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Identifying organizational barriers— a case study of usability work when developing software in the automation industry

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Abstract.

This study investigates connections between usability efforts and organizational factors. This is an important field of research which so far appears to be insufficiently studied and discussed. It illustrates problems when working with software engineering tasks and usability requirements. It deals with a large company that manufactures industrial robots with an advanced user interface, which wanted to introduce usability KPIs, to improve product quality. The situation in the company makes this difficult, due to a combination of organizational and behavioural factors that led to a “wicked problem” that caused conflicts, breakdowns and barriers. Addressing these problems requires a holistic view that places context in the foreground and technological solutions in the background. Developing the right product requires communication and collaboration between multiple stakeholders. The inclusion of end users, who fully understand their own work context, is vital. Achieving this is dependent on organisational change, and management commitment. One step to beginning this change process may be through studying ways to introduce User-Centred Design processes.

Keywords: Usability, KPI, Human Robot Interaction, Human Computer Interaction, User Centred Design, Wicked problem.

1. Introduction

Product quality is becoming one of the dominant success criteria in the software industry. One of the challenges for research is to provide the industry with the means to deploy quality software, allowing companies to compete effectively (Osterweil, 1996). Quality is multi-dimensional, and impossible to show through one simple measure, and research should focus on identifying various dimensions of quality and measures appropriate for it (Osterweil, 1996). Even though this was written in 1996, it is still valid today, when companies are competing in a rapidly changing and competitive global market.

Usability is one of the important quality factors. However, despite the fact that our study focused on usability, we do not present details concerning the theories and methods of usability work. The idea behind this article is not to discuss the technicalities of usability, even though usability has been the vehicle which we have focused upon. For more information regarding usability, see e.g. (Bevan, 2001; Dumas and Redish, 1999; International Organization for Standardization, 1998, 1999; Nielsen, 1993). Furthermore, we see that the situation that we have uncovered is probably not limited to the problems of performing usability work, but is representative of many types of settings, where complex issues are dealt with in complex organizations, and could therefore be of interest in many different situations.

The context of this study is a large multinational industrial company, with roots in a traditional engineering field, and extensive experience of working with industrial machines. One branch of the company produces and markets industrial robots and robot systems. The company acknowledges the importance of incorporating concepts of usability in their design and development processes, to improve the quality of their product. The entrance point to this study was a desire to find ways of measuring usability on the basis of Key Performance

Indicators (KPIs). Given our background in industrial cooperation, and our focus on usability and user experience, we were invited to perform a case study together with the corporate research department. The study was intended to result in new knowledge of how the industrial organization currently works with usability, and should lead to new theories of the problems involved in such work, and ideas that could facilitate this work.

Questions pertaining to the usability of robot systems are important to study. They deal with the changing conditions for traditional engineering organizations, where it becomes necessary to change the way of thinking when designing and developing products, in order to remain competitive in a rapidly changing and competitive global market. For a producer of robot systems in today's market, it is important to design systems that can be used by domain experts but not robotics experts (Scholtz, 2003). To study this field, practical real-world observations are important, as is the inclusion of experts from multiple domains in research efforts (Goodrich and Schultz, 2007).

In the context where we have performed the study, the area of operations is designing and producing industrial robots, so the study deals indirectly with human-robot interaction (HRI), which is the study of teams of humans and robots, and the ways they influence each other (Scholtz, 2003). HRI is concerned with understanding and shaping interactions between one or more humans and one or more robots. Essential components of HRI are evaluating the capabilities of humans and robots, and designing the technologies and training that produce desirable interactions (Goodrich and Schultz, 2007). One of the primary goals of HRI has been to investigate natural means by which humans and robots can interact and communicate (Dautenhahn, 2007). HRI is related to human-computer interaction (HCI) and human-machine interaction (HMI), but differs from them since it concerns systems that have complex, dynamic control systems, which can exhibit autonomy and cognition, and which operate in real-world situations (Fong et al., 2003). It is important to consider the interactions that humans will have with robots, and what software interface architecture and user interface can accommodate humans (Scholtz, 2003).

In this case, we investigate the areas of robotics and HRI from the perspective of the organization and organizational processes where the HRI is designed and developed. It is impossible to understand transformations occurring in the nature of work and organizing without considering both the technological changes and the institutional contexts that reshape organizational activities (Orlikowski and Barley, 2001). Therefore, it is important to focus on the situation within the organization. We must understand how human and organizational factors affect the execution of software development tasks, as many studies show how behavioural factors have a greater impact on software productivity than tools and methods (Curtis et al., 1988). Orlikowski and Barley (Orlikowski and Barley, 2001) stated that "IT researchers have yet to ask how institutions influence the design, use, and consequences of technologies, either within or across organizations". This study looks more closely at these aspects. The primary intention of the work at hand is thus to study the processes and communication within the organization, with particular focus on the role played by usability. This work has been performed as a case study (Yin, 2003). The data in the case study has been analysed in a grounded theory (GT) approach. (Robson, 2002).

The study illustrates a situation where the company successfully produces and sells a complex product that technically is at the front of the market, where adding features has been a strong selling point, and where usability is in line with other products of similar complexity and ability. There is however a growing understanding that usability is important for future sales, where a successful product has a good balance of price and quality, which includes both features and usability. The initial focus of our study concerned the introduction of KPIs, but we did not drive the process as far as finding ways to formulate candidates for these KPIs. However, we do show a number of areas where breakdowns occur in the organization, and see that a combination of different factors means that the company has difficulty in reaching the goal of formulating measurable usability KPIs. The factors involved combine to create what Rittel and Webber (1973) call a "wicked problem". To address these problems, we find that it is important to take context into account when designing and developing the product, and that a process of user centred design (UCD) may be a way to address the identified situation. However, we also see that in order to reach the stage where UCD is possible, and to address the issues that we have found, would require a shift in perspective within the organization. There must be an expansion of the understanding of the importance of usability, a commitment to making usability a central factor, and incentives for improving usability. There must be an overview of what is important to focus efforts upon. This overview could lead to useful KPIs, and a system of incentives to work with these KPIs, and a situation where the importance of UCD pervades the organization. However, in the situation that exists today it is difficult to create this overview, because of the factors that we detail below.

In the following, we discuss our methods in section 2, and then in section 3 present a detailed illustration and summary of the problems that we uncovered during the study. This is followed in section 4 by a discussion of the causes of these problems, in relation to work from a number of related areas, and we discuss possible solutions to some of the problems. The article ends with Section 5 with conclusions and some ideas for future work.

2. Methods

The study was performed as an interview-based case study. A case study focuses on a particular case, taking the context into account, and involves multiple methods of data collection; the data can be both qualitative and quantitative, although qualitative data are almost always collected ((Robson, 2002) s. 178). A case study approach allows the retention of characteristics of real life events, including organizational and managerial processes (Yin, 2003). Although the study has been performed in a limited part of a large organization, and it could therefore be claimed that it lacks relevance in a larger context, it has been informed by an ethnographic approach (Rönkkö, 2010), which provides an analytic focus that allows a focus on the types of challenges that are common for many software development projects, in complex design and development situations where many stakeholders are involved (Rönkkö et al., 2005).

The material in this study was collected in a series of semi-structured interviews (Robson, 2002), which took place between November 2009 and March 2010. The interviews were both preceded and followed up by a long process of industrial cooperation, including discussions, meetings and workshops. The interviews were performed by Jeff Winter, hereafter referred to as JWI, and Mikko Rissanen, referred to as MRI.

2.1. The Industrial Organization

The industrial organization, ABB, is a vast group of individual technology companies that operate in almost all of the sub-domains within the power and automation markets, for instance robotics products and supervisory control systems for production plants of all sorts. MRI belongs to ABB Corporate Research which is a research organization within the ABB Group, the umbrella organization. ABB Corporate Research is thus a unit that provides short and long term research support to individual ABB companies (here referred to also as business units) that own the products and businesses, such as the target of this case study. Corporate Research itself does not own products or develop them directly. Rather, it investigates new product and business ideas, technologies, methodologies and acts as the link to academia, with the aim of ensuring the whole company's competitiveness in global markets. Scientists and technology specialists at Corporate Research work closely with the business units in collaboration projects and bind the latest knowledge from universities to ABB-specific demands as needed.

2.2. Meetings and Interviews

The project began with an initial meeting at Blekinge Institute of Technology (BTH). Representatives of ABB's Corporate Research unit contacted Kari Rönkkö and subsequently visited the Use-Oriented Design and Development (U-ODD) research group (U-ODD, 2011) headed by Rönkkö at BTH. The purpose of the meeting was to discuss U-ODD's research methods and results, and more specifically to discuss their previous work in the area of usability and usability testing (see e.g. (Rönkkö et al., 2009)). This first meeting led to a general agreement to find areas for future research cooperation. MRI was our main contact at ABB Corporate Research and specifically its software research programme Industrial Software Systems. His background within the company, first as R&D scientist and later as principal scientist and coordinator for usability and human-computer interaction research, meant that he had extensive experience of performing research within the company, targeting various business units, systems and products by investigating various software technologies, product development methodologies and organizational factors, often in collaboration with universities (see e.g. (Aleksy et al., 2011; Andersson et al., 2011; Azhar and Rissanen, 2011; Björndal et al., 2011; Kume and Rissanen, 2011)). Thus, MRI acted as an important source of knowledge about the company and its development and history.

By September 2009, a specific plan had been formulated, and JWI, together with Rönkkö, travelled to the industrial site for discussions about the background to a potential project, the goals and expectations of the industrial and academic partners, and practical matters about performing a study. This resulted in an agreement to cooperate in performing a case study that would examine problems and possibilities of developing usability Key Performance Indicators (KPIs). In November 2009, plans for the project were finalised, a unit within the company was selected for study, and JWI travelled to the industrial site to prepare for the coming interviews.

An initial meeting took place to discuss general conditions and expectations. JWI was introduced to the industrial site, and he presented some of the results of his previous research to members of the Corporate Research unit, and other representatives of the company. He was given access to a workplace at the site, and had access to company documents to help him understand the structure and operations of the company in general,

and the industrial unit where the case study was to take place. After two days on-site, the process of interviewing began. The interviews were performed in accordance with a jointly written research plan, initially formulated by JWI and then validated and adjusted together with MRI. The plan specified how the interviews should take place and what they should focus upon.

Ten interviews were performed, at two different sites, on five different occasions. The interviews are listed below, with details of when and on which site the interview took place, and who participated. To maintain anonymity, the names are changed, and the sites for the interviews are simply listed as Site 1 and Site 2. For nine of the interviews (all except the second interview) at least one of the researchers was on-site together with the interviewee/s. Both of the researchers were on-site for the first interview, which allowed them to observe the interview process at first hand, and decide how future interviews should be structured and performed. In interviews three to ten, where only one researcher was on site, the second researcher participated via telephone. The call was made via a speaker phone, so that all of the participants could hear what was said and could talk to one another. Interview 2 differed, in that, whilst both of the researchers were at one site, the interviewee was at a different site. This interview was performed via a speaker phone, with a research manager at the parent company, who was responsible for a project dealing with usability KPIs.

The interviews took place as follows:

- 1 & 2. 11th Nov. 2009, at Site 1. Present on-site: JWI, MRI. Sandra (System owner), Martin (Project manager and Principal scientist). Telephone: Michael (Research program manager, Switzerland).
- 3, 4 & 5. 4th Dec. 2009, at Site 2. Telephone: MRI. Present on-site: JWI. Sam (Senior Specialist/ Architect). Harry (Program manager). Carl (Senior Consultant):
- 6 & 7. 7th Jan. 2010, at Site 1. Telephone JWI. Present on-site: MRI. Ben (Product Manager). George (Support Manager), James (Support Engineer, Training Coordinator).
- 8 & 9. 18th Jan. 2010, at Site 1. Telephone JWI. Present on-site: MRI. Oscar (Systems Architect). Charles (System Integrator).
10. 29th Mar. 2010, at Site 1. Telephone JWI. Present on-site: MRI. Mike (Vice President, Marketing and Sales), Andrew (Sales and support), Lars (Sales and support).

2.3. Interview Procedures

With the exception of interview two, all of the interviews followed the same general structure. As previously mentioned, the study was performed as a case study. In case studies, data are often non-numerical, so they are often referred to as qualitative research. However, they can be based on any mix of quantitative and qualitative evidence; they can even be limited to quantitative evidence ((Yin, 2003), p. 14). Case studies can be characterised as “flexible design” research (Robson, 2002), where flexibility means that the research design can evolve during data collection. In our research, the processes of interviewing and analysis influenced one another, as they took place in parallel. However, with the exception of interview two, all of the interviews followed the same general structure. Interview two followed a different structure since it served a different purpose: to gain the management’s view regarding the importance of developing measurable usability KPIs. With the exception of interviews 2 and 3, all of the interviews were performed in Swedish, and the quotes given in the following material were translated to English by JWI. The selection has been partly a convenience sample, thereby including those who have been able and willing to participate. The first participants were chosen by the researchers from the corporate research department, from their knowledge regarding suitable candidates. Furthermore, we have chosen participants based on suggestions from other interviewees, who suggested suitable candidates who could extend our study. As shown in the list of interviews in the previous section, we have tried to gain a broad cross-section of the organization, from product management to developers, and the roles (as listed above), range from a Vice President of marketing and sales, to program, product, and support management, to “shop floor” representatives for development, integration and support.

During the interviews, both researchers were active and could ask complementary questions, or ask respondents to clarify or develop their answers to certain questions. To begin, the participants were shown a PowerPoint (Microsoft) presentation, giving the background to the study and introducing the problems the researchers were studying, and some of the questions that they hoped to answer. The participants were guaranteed anonymity, and ensured that it would be impossible to identify them through the case study material, or publications related to it. It was also explained that nothing would be published without the permission of both the participants in the study, and the company.

When interviewing proceeded, the researchers began by explaining who they were, and which roles they held in the study, and gave some more general information about the purpose and structure of the research. They asked for permission to audio record the interview, and explained that the material would be transcribed verbatim, to be used in the analysis process. The participants were assured that the study material would be treated according to ethical guidelines: that the recordings and transcripts would remain in the possession of the researchers, and would be treated in a way that would preserve the anonymity of the participants.

Seven of the interviews were audio recorded, whilst three were not. All of the recordings took place at site 1, and the interviews were then fully transcribed. At site 2, the first interview took place with a member of staff at management level, and he suggested that the interviews not be recorded that day. The explanation given for this was that the researchers could choose between recording, which would probably mean that they were likely to give the official on-the-record version of things, and not recording, which meant that they could give a more informal and impromptu version of the situation. Given this, it was decided not to record the interviews that day, but extensive notes were taken during the interviews. These notes were then written in the case study logbook the same evening, whilst the material was still fresh, and the material was also commented in the logbook at the same time.

The general structure in the research plan was used in all of the interviews except interview two, which had a different purpose. However, although the general structure and focus of the interviews remained the same throughout the process, the analysis process meant that the researchers became sensitised to different issues, and these insights influenced the questions that were asked, the way they were asked, and the data that was collected.

Researchers kept in touch during the interview period. They did this via telephone and e-mail, in order to discuss ideas, findings and preliminary results. After the ninth interview, they held a longer telephone meeting, to talk about preliminary findings, and to discuss how the continued work of the analysis of the case study material should be done. This meeting was transcribed and used in the analysis process. For further details of the analysis process, see the following section.

Results were presented when Rönkkö and JWJ visited the industrial site on 2nd June 2010. At this meeting, the initial results of the case study were presented to and discussed with the main partners in the research project, other members of the Corporate Research group, and other stakeholders within the company. This meeting resulted in further input to the analysis process, and plans for continued cooperation. As a concrete result of our cooperation, we were co-organisers, together with Sanjay Tripathi, ABB Corporate Research, India, of the first Workshop in Industrial User Experience (WIndUX 2011) at the India HCI 2011 conference (WIndUX, 2011).

2.4. Analysis Procedures

The case study material was recorded in a research logbook containing transcriptions and notes taken when interviewing, which was the main part of the case study database. This collected all of the information in the study, allowing for traceability and transparency of the material, and reliability (Yin, 2003). The logbook contained marginal notations of thoughts and ideas concerning themes and concepts that arose when reading or writing the case study data.

In a study of this kind, where the methods that generate qualitative data are a substantial part of the study, serious attention must be given to how the data are analysed ((Robson, 2002), p. 456). In our study, the field studies have been informed by the underpinning assumption in ethnographic approach ((Rönkkö, 2010) section 2) and analysis has built upon techniques taken from grounded theory. Grounded theory (GT) is both a strategy for performing research and a style of analysing the data that arises from the research ((Robson, 2002), p. 191). GT studies empirical events and experiences, and a GT researcher follows up hunches and potential analytic ideas about them (Charmaz, 2010). The iterative approach found in grounded theory where data analysis fuels data collection, which then leads to further analysis, is a feature of the analysis of most qualitative studies ((Robson, 2002), p. 487), and many analyses of flexible design studies have been influenced by grounded theory.

The material has been analysed in a fashion inspired by constructivist GT. Constructivist GT differs from traditional GT as constructivists view data as being constructed rather than being discovered, and view their analyses as being interpretive, rather than objective reports (Morse, 2009). Objectivist GT assumes the discovery of data, that data are separate facts from the observer, and that the data should be viewed without preconception. Constructivist GT, however, assumes multiple realities, and multiple perspectives, which means that the data are not separate from the viewer or the viewed, but are constructed through interaction (Morse, 2009). Charmaz contrasts the Constructivist GT approach with the way that Glaser and Strauss (Glaser and Strauss, 1967) talk about discovering theory. In their approach there is an assumption that the theory emerges from data separate from the observer, whereas Charmaz assumes that neither data nor theories are discovered. Instead, since we are

all a part of the world we study and the data we collect, our theories are constructed through our past and present interactions with people, practices and perspectives (Charmaz, 2010). According to Charmaz, Constructivist GT is profoundly interactive, in both data collection and analytic processes. It adopts the inductive, comparative and open-ended approaches of earlier GT approaches, but also includes the abductive approach when checking and refining the developments of categories. Abductive reasoning arises from experience, leads to creative but logical inferences, and creates hypotheses for testing these inferences, to arrive at plausible theoretical explanations. Thus, when a GT researcher encounters a surprising finding, he or she should consider all theoretical ideas that could account for it, gather more data to put the ideas to the test, and adopt the most plausible explanation (Charmaz, 2009). The fact that we were inspired by constructivist GT led us to include the areas of related work that we discuss later in this text. It meant that we gathered theories and knowledge from a number of areas that were connected to the situation that we observed, but which otherwise might have remained outside the scope of the study. Thus, our approach has affected the analysis of the situation, the discussion of the situation, and the conclusions that we have reached.

The data in the study was discussed several times together with research colleagues. This meant they were given access to anonymised transcripts of the interviews. We held meetings and discussions after they had read the material and formulated ideas about the meaning of the data. This was done as a form of triangulation, to cross-check the interpretation of the results. The group discussed the data, and the thoughts and findings of both the researchers and their colleagues. The structure of the material was drawn on a whiteboard, to illustrate the contents of the data, and the connections between different elements. These discussions affected the continued work of analysing and collecting the data, the choice of areas of related work to look at more closely, and the interpretation of the case study material.

Thus, the processes of data collection and analysis have been iterative. At each step in the analysis process, the earlier material has been read and re-read, to see if support can be found for the new ideas and theories. At the end of the process, a theory has been formulated that is grounded in the empirical material.

We have worked in an interpretive research process, and must therefore have other notions of rigour that reflect the same sorts of quality notions that are used in positivist research, which discusses results on the basis of objectivity, reliability, internal and external validity. We have performed our study so that it complies with the quality standards as defined by Gasson (2003), which are Confirmability, Dependability/Auditability, Internal consistency, and Transferability.

The main issue concerning confirmability is that findings should represent the situation being researched, rather than the beliefs of the researcher, and interpretive GT research focuses on reflexive self-awareness, in an attempt to guard against influences and prejudices. Subjectivity is dealt with through a process of reflexivity, where we retain awareness of ourselves as part of a social context, and the fact that that we apply biases and prejudices to the collection, analysis and interpretation of data. This is in line with the ethnographic approach (Rönkkö, 2010), with its focus on “members’ point of view” that has influenced our research approach. Thus, we affect the course of the study, and the choice of the material that we see as being related to our case, but this is always borne in mind during the research process, whilst attempting to understand reality as it is experienced by the participants.

The main issue regarding Dependability/auditability is achieving consistency in the way in which a study is conducted, and it is important to show the use of clear and repeatable procedures. The procedures whereby data are collected and analysed must be recorded so that others can understand them. A research journal must be kept, where records are kept of all data collection and analysis, and we have done this through maintaining a log book where the study is recorded in detail, from the initial stages of the research process, through the interviews and the analysis of the material to the collection of related work that has informed the analysis process.

To achieve internal consistency, it is necessary to explain from which data and how the theoretical results are derived, and whose perspectives these constructs reflect. The source data and the process whereby it is collected should be described in enough detail to demonstrate a fit between the theory and the data. In this paper, we do this by discussing the research procedures that were followed, by showing the instances of issues that were described in the interviews, showing the connection to theories within the area, and then relating this to the results that we present. This is in line with Charmaz (2010) description of theory, which states that Constructivist GT is an abstract understanding of the case at hand. It can start with sensitizing concepts that address power, global reach and difference, to finally arrive at a theory, based on inductive analysis, which shows connections between local worlds and larger social structure.

The core issue of transferability is to which extent a researcher can claim general application of a theory, and this depends on similarities or differences in the context where the theory is to be applied. We discuss the context of our case in our conclusions, and there we discuss the scope of our theory

The empirical material and the related work that led to the formulation of the theory are discussed in the following sections.

3. Results

The long term focus of the business unit is on globalisation, efficiency and quality. According to one of the product managers, his focus was on maximising the number of users of his product, and to differentiate their product from their competitors'. Usability was seen as being a part of that focus. However, views of what usability actually is in this context, and its importance, were found to be varied.

Fig. 1. An overall illustration of the situation as it appears, based on the interview material

Therefore, the primary intention of the study at hand was to examine the role of usability in the organization, and was part of a management drive to find ways of measuring usability on the basis of KPIs. However, the case study material showed that there are many factors in the situation that we studied that make problems of the development of the systems that were discussed into what we see as a wicked problem. This is partly on the level of how to work with usability questions, but is also apparent on many organizational levels.

Figure 1 is an illustration of the situation that became apparent during the analysis of the interview material. The “warning signs” show areas where problems became apparent in the case study material. The “obstacles” illustrate breakdowns in communication or other obstacles that lead to problems. These problems, obstacles and breakdowns are discussed in greater detail in the following section.

As can be seen, there are several types of stakeholders involved, including several layers of company management, developers, support staff, end-users and integrators. This section looks at all of the elements in Fig. 1, and provides examples from the interviews to show the background to this description. We separate the illustration into its component elements, and provide illustrations for all parts of the larger picture.

3.1. Integrators Create Solutions Out of Reach of ABB

This description is based on material from the interviews, in combination with data from previous studies performed within the company. Integrators can be external to the company, or in-house. They specialise in tailoring robots and robot systems for end-user organizations and end-users. They have a number of goals, both internal and external. They are responsible for obtaining contracts, and ensuring that the robots are so well adapted to the customers’ operations that they receive no support calls afterwards. Their primary tasks are installing a robot cell at a customer site, and gaining a formal acceptance from the customer. Their intention is to satisfy customer needs, thereby making customers happy, and building a good reputation for the company. The main physical output of the integrators’ work is a functional robot cell, which runs first at the integrator’s

workshop, and finally at the customer site.

Fig. 2. The role of the integrators

Integrators begin by gathering requirements, which are used to write a technical specification draft. Then they buy the necessary components, such as conveyor belts or smart cameras, and buy a robot from a manufacturer. They program the robot, and make a customised robot cell, which can be tested with representatives of the end-customer. A manual is written, the robot cell is finalised at the customer site, and the robot is acceptance tested. Finally, end-users are trained, and the robot is fine-tuned and optimised at the customer site. The integrators handle any support calls that may follow.

A number of problems exist in the integrators' work. Firstly, the initial requirements that are produced can be inaccurate. This may be because the customers have limited knowledge of robots, but also because the environment at the customer-site is unspecified, and may even contain limitations that can stop the deal. An optimal solution is hard to prove and produce, before actual production. In many cases, micro-level customisation is needed to fit the robot to the customer's environment. Customer visits requiring travel are time consuming and expensive.

In the interviews, it became apparent that integrators can make far-reaching changes to the interface that ABB has no control over. In interview 1, Sandra said that integrators create their own human-machine interface and that "...we create an interface that lets them... short-circuit our interface." This can mean that the end-users never see the interface that ABB designs. There is a risk that "...they can make unwise decisions that make the product less efficient to use..." and therefore, it is important that the integrators really understand the system. This can lead to problems for ABB, and in interview 9, Charles said that "...the end-user sees that it says ABB on the robot, and if we have an integrator who doesn't do his job, it is ABB who ends up with the bad-will." He also said that he had seen situations where they have lost orders because an integrator had done a poor job, even though it was not the robot itself that was at fault.

3.2. Conflicts of Interest Between Departments

Fig 3. Conflicts between levels of the organization

We can see how differing interests can create obstacles between management and other levels in the organization. For example, product management may be reluctant to implement some directives that come from higher management. This is often for financial reasons. An example of this was that product managers could be reluctant to allocate funds to a problem that had been prioritised at a higher level in the organization, when they saw more pressing problems to deal with, and where the budget steers the work that can be performed. In interview 7, James said "...if I am going to be a project leader, and Research or Head Office come and say that I have to pay lots of money for some external resource to come and say what I should do [...] then I am going to say right away, no way! I would rather put the money into something of my own."

This type of problem was mentioned again in interview 7, where James said “It’s a question of budget. [...] the product division and the service division don’t have the same bosses... and that’s something that you find throughout the company, and that is more or less apparent depending on how well managers communicate.” This leads to a situation where e.g. the product department might create functions that cause extra work for the service department, but where the service department has no extra resources to deal with the problems. In this situation to ensure that service is satisfactory means “...there must be different models for allocating resources.”

3.3. Usability Problems Filtered Out

Different stakeholders have their own ideas of what the root of a problem is, and what the solution must be. Their choice of problem formulation, and problem solution, depends on their own viewpoint. In interview 1, Sandra said that “*There’s never any rigour, any stringency, and it’s very person-dependent, and we have the division in X-town, [...] and they have a bit different culture to what we have here.*” These differences affect the formulation of the problem space and the solutions offered.

Fig 4. Usability problems are filtered out when issues are prioritized

As a consequence of this, when the development organization plans and performs their work, it is often the case that usability problems are left unaddressed, even though they often appear to be relatively simple to address. One reason for this is the fact that issues that are reported, via the support organization, or through other channels, are prioritised by a Change Control Board (CCB). Given the number of issues that must be dealt with, usability issues often end up towards the bottom of the list of prioritised items. Other issues are seen as being more important for the use of the product. Development resources are scarce and must be channelled into the areas that are most likely to give a return on investment. The resources that are available, usually in the form of man-hours, set the bounds for what can be done, and usability issues often fall outside of these bounds. One of the reasons for this is that they are often seen as “added value”, and not a core feature, without which the product cannot be sold.

Fig 5. Usability problems are left un-dealt with

In interview 7, James said that they take up requests and issues that have been collected by the support organization, but that discussions in the CCB often get to be “...very hard and very technical, or whatever you would say, this is the problem, how can we solve the problem, OK... next problem, how can we fix that, and so on. When that happens, it is easy to lose sight of the wider perspective.” James also said that “Small changes

never get made. Things have to have a certain dignity before they are dealt with. If you want to change some small thing that would increase usability, it never gets done. It is so small that it is rejected right off." This is seen as a result of the fact that *"...the process is so gigantic from the case where someone has a problem till there is a solution in place."* Things don't get done because *"It isn't worth the process... things disappear into a void."*

A further complication is that using feedback from the shop floor is hard to manage. Sam said in interview 3 that "There is a matrix of users, from those who know what they want and know how to say it, to those who don't know what to say and don't know how to say it. The dangerous ones are those who don't know what they want, but do know how to say it, since they can influence things extremely negatively. The ones who know what they want but don't know how to say it are also difficult to deal with." He said that observation would give much more than collecting user feedback.

There is also a reluctance to let end-users influence the way the product is developed. In interview 4, Harry, a program manager and member of a Change Control Board, said that meeting individual customers was not desirable, since that could give the customer the impression that they would develop solutions for their particular problems. This was not seen to be possible, since many of the problems are too specific, and not general enough. Fine tuning products to particular needs is not feasible, since these small changes have no impact when it comes to marketing. The marketing department cannot make a case that extensive changes have been made in a product on the basis of a number of small changes.

Another factor that influences what gets done is the fact that the organization has a strong background in traditional engineering values. This affects the way in which problems are discussed and solved. In interview 3, Sam talked about the fact that the company has until now been mechanical-technology intensive. The developers within the company have been mechanical developers, and it is only recently that they have seen a division between software and mechanical developers. Sam was of the opinion that it was still difficult for developers to work at ABB, particularly when compared to a pure software company, since the company is still influenced by the traditions of mechanical engineering.

Since even small changes in a complex system can potentially lead to far-reaching and unforeseen consequences in the system as a whole, there is a reluctance to deal with small issues, including usability issues. In interview 3, Sam said that, although some departments were interested in making usability improvements, the general attitude was *"...if it is up and working, don't tamper with it."* In interview 7, James said that there are examples of known faults that create frustration for end-users, and that never get fixed *"...it isn't even like they are hard to fix; it's just the organization that doesn't think it is important to solve."* However, there are also valid reasons for not making small changes, because *"...everything affects everything else, and that's why testing is so important, since... it's actually someone's life that is in danger if something goes wrong there [...] That's why, before you make a change, you have thought it through, and planned it and worked on it and so on, so you don't dare make small changes."*

In interview 3, Sam said that *"...design takes place up-front, and they try to see 'is this going to be good and easy to use?'"* The concepts have to be established early on, as it is difficult and expensive to change things later on in the process, especially when the system is already launched." He used a simile that he returned to several times during the interview. It is like building a house; if it is really bad, the people don't move in, or move out soon after they have moved in. Some people live in the house a while and then want extensions or additions. Depending on the way that you have built the house, it can be difficult or even impossible to alter the house according to the wishes of the tenants. This is comparable to developing the system, where the architecture should be designed to allow alterations or additions as long as possible without having to demolish the house and rebuild from the beginning. The implication of this is that many of the functions that exist are given, since they are built into the system from its foundation, but the art of changing the system is to find the changes that mean that the tenants stay in the house.

However, despite the architecture, things are rarely simple to deal with. In interview 8, Oscar said that, when dealing with changes *"...usually, it isn't a case of just doing something in our unit, in the graphical interface, it is most often more holistic, that you have to do something in the steering system too. As a rule, lots of different partners are involved."* In interview 5, Carl, a developer, also said that it was problematic to fulfil a user's wishes without analysing whether it is a good idea to fix things, and as a developer, it was difficult to see the whole picture. He said that he was *"...out on one of the branches fixing things; I don't have time to see things holistically."* He was of the opinion that the simplest solution is to fix something out at the far end of a branch. You don't want to take too great a risk and end up doing something that no-one has asked for.

Since there is no holistic view of the problem or the consequences of choices, then choices made affect the product in unforeseeable ways. This means that when issues are "filtered", usability problems often fall through the filter, and disappear.

3.4. Lack of Muscle

There is an understanding of the fact that even small issues are important, and actors within the support department expressed the desire to have a stronger influence regarding what gets to be done when dealing with issues, even small issues. Through their contact with end-users and integrators, they gain knowledge of problems that are experienced in the field, and in some cases, they would like to ensure that the issues that they have knowledge of are taken care of. Issues which may be regarded as small issues in the eyes of some stakeholders are understood by the support organization as being important. Many customers report these and complain about them. In this light, even a small GUI bug fix that would only take a few hours to resolve would make a big difference to the customers as seen through eyes of the Support department. However, they describe a situation where they do not have sufficient power within the organization to ensure that these issues are dealt with.

Fig 6. Support cannot influence what gets done

The support organization has limited means of influencing the decisions taken within the CCB, and they express a desire to have their own budget that could be used to “pay” the development organization to take care of the issues that they see as being important. In interview 7, James said “*We suggest changes every day, which we have experienced, in meetings with program managers, but we don’t have the... it is a question of prioritising things, with other functions and requirements.*” He continued by saying “*A while ago, we discussed earmarking a certain number of hours in every project for support... that support had a certain number of hours to use in development projects, so that support could say that this case is so important that I don’t care about your priority lists, I want this done at once.*”

In interview 1, Sandra talked about previous experience of working with usability issues and said that her role was to “...work with these things from the point of view of a purchaser. And be able to influence things, because it often turned out that [...] you come back with an evaluation of a beta with, you know, shelf metres of ideas for improvements, but it isn’t always those that... (get done) [...] but if you are on the other side, as a purchaser, you could be able to, like, order beforehand things that would get left out otherwise.” However, this does not seem to have left any lasting changes in the way usability is worked with.

James said that although the support organization does have a voice, it is hard to make that voice heard “...we don’t own any products, we don’t have a pot of money to affect the product, and it’s a case of selling in to the product manager, or program manager, good ideas... It’s up to the individuals who are at the table, to sell in our ideas, and get them priority, new functions, above all.”

3.5. Lack of Two-Way Communication with the User Community

There is a lively user community/forum on the Internet, where end-users of the product can discuss problems and their solutions. This is another area where a lack of resources makes itself felt. Previously, the support department has been active within the support forum, but is no longer able to keep up this function. They saw this as being an important way to be visible within the user community and to gain knowledge of user problems. The knowledge gained could be used to suggest solutions for end-users, and to find ideas for improving the functionality of the product. However, they now find that they do not have enough resources to be active within the forum/community, and see how they miss valuable opportunities for product development and improvement.

The web forum had been running for years and customers were active in presenting their problems and improvement ideas, but James seemed to feel under-resourced in comparison to the potential. In interview 7, he said that “...we have our web pages and forums and suchlike... but the processes around them, and who is responsible for it all, we aren’t so mature in how we deal with it all”. On the subject of user feedback on software issues, James said that “...we just don’t have the resources to take care of everything. Or to keep it

going it the way we would like to.” He said that this was also under-developed on the hardware side, that there was a lack of organizational maturity, and that they would find it difficult to deal with the extra work that getting the feedback would involve. Nevertheless, getting remote feedback would allow them to “...look at their scenarios, and see what they are talking about, and get a picture of how the land lies. And it would be much more cost efficient.” If this was possible, it would allow them to spend the time actually getting things done, and would allow them to choose “key partners, the ones who use our PC products or robots to their limits, and we could have workshops with them, where they could tell us about their troubles... it would be very rewarding. But still, setting up something like that means that you have to have the resources available.”

Fig 7. The support organization cannot reach the user community

Efforts have been made to collect data automatically, by building a support tool in the software, so that when a problem made itself known, the support tool would report it to support, and transmit the data from the system, so that the customer did not need to do so. However, they found that “...it demanded too many resources – from the development organization and from us, to deal with certain types of data and so on. So even if we built it in, there was no organization to receive these things. There was no organizational maturity. When we came with all these cool files... there was no-one who could take care of it or deal with it.”

In interview 6, Ben said that, since the product is in the whole lifecycle of a production system “...my problem is that I have a large number of different types of users.” It is difficult to communicate with end-users, since although there is a register of people who have purchased their product, they do not know who the end-users are, since the customer is not necessarily a user. “When you purchase the product, we register an e-post address, but that could be the user, it might be the user’s boss, it might be a purchaser, it might be an integrator [...] it could be anyone.” A solution for this could be to collect information via Internet. However “...it’s tough [...], we have like, a... we have a tendency to have a one-way web, and a web that moves forwards... rather slowly.” There are a number of tools that are available for use, but they do not contain the tools that they need, and sometimes they find that “you have to like, go head-to-head with... with the web police, as I call them.” The one-way web means that they can’t reach their customers. In interview 2, Sam also mentioned cases where the web policies in operation in the company meant that it was harder to reach customers with information.

Fig 8. Communication problems

The interviews showed that in general there are problems of communication between the support organization and the end-users. There is a desire for close two-way communication between support and end-users, but there are organizational obstacles that hinder this communication. James said that, in his support role, he has to filter out the information that he receives from end-users, but that “...in a modern age, end-users want to be able to submit their opinions, or points of view, or wishes or whatever, straight to developers”. He only has a small contact area with users, and said that “...end-users can’t necessarily be bothered getting in touch with me, so that I can then get in touch with the product departments”. Also, he said that even if they could include the

community, there must still be people who can “...give help and answer questions, filter things, and send them to the right person, and so on. And at the top level, they don’t want to allocate these resources... There aren’t enough of us to manage this kind of quick response.” He said that “...from the beginning, our goal was that we should be active in the forums, now we are more... we have the role of watchers.

There are many ideas for improving the communication, including allowing support to communicate with end-users directly via the product itself. This is already technically possible in many ways, as the product can already collect and send data to the organization, but it appears to be the case that there is a lack of resources that would allow these solutions to be developed. In the situation that exists today, there are no routines for analysing the data that can be collected, few possibilities to develop new ways of collecting and using the information, or for developing the processes for communication, which are currently regarded as immature.

3.6. Lack of User Knowledge

The primary stakeholders who are external to the organization are end-users and purchasers of robots and robot systems. These stakeholders differ greatly, both in their knowledge and experience of robots, and in their requirements. They include actors within the automotive industry, and other “heavy” industries, where there is a long tradition of the use of robots and robot systems, but they can also include actors with little experience or knowledge of robots. These inexperienced actors are becoming more important in the marketplace, as the company attempts to expand the market for their products, by finding new customer groups. In interview 10, Mike said “...what we see as being the future is all of those small customers, rather than the traditional approach to the car industry, the volume purchasers.”

However, in interview 10, Lars said that “...we are very technology driven, and actually have very complicated systems, and you can do a lot more with our systems that with lots of our competitors. But that means that they are complicated, too. The more possibilities you have, the more you have to learn to understand the system.” They mentioned the fact that small customers do not necessarily see the cost benefit or appreciate the possibilities “... they cost money. And they... maybe they don’t see the benefits of them when they are purchasing. They would earn from it in the long run, but when they are buying, they don’t see it.” The same theme arose in interview 9, where Charles talked about customers who have a low competence level of software in general and robots in particular. “...they start from scratch as far as robots are concerned. [...] It’s a big step for them, technically [...] these customers are anxious about investing in such complicated equipment. We have competitors who have a more homogenous software offer [...] and we often lose orders because customers feel that it’s easier to buy from them, because they have more integrated solutions.” He said that these customers “...know nothing about robots, and find it difficult to find competent staff... this is a big problem within the engineering industry.”

Obtaining and understanding information from end-users is difficult. In interview 7, when asked how they obtained information about what end-users think about the product, Ben said that “...we have no systematic way of doing it at the moment [...] I am going to start with customer satisfaction surveys. [...] to periodically go out and gather in information from our users, about what they think about our product, that we can use to improve it.” This was not just to gather information about usability, but about all sorts of factors. He said that they had done some such surveys, but that “...we have never really managed to do so much with the material that we have collected, maybe not even really understood it...”

Fig 9. Lack of user knowledge

In interview 8, Oscar expressed the fact that, when they are developing the product “...it is important to remember, that we hardly ever use it the way it is used in reality.” In development they test on small systems, and perform simple actions, whereas customers “...have, like, hundreds of IO signals, and huge robot systems,

and such like [...] we get indications that things don't really work... when you use it with loads of IO signals, for example."

There is a high risk when working with usability that the company develops the things seen by the developers as important, rather than what is important for the end-users. In interview 1, Sandra described how they do not know what the end-users really need. When developing a product, they begin to work in the situation that already exists, and this affects what gets developed. It was described as *"...we always come along with a huge rucksack of functionality, that has to be led over to the next product, and in the end [...] maybe we are just fine-tuning, polishing the interface and the logic of some function endlessly [...] and testing the interface, and using someone who is fantastic at creating interfaces, but if that functionality isn't what gets used..."* In this way, they can end up developing the wrong things, *"polishing the interface"* because they think that they are developing what the end-users want, but if it then isn't what end-users want, then all of the work is to no avail.

In interview 7, James said that it is the end-users who *"...are going to have the most opinions. They are going to experience problems that we can't even imagine, because their scenarios are unique every time."* In interview 1, Sandra also said that the developers do not understand the end-users, and the end-users do not understand the developers. The end-users do not use the functionalities that the developers are concerned with. She said *"it's important to talk to the customers out in the real world... it's pretty cool, because I found that the people who use our products don't understand what I am asking about, the details, and I don't know what they mean, because they often [...] use our products in a way that I don't... I don't understand how they do it. I don't know our products to 100%, how they are used, but I know some of the finer points, and tricks, that they don't know."*

This was confirmed again in interview 4, where Harry said that developers and end-users think in different ways. Developers are given a lot of responsibility, and they build in extensive functionality that lets the end-users do things that many of them are not capable of. The end-users have enormous possibilities to adapt the system, but this has greatly increased the complexity of the product. In interview 6, Carl also said that it is easy to develop cool solutions and functions that there is no actual demand for, whilst at the same time it is easy to miss simple things that are actually needed.

In interview 7, James said that *"There are probably lots of areas where we assume that the end-users understand things, or work in a particular way, and in lots of cases, perhaps things take much longer, or are much more frustrating than we realize. It isn't certain that we have the right idea of how the end-users experience the products."* When they look at the support errands that are submitted they find that *"... we get lots of things, but I wouldn't say that we understand everything about how the customers experience the product"*.

According to Sandra in interview 1, *"If we are going to measure what is important [...] then we must know it [...] that this is what is most important, not for us, but for them. The ones who use it. If we can't formulate it, why should we do something? [...] We are a large organization, and can be, like, too far from – and I won't say the end-user, but even from the user."*

Thus, we see that there is a lack of knowledge of who the end-users are, how they work, and what their needs are. This lack of knowledge means that the solutions that are developed today are not adapted to the actual needs of the end-users. To deal with this is important for the end-users of today, and is even more important if the company is going to adapt to the demands made by tomorrow's end-users.

3.7. Summary

The situation that we have detailed shows some of the organizational barriers that make it difficult for the company to reach the goal of formulating and introducing measurable usability KPIs. Here follows a brief summary of the main points for each specific area above, to aid the reader in gaining an overview.

In section 3.1 it is visible that **1) Integrators can make far-reaching and unexpected changes to the interface designed and produced by ABB.** The integrators themselves experience problems producing satisfactory solutions, due to a high degree of uncertainty regarding what is most appropriate for the customer.

In section 3.2 it is clear that **2) Divergent interests on different organizational levels create conflicts regarding the use of scarce resources, and departments can create work for another department that has no resources to deal with it.**

In section 3.3 it is demonstrated that a consistent view of the root causes of problems experienced by end-users, or their solutions, is lacking. The lack of consistent view has the effects that **3) Resource limitations force a prioritisation of tasks, and the fact that usability issues are often regarded as minor problems results in their being left unaddressed,** as other issues are seen as more important and pressing, and likely to lead to revenue.

Furthermore, **4)** *the product is so complex that small changes have potentially unforeseen effects on other parts of the product, so the consensus is often to change as little as possible.* These decisions are often based on judgements made from an engineering perspective that prioritises functionality rather than usability. In fact **5)** *there is an expressed reluctance to allow users to influence the product, since user feedback is hard to manage,* and **6)** *there is low understanding of what users actually need, or the importance of taking this into account.* This means that many usability issues are filtered out and disappear.

In section 3.4 it is visible that there are some stakeholders, for example in the support department, who understand that even “small” issues are important for the end-users. However, **7)** *the actors who understand end-users are in the position that they do not have the power in the organization to push the changes that they see as important.*

In section 3.5 it is visible that many of these issues are discovered via contact with the end-user community, via the channels that exist and are active today. But even here, **8)** *there are both economic and systematic barriers that make it difficult to maintain the level of contact that is desirable* or to even to deal with the information that is collected today.

In section 3.6 it is demonstrated **9)** *there is a wide range of end-users, and there is a lack of knowledge of who the end-users actually are.* They range from the traditional users with long experience of using complex robot systems, to newer users with little experience or knowledge. These newer customers are seen as important for the future of the product, but the complexity of the product can make things difficult for these users, and even motivate them to choose simpler products. As already mentioned, it is difficult to gain information about the end-users’ opinions, and **10)** *there is insufficient knowledge of how the product is actually used in the end-users’ context.* The product is used in ways that the developers cannot begin to imagine. Users and developers do not understand one another, and think in different ways, leading to a situation where “cool” functionality can be developed on the basis of incomplete knowledge, whilst important things can be missed.

To summarise, here is a list of identified obstacles hindering introduction of KPIs for usability:

1. Integrators can make far-reaching and unexpected changes to the interface designed and produced by ABB
2. Divergent interests on different organizational levels create conflicts regarding the use of scarce resources, and departments can create work for another department that has no resources to deal with it
3. Resource limitations force a prioritisation of tasks, and the fact that usability issues are often regarded as minor problems results in their being left unaddressed
4. The product is so complex that small changes have potentially unforeseen effects on other parts of the product, so the consensus is often to change as little as possible
5. There is an expressed reluctance to allow users to influence the product, since user feedback is hard to manage
6. There is low understanding of what users actually need, or the importance of taking this into account
7. The actors that understand end-users are in a position that they do not have the power in the organization to push the changes that they see as important
8. There are both economic and systematic barriers that make it difficult to maintain the level of contact that is desirable
9. There is a wide range of end-users, and there is a lack of knowledge of who the end-users actually are
10. There is insufficient knowledge of how the product is actually used in the end-users’ context

The background to the case study was an interest within the company to introduce measurable KPIs for usability, and to find candidates for possible measures. As shown in the above, the interview material illustrates many of the problems that make defining and introducing such KPIs difficult. The situation that we have studied is found to be complex, in its mixture of technical, organizational and social factors, and this complexity is seen to lead to many problems and breakdowns. We find that there are many organizational factors, both internal and external to the company, which lead to the situation that exists today. However, this is not new knowledge. The types of problem that exist at ABB are not new and unique problems, but have been in existence for a long time, and although much research has been performed on investigating and remedying these types of problems we find

that they are still in existence. Existing research on organizational and social factors will be presented below, in order to shed light on and place our findings in a wider organizational context. Our findings concern usability efforts, which have not been widely discussed in terms of the organizational and social challenges below, whereby we see the importance of contributing here.

4. Discussion of Results

In this section, we look at theories regarding the importance of organization and organizational change in the field of systems and their development, and compare those with the ABB situation. The theories, which are chosen from areas that we were led to through the constructivist GT approach used in the study, are taken from several different academic discourses: This approach is also supported by Fuggetta's view that it is important to reuse experiences gained in other communities, such as organizational behaviour research (Fuggetta, 2000). We also look at the material from a design perspective in order to see what might be required to remedy some of the problems that are apparent in our case. One important aspect here is to understand the nature of the problem that we are confronting. We need to understand how the identified problems are related to contexts and how to approach them, whereby we introduced the concepts of wicked problems, collaboration over coordination, and User Centred Design, to explain and address the situation.

4.1. Organizational factors are important

The complex process of developing software was discussed in Fuggetta's roadmap for software process (Fuggetta, 2000). He claimed that developing software is a collective and creative effort, and that the quality of the product is dependent not only on the procedures used to create and deliver it, but also on the people and the organization. Our case exhibits ways in which the institutional processes and cultures within the company shape the way in which the product is designed and developed. In many cases it is the organizational influence, rather than the dynamics and limitations of the technology itself, that decides what gets to be done, or conversely does not get to be done. By showing the structure and complexity of the organization, we show some of the connections between the ways in which the technology is designed and developed. Iivari (2006) discusses the way in which organizational culture affects usability work, and states that the cultural context can reinforce and advocate some aspects of usability work, and deem other aspects unimportant. Iivari shows that many studies suggest that culture plays an important role in affecting user involvement in organizations, and suggests that culture is a factor that is intertwined with organizational change efforts to introduce user involvement into organizations. In 2001, Orlikowski and Barley discussed how important it is to take into account the role of the organization when analysing IT (and by extrapolation other) systems (Orlikowski and Barley, 2001). They state that there is a lack of knowledge in this area, and that "*IT researchers have yet to ask how institutions influence the design, use, and consequences of technologies, either within or across organizations*". They show how studies have taken place at a "lower" level of abstraction, and have not looked at how regulative processes, normative systems, and cultural frameworks shape the design and use of technical systems. They claim that understanding and guiding techno-social developments requires knowledge of technological systems, social processes and their interactions. There is a need for research that concerns both technology and the social dynamics of organising; that embraces the importance of understanding the role of the human agency as embedded in institutional contexts, as well as the constraints and affordances of technologies. Our results show that this is still relevant today related to organizations' efforts to improve usability.

Work published by Curtis et al (1988), regarding the problems of designing large systems, also shows that the types of problem that exist at ABB are not new or unique problems, and neither were the problems new when their work was published. They state that "*...these problems have survived for several decades, despite serious efforts at improving software productivity and quality*". They characterise the problems as behavioural, and claim that these problems affect software productivity through their impact on cognitive, social and organizational processes. They maintain that the effect of these behavioural factors on software development is much greater than the effects of tools and methods. They also maintain that, since tools and methods that aid individual activities often fail to provide benefits that justify their impact on the team and organizational factors that affect design processes, it is important to understand how behavioural factors affect the execution of software development tasks. The most salient behavioural problems, in terms of the additional effort or mistakes that were attributed to them, were: the thin spread of application domain knowledge; fluctuating and conflicting requirements; and communication bottlenecks and breakdowns (Curtis et al., 1988).

When we compare our results with those of Curtis et al, we see that their description corresponds well to the

findings in our case, where a large proportion of the problems are based on insufficient knowledge of the expanding domains where the robots are used, and of the users' characteristics and needs. This leads to a situation where requirements are hard to specify, and once specified can be found to be in conflict with one another, or impractical to implement because of dependencies within the system, or organizational limitations. We see situations where communication breakdowns occur, and a number of factors that lead to bottlenecks in the design and development processes. The problems that were mentioned in the interviews were behavioural problems rather than problems associated with tools and methods and our case is an illustration of the way in which behavioural factors still make it difficult to design and develop systems.

Uldal-Espersen et al (2008) argue that most studies of usability work disregard the organizational setting where the work is situated. However, they state that real-life organizational settings are important when studying practical usability work, and that projects focusing on usability must be based on genuine interest on the side of the stakeholders, including management, users, IT representatives and usability experts. Thompson et al (2010) describe a situation where, as practitioners, managers of design and UX teams, they find it difficult to position the work of team members, and that roles are often misunderstood. Other disciplines, such as product management and development see the UX work as unnecessary, or even threatening. They experience a situation where, when deploying UX resources, the corporate culture is unready to accept them, and the role of UX manager becomes more that of a change manager. It was found to be difficult to communicate the UX vision and to engage the other disciplines. Rohn and Wixon (2011) also point to a number of what they call persistent questions, such as the fact that there is a lack of clearly defined challenges and opportunities that UX teams face or will face, to which extent design and user research are accepted and influential parts of company leadership, and whether there is a commonly accepted vocabulary to describe tools and methods, both within the teams and for business and technical leaders. These descriptions are illustrative of a situation that we recognize from this case study, where the usability workers found it difficult to make an impact in the organization, and where the resources available for usability work were often cut back, since there was no clear view of the importance of the usability work within the projects.

Curtis et al claim that developing large systems must be treated as a learning, communication and negotiation process. They say that *"...three capabilities that we believe must be supported in a software development environment are knowledge sharing and integration, change facilitation, and broad communication and coordination"* (Curtis et al., 1988). They found that conflicts among requirements often resulted from differing needs of customers, changing needs of individual customers, changes in underlying technologies or competitors' products, or from misunderstandings regarding the application domain. They even resulted from internal sources, such as marketing, corporate politics, and product line management. Design teams often negotiated to reduce problems and limit requirements to those that could be implemented within schedule, budget, and time restraints. All of these types of mechanisms, such as conflicting requirements, internal conflicts and breakdowns, and adaptations intended to reduce and limit problems and requirements, were found in our case.

The problems discussed by Curtis et al emerged from processes at one level in a layered behavioural model but affected processes at several levels. They operated through different mechanisms and required different solutions. Their model encourages thinking about projects on multiple levels of analysis. It advocates an extension of the evaluation of software practices from individuals, to teams and projects. The picture that they paint fits in well with our findings of conflicts, breakdowns and barriers originating in different parts of the organization, which then spread to and affect other parts of the organization. These problems cannot be dealt with on an individual level, and to understand and treat the mechanisms that lead to the problems, it is necessary to approach them by taking a more holistic view of the structures and processes involved, than is taken today.

4.2. The existence of a Wicked Problem

Curtis et al found that the problems that are experienced in large system development projects were not experienced in smaller well-understood applications with stable and complete specifications, and they characterise these problems as wicked problems. Problems of importance are seen as being 'wicked.' (Coyne, 2005) The concept of wicked problems originates in the work of Rittel and Webber (Rittel and Webber, 1973), who discussed the fact that the professional's job has traditionally been seen as solving problems that can be regarded as "tame", meaning that they are definable, understandable and consensual. However, they maintain that a shift has occurred in the types of problems that professionals are called upon to solve. Unlike in the natural sciences, societal problems are not definable and separable, and have no solutions that are findable. They are ill defined and rely on political judgement for solution. The term wicked is used *"in a meaning akin to that of 'malignant' (in contrast to 'benign') or 'vicious' (like a circle) or 'tricky' (like a leprechaun) or 'aggressive' (like a lion, in contrast to the docility of a lamb)."* (Rittel and Webber, 1973) Wicked problems are only loosely

formulated, and there is no 'stopping rule.' They can be redefined and resolved in different ways over time, and their formulation depends on the viewpoint of those who present them. There is no ultimate test of a solution to a wicked problem. Solutions can only be tested in a practical context, and the solutions are not easily undone (Coyne, 2005).

The concept of wicked problems has been referred to in many cases. Keating et al discuss the ways in which systems engineering approaches have successfully addressed well-bounded problems, and how engineering disciplines have traditionally been directed at solving clearly defined problems, with clear goals, that can be attacked from an established body of theory and knowledge. However, these conditions are no longer the rule, and increasing information richness, and higher degrees of complexity lead to a need to address a situation where complex systems problems are emerging. These environments are characterised by ill-defined and potentially tacit goals that are value-laden and that may be impossible to define explicitly (Keating et al., 2003). Denning describes wicked problems as messes, which are seen as being worse than problems (Denning, 2007). Problems are difficult situations where there is an expectation that solving some difficulty will end the problem, whereas messes are complex, and there is often no agreement on whether the mess consists of a single problem, or the convergence of many problems (Denning, 2007). This description is applicable also in the case of ABB. In the "*list of identified obstacles hindering introduction of KPIs for usability*" found above (hereafter this will be referred to as *the list*) increased information richness and higher degrees of complexity relates to point 4, 5, 6, 9 and 10; "Ill-defined and potentially tacit goals that are value laden" relates to 1, 6, 9 and 10; "expectation that solving some difficulty will end the problem, whereas messes are complex" relates to 2 and 3. Some of the signs of a mess are the existence of a disordered condition, the absence of an obvious problem statement, a lack of apparent causal relationships, a feeling of confusion or of being stuck, discord and controversy (Denning, 2007).

According to Denning & Yaholkovsky (Denning and Yaholkovsky, 2008), messes are often found to be non-technical in origin. This is certainly so in our case, where it is not the technology in itself that leads to the problems that we have detailed, but the behavioural problems that we have discussed above. They maintain that messes are best addressed through collaboration. Collaboration is a stronger form of working together than coordination (meaning a system of regulated interaction for people and objects to fulfil their goals), or cooperation (which means playing according to a set of behavioural rules). In collaboration processes, solutions or strategies are created through a process of group interaction. The complexity of collaborative design arises from a need to manage large amounts of information, and understand design decisions that have determined an artefact's long term evolution (Fischer, 2001). Collaborative design leads to work-products that are enriched by multiple perspectives of the participants and the discourses that result from the collaboration. In our case, the factors that lead to the existence of the wicked problem lead to a situation where collaboration, as it is defined above, becomes problematic. The mechanisms of coordination obviously exist, and the normal design and development processes work in a way that allows the product to be successfully developed and marketed. However, the breakdowns and barriers that exist make collaboration difficult. This is supported by the work of Easterbrook (Easterbrook, 1995), who maintains that collaboration is difficult. Beyond the work necessary to make progress on the task itself, work is also necessary to maintain relationships between partners and negotiate the nature of the task. Two key factors are to what extent collaborators need to develop and maintain a shared understanding, and how collaborators deal with conflict (Easterbrook, 1995). Given the situation that we have shown to exist at ABB, where there are a number of non-technical breakdowns and obstacles to cross (see points 1, 2, 3, 5, 6, 7, 8, 9 and 10 in the list), there are obviously many barriers to introducing a collaborative way of working.

The work of Arias et al (Arias et al., 2000) also deals with breakdowns and wicked problems. They discuss them mostly in terms of symmetries of knowledge, rather than the general behavioural problems that we have shown to exist in this case, but there are many parallels to our case and their results can be used to draw interesting parallels. They claimed that the major changes that have occurred in HCI have been at the levels of design, systems, technology and media, where actions and changes can take months or even years or decades. When working at these levels, they state that the relevant theories would probably be grounded in social and organizational themes. This is in accordance with the discussion above, and is clearly relevant to our study, where we are dealing with a technically complex product that has developed and evolved over a long period, and where we have seen that many of the problems are based in organizational factors, and in communication breakdowns between individuals and departments. They claim that these types of breakdowns are important to take into account as they see that the main activity in designing complex systems is that participants instruct one another (Arias et al., 2000). The view of the domain expert as the sole source of design knowledge does not recognise the fact that all stakeholders can contribute. Knowledge is distributed between stakeholders, and complex design problems, such as the ones in the situation that we have studied, require more knowledge than any single person can have. Therefore, different stakeholders are required to participate, communicate and collaborate. However, as we have already discussed above, factors in our case make the processes of collaboration difficult, and even communication and participation, particularly on the part of end-users, is hard to

bring about. Bringing together different points of view is important, since by doing this, it is possible to create a shared understanding that can lead to new insights, ideas and artefacts. However, communication breakdowns often occur, since different stakeholders use different norms, symbols and representations (Arias et al., 2000). Applying this knowledge to our case would provide some explanations for the situation that exists today, and would suggest the importance of creating ways for stakeholders to communicate more effectively, in particular with end-users.

However, they also maintain that design problems are wicked, and the design context is characterised by change, conflict and multiple stakeholders. Coyne states that “*Wickedness is the norm. It is tame formulations of professional analysis that stand out as a deviation*” (Coyne, 2005). Problems of designing for complex situations are well known, and have been in existence for a long time. In the field of Computer Supported Cooperative Work (CSCW), for example, Easterbrook (1996) stated that “*Software products succeed not because they are designed to suit their users, but because the users can adapt to suit the software*”. CSCW design is hard, because there is no framework for understanding how group members adapt to cope with coordination breakdown and conflict. In a case such as ours, where there is considerable complexity, given the complexity of the development process (2, 3, 5, 6, 7, 8 in the list), and the fact that the integrators affect the product offered to the end-users, it is hard to understand how the end-users adapt to the product. It is also hard to know how to make the product adaptable in the most suitable way (1, 9 and 10 in the list). However, we see that even wicked problems are solved, although we cannot find optimal solutions to them, and this is often done in a “satisficing” manner. Satisficing is the process whereby humans, given all of the alternative possibilities, still make decisions and solve problems. Instead of looking for optimal solutions, decision-makers set feasible goals and use decision methods that look for good, or satisfactory solutions, instead of optimal ones as rationality might suggest (Atwood et al., 2002). Hughes et al (1994) discuss the way in which design is, at best, a ‘satisficing’ activity, often dealing with ‘wicked’ problems, and that this involves being governed by, and influenced by an interplay of political, moral as well as technological considerations.

4.3. The importance of context in design

It is often impossible to reach consensus in design processes, where the best that we can hope for is an informed compromise, since there is a symmetry of ignorance, where crucial knowledge for problem resolution exists as tacit knowledge in the heads of individual stakeholders (Arias et al., 2000). In the context of our case, as long as there is a situation where breakdowns occur and communication is problematic, and where there are difficulties getting and using input from key stakeholders such as end-users, then it is difficult to create a situation where it is possible to produce the product that satisfies the largest number of end-users. Arias et al (Arias et al., 2000) claim that solving design problems requires that the owners of the problems are put in charge, thereby promoting direct interaction that involves people in the decisions that affect them. All stakeholders can make important contributions and should be turned into designers and co-developers, to bring their important perspectives to the design process. Being a consumer or designer is not binary; there is a continuum ranging from passive consumer to designer, and problems arise when, for example, someone wants to be a designer and is forced to be a consumer. In our case, this would for example highlight the importance of obtaining and using end-user feedback, allowing the end-users to become stakeholders who can become more active as designers. All of these things have been found to be difficult today. In agreement with Olsson and Jansson (2005), we believe that addressing usability problems in highly qualified work settings requires involving users to a much greater degree than today, and much earlier in the development process. They found that types of problems addressed when developing for a highly qualified work setting were such that they hindered the users from achieving their goals efficiently in relation to their work activities. The work activities themselves were often complex, demanding that the users plan and make important decisions, and collaborate and exchange information with others. They state there are business goals that drive the organization, and that the goals for computer systems are heavily influenced by assumptions about how people work and how the organization functions. Different individuals have different goals, and so the implications for the design of work and technologies differ, leading to the situation where system goals are not always the same as the users’ goals. This is reflected in the situation that we found at ABB.

ABB is in a situation where robot systems have become complex systems, and there are parallels to the work of Keating et al (Keating et al., 2003), who, in their work on System of Systems Engineering (SoSE) discuss the way in which systems that once were developed as stand-alone systems to address singular problems can no longer be regarded as isolated. Traditional Systems Engineering has placed context in the background, and therefore finds it difficult to cope when addressing areas with high levels of ambiguity and uncertainty, and problems with a high degree of contextual influence. SoSE attempts to deal with some of these problems, but there are still challenges, including working in a situation where focus is placed on technical problem solving, which we have found to be in focus in our study (e.g. 3 and 4 in the list). In reality, it is the contextual, human,

organizational, policy and political dimensions that shape the decision space and solutions for the technical system problems, and this requires the ability to design and develop across the traditional boundaries placed by program budgets, operating philosophies and different objectives. All of these factors that have been found to be problems in our case. Design cannot be restricted to what have been regarded as stable contexts and isolated systems, and context must be placed in the foreground, whilst technical solutions are in the background.

Here, we see the importance of context, and this focus is also reflected in the work of Orlikowski and Barley (Orlikowski and Barley, 2001), who state that technologies are both social and physical artefacts. Most engineering requirements can be met with multiple designs, so all technologies represent a set of decisions made by specific designers. Accounts of technological change need hybrid explanations that weave human actions and choice with the functions and features of technology and the contexts of technology use, in a way that attends to the micro-dynamics of situated practice.

So far, we have seen the presence of behavioural problems, leading to the existence of a wicked problem, the importance of the roles played by multiple stakeholders, and the importance of context when addressing the problems of designing complex systems. This focus on the importance of context and practice, highlighting the role of end-users as designers, lead us into a discussion of the way in which design processes can be managed.

4.4. The Need for User Centred Design

Although they address knowledge management (KM), the work of Fischer and Ostwald (Fischer, 2001) is interesting to consider from the point of view of the design and development practices that we have studied at ABB. They discussed KM from a design perspective, where the goal is to enable innovative practice at an organizational level, by supporting collaboration and communication among knowledge workers within and across domains, which we have seen as problematic in our case. They see workers as reflective practitioners who struggle to understand and solve ill-defined problems. They show that users are more concerned with doing their work than with the system itself, but the system must be an adequate tool for their work. Users see whether or not the tool fits their needs. Since other specialists do not use the tool to do their own work, they cannot have this knowledge, and this should be reflected when the system is designed. The needs of workers are unique, since they result from efforts to understand a problem. The context of problem solving dictates the information demands and the context for learning. The need for learning comes from the work, and the learning takes place in the context of the work situation. This is very important to consider in our case, where the interface that is designed must be made adaptable for users, allowing them to tailor it to their own needs, whether they be simple or advanced. Doing this needs knowledge of the context where the tool is to be used, and as we have seen, this knowledge is difficult to gain and to use if it is gained.

Although Fischer and Ostwald discuss in terms of computers, their findings can be relevant in the case of robots, which can more and more be considered to be related to computers and computer systems. Their KM perspective goes beyond individual perspectives and requires stakeholders to learn new relationships between practices and attitudes, which we have found to be difficult in our case (e.g. 1, 6, 7, 9 and 10 in the list). There is a need for an environment that supports social interactions among communities of practice and communities of interest. However, this does not mean that the needs of the individual must be superseded by the interests of the group. Individuality is important, and communities gain their strength from the creativity and engagement of the individual. It is important to understand and maintain the balance between the individual and the community, and “*Collaborative systems will not work in a noncollaborative society*” (Fischer, 2001). Thereby, they highlight the need for including the individuals in the design processes, and over a period of a few years, this is one of the areas that the HRI community is beginning to become aware of.

We have already seen in our case study that the engineering approach at ABB has been successful at producing robot technology, but that it is no longer found to be adequate to approach the new challenges that they face, where usability is becoming a key factor. One widely spread way of working with usability problems is by engaging usability specialists, and to some degree that has been done at ABB, but even this kind of usability work is lacking in some areas. Friess (2011) highlights the problem that even usability experts have trouble translating issues found in testing. It was shown that many findings from usability testing sessions do not make their way into reports, and those findings that are in usability reports can differ substantially from what was uttered in the testing sessions. Consistency and continuity varied greatly between sessions (Friess, 2011). This illuminates a situation where developers cannot be expected to understand and deal with issues that are found, when even usability experts find this to be difficult. This points to the importance of including users at all stages.

One way of approaching this area is through a process of User Centred Design (UCD). Fong describes how

communication between humans and machines is usually mediated by an interface, which although it can offer great power and flexibility, comes at the cost of high learning. Other interfaces, for example menu based ones, may be easier for novice users, since they do not make assumptions about what the user knows (Fong et al., 2003). This correlates well to what is found in our study, where experienced end-users can make use of the advanced functionality built in to the interface, whilst the same interface can become an obstacle for novice users, which can lead them to choose a simpler alternative product. This fact highlights the need to take into account the needs and skills of the end-users when designing the product. However, work analysis and user involvement are required to develop common ground, but the UCD principles of early and continuous focus on users, and understanding of users and their tasks, are easily neglected when different development activities compete (Olsson and Jansson, 2005), which we observed clearly in our study. According to Gulliksen et al (Gulliksen et al., 2006) the design process must be cooperative, dependent on the input of several disciplines and the users. They state that UCD is essential, and that the usability professional is vital in the process, since this role drives the UCD process. This role has the potential to fill the gap between analysis, evaluation and construction, and fill the gap between UCD and software engineering. Usability experts need to be involved continuously in the development process, since they can make the greatest impact when they are involved in projects on a day-to-day basis, including the construction phase when many usability issues need to be dealt with. However, they should not simply become substitutes for user participation.

HCI is becoming more and more interested in the design process, and there are many interpretations of what design is, but good design usually implies a sense of fitting a purpose that can be verified empirically, and the contribution of satisfaction, and similar concepts, will be a topic of increased interest in the future (Karat and Karat, 2011). Design is a collaborative process between users, designers and developers, where the expertise of every group is important for the outcome. This approach requires cooperative methods, and the design process is a process for creating knowledge and common ground (Gulliksen et al., 2006). Uldall-Espersen also highlight the fact that usability work must involve a multitude of stakeholders, and their study showed how a usability improvement process benefitted from bringing different areas of expertise into play, by applying different techniques, and through close cooperation between people with different types of expertise. The approach taken in their study has important similarities with UCD, where design teams in iterative processes create designs based on studies of real users, tasks and needs, and can respond to changes in the surroundings (Uldall-Espersen et al., 2008).

Keinonen (2008) states that socially relevant design must be related to the needs of people. UCD of ICT is born from a need to transform complicated technologies into real-world applications. UCD was previously concerned with optimising the design of HCI, but is now concerned with a wider range of interests, aimed at matching interactive technologies with human-human communications, organizational requirements, and social and emotional perspectives. Gulliksen et al (2006) show that attitudes held by the people involved in the process are important, and are crucial for results. If the attitudes of developers, program managers, management and clients are not conducive to UCD and usability, then there is little point in introducing usability and UCD. They state that usability needs a UCD process, and discuss the importance of having a user-centred process, where usability must be tightly integrated. They found that moving from a technically oriented process to a user-centred approach requires more than a few usability activities.

Including users in design and development is important for many reasons, including gaining domain knowledge in complex contexts, and to gain credibility in usability work. Chilana et al (2010) found that usability experts struggle in gaining credibility with management and persuading developers to make changes based on user data, and these problems are made worse when domain knowledge is lacking. Complexity leads to a situation where more effort is needed to communicate with design team members, managers and developers. Usability experts also found it difficult to make usability an integral part of software development instead of an overhead. Particularly in the case of developers, who were sceptical about usability recommendations, motivating changes was difficult when usability experts lacked domain expertise. The more domain experts were involved, the less credibility became an issue. In our previous work on usability, we have found that there is a general need for usability process improvement, and that UCD, which can have a serious impact on HCI and usability practices, can have an important role to play (Winter and Rönkkö, 2010). In UCD, the role of the human, who was once reduced to an operator, part of an information processing system, is replaced by a more active and holistic contributor (Keinonen, 2008), and based on the results of our study, we believe that this is necessary to resolve some of the problems that we have uncovered, and this is a movement that is gaining focus in the area of HRI.

Regrettably, much usability thinking, based on quick and cheap usability testing, has removed emphasis from the holistic view of the users, and has allowed teams to fragment usability into features supplemented by fanciful use cases derived from these use cases, which became apparent in the material in our study. User experience is supposed to be defined by realistic tasks that are meaningful to users, described in terms that they would

understand (Wixon, 2011). However, this cannot be done without the domain knowledge that only users can provide, and UCD could avoid this problem. Factors connected to why users buy or use products can be expressed in terms of what the user can do, and how easily they can do it, and this approach is captured by usability engineering metrics and goals. However, these metrics and goals must extend beyond a list of functionality and features to a more holistic product concept that reflects value. This kind of evaluative construct can only be measured through user research (Wixon, 2011).

In the HCI field, there has been a move away from studying small groups of users who mainly used desktop computers, to groups of users looking for productivity tools, to studying the role of computers in entertainment (Karat and Karat, 2011). Thus, HCI practice has changed radically, and it has been found that HCI practitioners must work in multidisciplinary teams, and coordinate with other areas in the company. Multiple perspectives are valuable, and Karat and Karat found that, as usability specialists, they needed to expend a great deal of time identifying and recruiting users to work in the HCI efforts, but that working with truly representative users is crucial in performing high quality usability work (Karat and Karat, 2011).

As early as 2002, Adams claimed that the HRI community ought to approach HRI development from a human factors perspective, rather than an engineering perspective (Adams, 2002). This is important to consider, given the focus we have seen in our study, where the engineering perspective has been prevalent. Adams maintains that the user's perspective must be included throughout the design and development process in order to develop good interfaces. The HRI community should build upon results produced within the human factors community, and include users in the design and development of robot interfaces. Since an initial consideration in UCD is to examine the needs of users, it is beneficial to implement UCD in the HRI processes (Adams, 2002). In 2003, Scholtz cited Hill, who also states that research teams in HRI should include human factors practitioners in multidisciplinary fields, and that HRI is more than simply creating a smart interface for the user. It is important to consider the skills of both humans and robots, and develop systems that allow both actors to fully use their skills (Scholtz, 2003). However, it takes time to change paradigms, and in 2005, Adams (Adams, 2005) still claimed that that HRI must move beyond the prevailing engineering approach to a UCD process. She maintained that it was only recently that the HRI field had become aware of the need to apply UCD and other standard human factors techniques. There were still few efforts at implementing UCD, and it was difficult to gain access to real users, and this difficulty of has been one of the key factors of our study.

ABB has an extensive background in the area of mechanical engineering, and in recent years, there has been an increasing interest regarding the role of engineering in HCI. Since 2006 there is an Engineering Community SIG at the CHI conference. The engineering community sees that the role of engineering is becoming more important as the HCI field matures, and they are concerned with improving the economics of operations and improving safety to life or property. However, they find that they are still at the stage where they are discussing key issues, such as what is the importance of engineering in the greater HCI community, and are concerned with finding ways to develop positions that address these issues. They see the importance of HCI professionals making an impact in engineering projects, in order to realize the potential impact of CHI (Butler, 2010). In 2011, the discussion at the workshop still concerned the serious challenges that faced the role of the engineering community in the larger CHI community. At the workshop, great emphasis was placed on practical matters, and on summarizing the issues and objectives of the workshop, and defining the key issues for 2012, where one of the issues was how HCI can work better with software engineering, which is the project context where the value of the field will usually be realized (Butler and Brooks, 2011).

As previously mentioned, the case study began based on a desire to formulate and introduce measurable KPIs for usability. During the study, we discovered issues that make it difficult to formulate and agree on suitable candidates, due to obstacles and breakdowns in the organization, even though a number of candidates for KPIs could be created on the basis of the material in this study.

We have now traced the theories related to our case study, beginning with the fact that many of the problems that we have observed have their basis in organizational or behavioural problems. Given the complexity of the situation, we conclude that a wicked problem exists, that cannot be solved using the methods and techniques that are currently in use, and that attempts to introduce usability KPIs are not likely to solve the problems that they are aimed at. However, we do see that usability efforts, which have their basis in an attempt to understand the context and everyday work of the actual practitioners, are important, given the importance of including context in design processes. We also see that the only way to see and understand the context, and work practices that exist there, is to work in a process of UCD, which naturally includes the participation of actual users. However, we have also seen that there are a number of obstacles that must be overcome before this can be realised.

5. Conclusion and Further Work

In this final section, we present our work based on our focus on and discussions concerning usability, which was the main area of interest in the study. However, we see that the conditions that exist reflect a situation that could be equally relevant for many other factors. Thus, the results are interesting as a general illustration of the problems of working with complex questions within complex organizations.

We have presented how problems occur when working with combinations of engineering problems and usability requirements in a complex organization. In a competitive world, there is often a consensus that it is new features and new products that are sold to customers. Each new feature can be a competitive advantage, as something that adds value or increases the price. Both adding value and increasing prices tend to increase profits. However, usability is only an added value which is hard to formulate, and is therefore a feature that is hard to sell as such. All products in the markets are said to be “usable” or “easy-to-use”; therefore, new features gain more attention by default. This leads to a situation where usability issues are often poorly formulated and understood, and there are few mechanisms that lead to satisfactory solutions. From a marketing point of view, it is too easy to just say “our product is easy to use” although proving it is difficult and would take a substantial effort. It is more cost effective to create a positive impression about usability by good marketing than by other means, whereas the functions promised must be found in the product, at the risk of litigation.

The context of this study is a large multinational industrial company, with roots in a traditional engineering field, and extensive experience of working with industrial machinery. The context is affected by the history and traditions of the company, which mean that the organizational structures and cultures that exist are still rooted in the successful strategies that have previously worked well for the company. However, changes in technology and in the marketplace mean that demands for usable products are forcing changes in the products that are produced and marketed, and in the way these products are used. This means that these structures are being challenged by the changes that are occurring, and in order to produce products that compete, it becomes necessary to change the view of what constitutes quality, and how this quality can be achieved. The business unit that was the object of study produces and markets industrial robots and robot systems. Regarding quality, the product is technically at the forefront of the market, and as far as usability is concerned is in line with other products of similar complexity and ability. So far, the engineering approach that has been followed has been successful in business terms when applied to clients within the traditional engineering background. However, the market has changed to include also smaller actors with diverse backgrounds and there is a realisation that usability is becoming a quality indicator, that improving usability is important and valuable, and the company was committed to finding ways of working with it. We believe that the situation that we describe is representative of other large organizations that are facing the same challenges of moving from a situation where changes in technology and markets force changes in deep rooted assumptions about how products should be produced and what constitutes quality.

In this study, we show that a combination of problems made it hard to work with usability KPIs in the way that the company hoped. Firstly, there are inherent problems that can be characterized as behavioural, and which are a result of organizational factors. We see how these organizational factors caused conflicts, breakdowns and barriers. The resulting problems were found in many different parts and on several levels of the organization. They affected other parts of the organization, and were compounded by the kinds of communication problems that are common in complex organizational structures. These characteristics led to problems when attempting to decide upon usability KPIs. Addressing these problems requires a holistic view of the structures and processes involved including a view where context is placed in the foreground whilst technological solutions are in the background. However, gaining that view is difficult. These behavioural problems, combined with the complexity of the marketplace, where there are uncertainties regarding domain knowledge and user needs, especially when expanding to new domains or sub-domains, lead to a situation where a wicked problem occurs. Such problems cannot be addressed through the engineering approach that has so far been used so successfully to target a market consisting mainly of engineering clients. However, the market has changed and today there is a need for a new approach targeting a much more diverse group of clients including non-engineering actors. This is difficult to realize in practice if adhering to the old approach targeting engineering companies.

The problems that are encountered are not based in the technology itself, but have their foundation in the behavioural problems. The above mentioned engineering approaches that have prevailed so far have been directed at solving clearly defined problems with clear goals, but these conditions are no longer the rule, as the complexity of the environment increases. In the design and development processes involved, the knowledge that is needed is distributed between different stakeholders, including end-users, who are required to participate, communicate and collaborate. These processes are characterized by change, conflict and multiple stakeholders, and the behavioural problems involved make participation, communication and collaboration hard to bring about, whereby reaching consensus becomes a problem.

Reaching a consensus amongst stakeholders is nonetheless of great importance. Solving design problems requires letting all stakeholders bring their contributions to the design process, in essence taking context into account. However, the fact that the situation is characterized by breakdowns and barriers makes it hard to get and use input from key stakeholders, whereby it becomes hard to include context, to reach consensus, and to produce the product that will satisfy the maximum number of customers. To reach a situation where this is feasible would require changes in the organization and organizational culture, and as we have previously discussed, organizational change is a long and complicated process that is difficult to guide and manage. Still, we believe it to be the case that it is only if these changes occur that it will be possible to reach a state where usability work is seen as a natural and important part of the design and development processes, where incentives are created for working with usability, and where it becomes possible to work with usability KPIs that different stakeholders can agree upon. This change process must have backing from management, but should, according to the principles of PD, involve staff and their representatives from all levels of the organization.

As discussed above, developing a complex system such as this requires us to deal with ambiguity and uncertainty, which requires us to place context in the foreground, whilst placing the technical solutions in the background. This is the opposite of what the organizational culture has traditionally been focused upon. To actually achieve this requires the active participation of end-users, allowing us to create designs that combine human actions with the features of technology, to attend to the dynamics of situated practice. Only by doing this, we believe, is it possible to achieve consensus and thereby produce the best possible product.

Thus, to design the product that best serves the end-users requires knowledge of the context where it is used, and as we have seen, it is only the end-users who have that intimate knowledge. The end-users have unique needs, as they strive to understand and solve the everyday problems they are faced with, and they are the only ones qualified to judge whether a product fits their needs. This calls for a design environment that supports interactions between stakeholders, and the inclusion of end-users in the design processes. This need is something that the HRI field is only now becoming aware of, but which has become very clear in our study. One way of approaching this is through UCD, which is born from the need to transform technologies into applications, and the HRI community is becoming more aware of the fact that UCD is an important component. UCD sees the user as an active contributor who brings their own perspective to the design situation. Given the importance of context mentioned above, we believe that the contributions to be made by end-users are necessary to surmount some of the problems that we have found in our study. The inclusion of end-users is vital, to ensure that there is a balance between the skills of both humans and robots, to allow both actors to fully use their skills. However, although we see this as necessary, we still find that there are many barriers to be overcome before this becomes possible to realise in practice – in other words, we are still in a situation where we cannot reach the consensus needed to produce the best possible product. We believe that this cannot be done until UCD becomes a natural part of the development processes, allowing us to overcome some of the organizational barriers to usability work.

To summarize this discussion, we find that working with usability KPIs in the kind of organization that we have studied is difficult, and that achieving a situation where this is natural would require cultural and organizational changes that are likely to be far reaching and difficult to manage and achieve. However, we believe that to succeed in the long run with the type of product development in the kind of marketplace that we have studied requires that the company to make these changes.

To do this will require management to devote resources to actively encourage the change processes, and these change processes must involve staff from all levels of the organization, working not only with change processes but with the creation of KPIs. In order to create an understanding of the importance of usability, there must be a focus on developing KPIs that reflect the importance given to usability, and there must be incentives for meeting the goals set in the KPIs.

In order to create KPIs that reflect the actual user needs, it is important to know more about the users, and how they use the products in their everyday working life, and this requires mechanisms for user research and user participation. These methods do exist, but are still not widespread in the area that we have studied.

Most importantly, we believe that finding ways of involving different types of actual end users, with an ultimate goal of making UCD an integral part of the design and development process, is the most important factor to work with, and believe that this could be used to start the process of change that is necessary to work with effectively with relevant KPIs. Furthermore, we see that the process of UCD is vitally important for designing and developing products that can compete in a changing marketplace.

To conclude, this study is an investigation of the connections between usability and organizational factors. This is a field of research which, although it has been subjected to research, e.g. in the field of HCI as can be seen in the material above, still appears to be somewhat under-researched and discussed. It is however an important area, given the complexity of companies and the need to develop successful products. Beyond being a

graphic illustration of the situation in a complex organization, this work demonstrated that there is a clear need for organizational change that can lead to a situation where it is possible to work with usability, and that one way of achieving this could be through working with a process of UCD. This is in accordance with the discussions that are beginning to take place within the HRI community, where the importance of UCD is becoming clear. We do find that the existence of a wicked problem means that there are no obvious paths to follow today to alleviate the situation that exists today, but although a wicked problem can, by its nature, never be fully solved, we believe that working with these factors can be a way of working towards a satisficing solution. Thus, work still remains to be done to actually solve some of the issues that we illustrate here, to find methods of including users in a collaborative process, in a fashion that is suitable for this kind of complex organization, working with a diversity of users in a rapidly changing field. Beyond looking to the fields of HCI and UCD, it should be possible to look at the fields of participatory design and action research, to see in which way users can be included in these processes. Thus a future study may be to return to the organization, and through an action research process implement change by working closely together with and users and members on different levels of the organization.

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Appendix 1: Research plan

Introduction to interviews

Introduce myself and BTH, and the study that we are hoping to perform:

- Explain how we got in touch with ABB, and who we are working with
- BTH and the research group – first BESQ, now GSIL (check for more details about GSIL)
- Research into Usability and UX
- A long history of industrial cooperation
- A background in PD, and what PD entails
- Involved in WeBis, trying to find ways of encouraging innovation

Start by explaining how the study will be performed

- Say that it is a case study and explain how the material will be dealt with
 - Qualitative research: “focused on a contemporary phenomenon in a real-life context”
- Based on interviews, open ended questions
 - The interviews will be based on open-ended questions, and will be audio-recorded if the interviewee permits it.
- Explain that all participants are anonymous, and that it will be impossible to identify the participants through the study material or what is published
- Explain that nothing will be published or presented without the consent of the study participants
- Ask for permission to record the interview
- The interviews will be transcribed and the material will be analysed to discover individual’s requirements
- If possible, the researcher may return to the interviewee with follow-up questions based on the results that have emerged from the study
- Explain that we intend to present the results of the study for the participants and other interested stakeholders.

Start recording if it is permitted

Explain the purpose of the study

- The purpose of the study that we are hoping to perform with ABB.
 - To identify requirements for measurable usability goals at different organizational levels within ABB
 - To complement research performed at UIQ Technology AB
 - The previous research dealt mostly with requirements within the development organization
 - This research is in order to elicit new perspectives from other layers in the organization
 - The results of the research are to be included in academic papers (published at conferences and in journals), which will be the basis of a doctoral thesis to be presented at BTH.
- The limitations of the study
- What we want to ask the interviewee about
 - Their role

- Their expectations
- Their background
- Their views and thoughts about usability now and in the future

Thoughts so far about questions for stakeholders

Their role

- Name
- Organization
- Role (title) in the organization
- Time in the organization
- Tasks in the organization

Their expectations

- Why are they participating in the study?
- What do they hope the study can achieve?

Their BU operations

- Do they know if a vision and strategy has been formulated for the BU?
- What is the “product”?
- Who are the customers?
- Who are the users?
- How much impact can the integrators have on the interface/operations when the product leaves ABB?

What is their view of usability?

- What does usability mean to you?
 - From a personal point of view
 - From the point of view of your work?
- Do they know if they already work with usability in their BU?
 - If so, in what way?
- Do they see usability as being important for their BU?
 - Why do they think this?
- At what stage in a project should we begin to work with usability?

More concrete questions about usability metrics, influenced by the factors found in Balanced Scorecards (BSC) (preceded by a brief introduction to BSC when necessary):

- Ask if the interviewee is familiar with BSC
- Discuss the four factors from BSC:
 - The customer perspective – How do our customers see us?
 - The internal business perspective – What must we excel at?
 - Innovation and learning perspective – Can we continue to grow and create value?
 - The financial perspective – How do we look to shareholders?

- Does the interviewee think that principles taken from Balanced Scorecards can contribute to usability work at ABB?
- From the interviewee's perspective, how could these factors be translated to the area of usability?
- What elements of usability would need to be measured to gain information about the Four factors (this is to be related to the 4 factors if this is seen as being relevant, otherwise it will deal with usability in general)
- How often would they need to see KPI's for usability?
- Do we measure for every product/project, or take a helicopter perspective? (not relevant if we are only looking at one product)
- What should it be measured against? Should there e.g. be a 20% improvement for each project/time period?
- Do you know if there are ways (existing/future) of engaging different actors in eliciting the usability goals?
 - Customers, users, developers at ABB, R&D, Sales, Service, others?
- Can you think of any other people who could make a contribution to and would be interested in participating in the study?