for tier 3 interviewees

- By who you are contacted most commonly for support? (technician or specialist)
 - How are you contacted (phone/email)?

- What is the typical troubleshooting process? Please explain how do you start solving the case and how do you proceed.
 - How long does the typical troubleshooting process usually takes?

 - What are the most common pain points for you when providing peer-support? Why is that?

 - What are the ways how person can describe the situation to you? (verbally, sending photos etc.)

- What type of database do you have in use when providing support, or where do you search for info?

- Based on the data, three most common faults why technicians require peer-support are the following:
 - 1.
 - 2.
 - 3.

Could you specify any special characteristics related to handling these faults? (similar troubleshooting processes occurring, some extra difficulties etc.)

- What are the most difficult things related to remote assistance now?

Appendix 4: Second interview round field guide for field pilot participants

- How many times have you used the application during the pilot phase?
- What are the use cases related to?
- Have you find it useful in troubleshooting cases? Does the application helps in communication with technicians?
- Can you estimate has there been any time savings in handling troubleshooting cases? If yes, how much in estimation?
- On what fault types the application you find most useful?
- What was negative about the application?
- What features did you find useful and why?
- What features you find not so useful?
- What type of features you would like to see in future version of the application or similar type of remote assistance application?

Appendix 5: First interview round, Persona A



“Language barrier is significant obstacle when providing remote support to non-English speaking branches. This, and lack of details about the case (location, customer, crane) together can make fault finding slow”

Experiences about troubleshooting

- Contacts coming primary from techs. by phone or email
- **In most contacts Tech is looking for confirmation to his own suspects.** Has analyzed the fault but not 100% sure.
- On the other end Techs calling may be totally unaware of the fault which causes that GTS expert has to map the situation from scratch.
- **Duration of the cases varies depending on the fault from 30 min to 2 hours**, and when unknown fault up to several days before closure.
- The most common contacts for GTS are related to **electrics or drive train (functions)**

Tensions or surprises

The amount of databases for retrieving material (VertexDM, Aton, TeamCenter, Alfresco, team hard drives)

Painpoints in troubleshooting

- **Especially inverter parameters are difficult to locate** (they are updated on quick pace and documentation is not following)
- **Language barrier is significant in some areas** (translators are required in communication)
- **Details of the case** (what location, what equipment, previous service history, faults occurred previously) would be beneficial to have in advance or ready. This would speed up the troubleshooting.
- Some faults are in nature that they are impossible to recognize with current setup (requires that GTS expert is sent to location)

Key insights

- Techs have significant differences in experience which makes troubleshooting “customized” service (every case is different)
- Techs find it difficult to read inverters (bad UI and updates in parameters)
- Finding correct documentation may be difficult in many cases due to the fragmentation of databases, but this is not large issue (expertise helps more)

Appendix 6: First interview round, Persona B



"It would improve the communication if technicians would have possibility to provide details and information about the case beforehand. Technical support by GTS must be absolutely correct to avoid false information spreading in the field"

Experiences about troubleshooting

Contacts coming primary from techs. by email

Insight that **remote support focuses mostly between the techs**

Troubleshooting situations **may be quite often "communication troubles" by their true nature**. They are just commonly handled as technical issues.

Tensions or surprises

- **USA has the high threshold for using official remote support** (this is due to not to reveal own "uncompetence")
- Some cases technician is reluctant to give the real reason of the fault. This might be due to constant misuse of crane or maintenances done wrongly in past.
- There are certain faults that cannot be handled with GTS due to their sensitive nature in terms of quality perspective.
- **GTS must be aware of what type of troubleshooting they are giving to the field for it might be either be misused or create unnecessary fears**

Painpoints in troubleshooting

- **Language barrier is significant in some areas** (translators are required in communication) middle-east, France, Africa countries.
- Communication between the GTS and technician has issues because of communication, which is caused by **lack of pre-information about troubleshooting case**.
- Techs should have access to the remote data (customer usage data) of the equipment before starting to solve the problem. This would help to gain understanding for troubleshooting.
- **When same fault occurs many times it would be beneficial to have these previous cases documented and available** (better overall picture)
- Support material (documents) should be available through single portal, and not that person has to log into the many systems. (silos-effect)

Key insights

- The number of inverter related faults is because of techs competence is mechanical oriented.
- **Having Initial Information about problem would be big improvement, and having shared view on situation would impact on quality.**
- Some cases the problem described is not corresponding the actual problem

Appendix 7: First interview round, Persona C



“Reducing the possible fault to few options with case information sent beforehand would be beneficial in providing support. Video connection to site with ability to share documentation would be useful addition to current setup”

Experiences about troubleshooting

- **Contacts come from both techs and specialists** mostly by phone (mechanical issues are often sent by email, drive issues are phoned)
- The description of the issue can be sent also by an email depending on the background work required to solve the fault (inverter fault codes -> what is it and how to approach)
- When the fault is drives(inverter) related expert asks what tech understand about the issue and what tools he has dispose of. If tech can take the parameters out they are sent by email to expert who makes the required adjustments and sends them back to tech who can install them

Tensions or surprises

- In Finland the expertise of techs is relatively high so remote support calls to GTS are quite rare

Painpoints in troubleshooting

- **It would be good if the initial information about troubleshooting case would be available instantly when call starts** (what is the equipment, what has been done, are there previous fault history)
- **Sharing information from one location is difficult** (scattered databases)

Key insights

- Service specialist role is to provide remote support for techs before GTS contact (by phone first, and if issue is not solved than dispatched to location) It depends on techs in the branch how well SS is known and used as contact point
- **Techs seem to call colleague when remote support is needed**
- The initial information about the issue or fault is often uncomplete

Appendix 8: First interview round, Persona D



"Technicians inside the same branch require GTS support quite rarely because they know that colleagues have knowledge about different faults. However, when the situation is on, it is difficult to remember/determine on who to call for support."

Experiences about troubleshooting

- With 30+ years experience need for troubleshooting is quite rare. When the equipment base are familiar, it is rare that you require assistance.
- Own understanding is that other techs are having often troubleshooting situations and they primary call to each other
- Automatic cranes are most often causing calls to GTS. This is because the faults are related to software and there is no access when in field situation
- First person to contact depends on the type of fault and it usually takes some time to find out who to call/who could know about the issue (tech colleague)
- Techs usually know within their branch who has competence on what

Tensions or surprises

- Fixing the problem usually happens by replacing the old component to new
- Only access for tech to have access to the software and data is through the GTS where the response usually is found.

Painpoints in troubleshooting

- Finding the correct contact for each troubleshooting situation is sometimes difficult and takes time. Some cases even the techs in own branch does not know the answer (useless even to try)
- Changing inverters to new is difficult due to different versions (new vs. old)
- Inverters and components generally which include software are difficult to maintain.

Key insights

The newer the equipment more there are troubleshooting situations

Improvements for troubleshooting are welcome but adding new applications and software is not desirable (previous ones are already overloading)

Appendix 9: First interview round, Persona E



“The help can often be found among the technician colleagues, however the faults that are not common tends to forget (how to fix), and this causes the needs for support. Sending only a photo about the situation would be beneficial in describing the fault.”

Experiences about troubleshooting

- Troubleshooting situations are quite rare (two-three times per year)
- **Remote support takes place mostly between the techs inside the same branch** (+some other previously known persons to contact for certain issues)

Tensions or surprises

- Calling to GTS is rare because contact to TIER 3 is not officially given out in the branch
- Manuals are easy way to search info

Painpoints in troubleshooting

- It would be important to have **situation shared for both persons to have common understanding about what is going on. Taking a picture would help in many cases (video would be useful when crane is acting strangely)**
- **Sharing a documentation in electrical form** would be useful
- **Inverters are causing most common cause for remote support due to change of models and updates on versions.** Old and new parameters may have different meaning and manuals do not keep on changes
- **The confirmation about inverter codes are often required**

Key insights

- **Different techs has different knowledge inside the branch and this is utilized in troubleshooting (call to who knows)**
- The describing of issue happens verbally in most cases. **If something is physically and visually broken than picture is taken by phone to share the situation.**

Appendix 10: First interview round, Persona F



“The faults that are difficult to identify and solve are taking weeks in total worktime annually. In addition, out-of-date documentation is a big problem currently as you have to call for confirmation about the info of equipment details. Instructions should be easy-to-read to novices also.”

Experiences about troubleshooting

- The need for remote support is seasonal (depending on the production of customers)
- Older equipment and process/automated cranes are causing the most cases in troubleshooting.
- **The first contact in troubleshooting is depending on the equipment (who knows about the issue)**
- Usually fault is solved during the call (sometimes takes a whole day)

Tensions or surprises

Finding documentation is said to be difficult but also said that there are manuals available (in van, at computer, some customer locations)

Painpoints in troubleshooting

- **Cases when drawings of equipment and drawings of the structure are different are drag because this makes identifying of possible fault difficult** (can take weeks of total worktime annually)
- **Generally the cases when the fault is visible only a short period** (broken wirings for e.g.) can take huge amount of time to solve.
- **Documentation is not up-to-date in most cases** (have to be inquired from equipment provider)

Key insights

- Usually the **fault can be identified with own competence but troubleshooting is needed to have the confirmation to support own deduction.**
- When there is no previous knowledge about the equipment, remote support is quick decision.

Appendix 11: Second interview round persona A



"Video & picture sharing features are feasible and would make lot of sense in field work. I do not see particular need for making annotations on screen"

Experiences about PointR

- 1 actual out-call made
- Overall experience was **positive**, the **video sharing feature would clearly bring value** to the situations when it is difficult to explain the fault verbally.

Example use case with PointR

- Contactor was "burnt" and application was used to send a picture of component ID number to the colleague to ask which type of replacing component should be. This was **to have a confirmation from the colleague** to make sure that correct component will be ordered.

Painpoints in PointR

- **Voice is very vague while using the application. Even slightest background noise makes it impossible to hear what other person is talking.** This is partially due camera is held apart from ears while sharing the view.
- Application takes lot of battery when in use. Would be very problematic during the on-call or middle of a workday.

Key insights

- Estimated time savings if applied **In inverter related faults is 30 min to 1 hour.** Usually these cases can take several hours. If situation can be **shared through video, time spent is reduced quite much.**
- Most usable with faults related to PLC and inverters (when crane is doing something it shouldn't)

Appendix 12: Second interview round persona B



"There are clear benefits with application with ability to share video image. Particular value when introducing beginner to new situations in addition to troubleshooting cases. I would have used it even more during the pilot phase but due to voice issue it was not possible."

Experiences about PointR

- Total usage 2 calls (1 in call and 1 out call)
- **Overall experience: positive**, and most probably would use the application in work.
- In general, application works better when communicating with GTS due to their better ability to share files and other material to solve the cases.
- **All features are working well, although everything could be somewhat improved.** Annotation feature is the most beneficial

Example use case with PointR

- **Most usable with faults related to inverters, PLC or other software cases.** This is because visual sharing is valuable when trying to recall the solution or vise versa when trying to explain such faults.

Painpoints in PointR

- **Voice is very vague** while using the application. Even slightest background noise makes it impossible to hear what other person is talking. This is partially due camera is held apart from ears while sharing the view.
- **PointR does not make alarm when someone is calling to you.** Only way to establish the call is to note the person beforehand
- **It is problematic that using PointR requires at least other hand to hold the camera when receiving support** and perform tasks at the same time. This makes many situations unbearable.

Key insights

- The approximate use if commonly available is **2 times per month + cases which require GTS**
- Estimation of time savings is achieved mainly by **reducing the need for multiple calls per case**. For example case can be that call is made (takes 5-10minutes), after half an hour second call is needed for same case which can again take 5-10 minutes. Application is suitable to reduce multiple calls in this sense.

Appendix 13: Second interview round persona C



Tier 1 Tier 2 Tier 3
Pilot participant C
Service technician

"Videolink definitely brings extra value to troubleshooting situations in terms of explaining and understanding the situation. Sharing know-how between technicians is in most cases key to find solution, this is where video helps."

Experiences about PointR

- Use cases 4 (3 in-calls, 1 out-call)
- Cases were all short calls concerning electrical wirings, setting mechanical limits, and profibus issue. Topic was to guide colleague to do wirings correctly and describing the brake details.
- Out-call concerned profibus details of how to make the adjustment
- **Overall experience: positive.** In general, **application is feasible in use and it saves some amount of time.**
- Videolink is the most beneficial feature, video & audio is enough. **Annotations are not too important**

Example use case with PointR

- **Most usable with faults related to electrics, especially wirings.** This is because you are able to see the colors and positions of wires more easily. Extra value also with mechanical issues similarly due better visualization. In addition, beneficial in rare occurring faults when person does not recall the solution.

Painpoints in PointR

- **Voice is very vague** while using the application. Even slightest background noise makes it impossible to hear what other person is talking. This is partially due camera is held apart from ears while sharing the view.
- **PointR does not make alarm when someone is calling to you.** Only way to establish the call is to note the person beforehand
- Application **takes lot of battery** while use

Key insights

The approximate use if commonly available is 1 – 2 times per month

Estimation of time savings is **approximately 5 minutes per case.** This is because normally calls take 10 – 15 minutes. The time savings result from quicker understanding of situations.

Appendix 14: Second interview round persona D



"There is an ongoing tradition to use WhatsApp to share situations in the field. WhatsApp is used to share pictures and to describe the situations through chat. There are custom groups of technicians in WhatsApp who are participating in conversation. PointR can be seen as a competitive solution for WhatsApp in this sense."

Experiences about PointR

- **PointR is helpful and on the other hand it's not.** This is because in **most cases the situation can be described in phone** with no need of additional channels. On the other hand **few cases now and then are so very difficult and this is where video and annotation come handy.**
- **Annotations are useful when marking some strange component or part.** Video stream is usable in some cases.

Example use case with PointR

- Cases when you must show something from inverter display panels to be shared with colleague. **In general, everything that is related to automation and computers (when explaining the fault is difficult)**
- Also the **faults that happen in previously unknown site** (when the support person does not know the equipment or locations of the cranes)

Painpoints in PointR

- **There are serious problems with hearing the audio when using PointR on site.** Even the smallest background noise will make it almost impossible to hear the other person.

Key insights

- Estimation is that remote **application tool would save time on 5-10 minutes per case** on average. The benefits come from easier understanding of situation and explaining what to do
- The estimation is that using remote assistance tool would **reduce some cases when call is made to upper TIER level, approximately 5 - 10 %**
- There should definitely be a handsfree when using the PointR to make it possible to hear the audio.