LAPPEENRANTA UNIVERSITY OF TECHNOLOGY
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Master's Thesis: Lauri Salminen

REENGINEERING AND MODELLING OF A PRODUCT CERTIFICATION PROCESS

Examiners: D.Sc (Tech.) Hannele Lampela and Professor Tuomo Uotila

ABSTRACT

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The theoretical framework of the study focused on business process reengineering, business process modelling and business process measuring methods. The aim was to find an efficient method to be used in reengineering the current certification process of the organization under study. This required modelling of the current certification process and development of a feasible measurement system which would provide valuable information for the management on how effectively the reengineered process functions.

The study was carried out as a participatory action research process. The thesis worker was a long time employee of the organization under study and therefore utilized his own knowledge of the current processes and the improvement ideas for reengineering as a full member of the team.

The result of the study is a new certification process which is streamlined and more effective than the previous process. A new measuring system was developed as a management tool which gives reliable information of the process stakeholder efficiency and the quality of the products. These measurements can be used in further enhancement efforts to be taken in the future. As a byproduct the organization gained detailed process models of the current certification process and the reengineered certification process which can be used as training material for new employees and as an instructive tool for certification authorities inquiring detailed information of the steps taken in the certification process.

TIIVISTELMÄ

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Työn nimi: Tuotesertifiointiprosessin uudelleensuunnittelu ja mallintaminen

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Hakusanat: sertifiointi, liiketoimintaprosessi, uudelleen suunnittelu, mittaaminen, mallintaminen, tapahtumaohjattu prosessiketju, osallistuva toimintatutkimus

Työn teoriaosuudessa tutkittiin prosessien uudelleen suunnittelua, prosessien mallintamista sekä prosessimittariston rakentamista. Työn tavoitteena oli uudelleen suunnitella organisaation sertifiointiprosessi. Tämän tavoitteen saavuttamiseksi piti mallintaa nykyinen ja uusi prosessi sekä rakentaa mittaristo, joka antaisi organisaatiolle arvokasta tietoa siitä, kuinka tehokkaasti uusi prosessi toimii.

Työ suoritettiin osallistuvana toimintatutkimuksena. Diplomityön tekijä oli toiminut kohdeorganisaatiossa työntekijänä jo useita vuosia ja pystyi näinollen hyödyntämään omaa tietämystään sekä nykyisen prosessin mallintamisessa, että uuden prosessin suunnittelussa.

Työn tuloksena syntyi uusi sertifiointiprosessi, joka on karsitumpi ja tehokkaampi kuin edeltäjänsä. Uusi mittaristojärjestelmä rakennettiin, jota organisaation johto kykenisi seuraamaan prosessin sidosryhmien tehokkuutta sekä tuotteiden laadun kehitystä. Sivutuotteena organisaatio sai käyttöönsä yksityiskohtaiset prosessikuvaukset, joita voidaan hyödyntää koulutusmateriaalina uutta henkilöstöä rekrytoitaessa sekä informatiivisena työkaluna esiteltäessä prosessia virallisille sertifiointitahoille.

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LIST OF ABBREVIATIONS

EPC	Event-driven Process Chain
HW	Hardware
ICT	Information and Communications Technology
IT	Information Technology
PDSA	Plan, Do, Study, Act
R&D	Research and Development
RF	Radio Frequency
SW	Software
TQM	Total Quality Management

1 INTRODUCTION

The introduction chapter of this thesis is divided into four parts: background, goals and definitions, methodology and structure of the report. Background part provides information on what were the reasons behind the research process and how the researcher became involved in the process. Goals and definitions part presents the questions which the research aims to provide answers to. In methodology the general methods used in completing the research process are explained. The last part – structure of the report – presents the general contents of each of the following chapters and how the thesis is divided into theoretical and empirical parts.

1.1 Background

In today's world quality is considered as a primary factor for the economic competitiveness and efficiency. It consists of attributes and characteristics which are part of the material or immaterial entities which in turn facilitate the satisfaction of product customers or fill the needs surrounding the production process. In other words the target of quality is to satisfy social, material, economical and moral needs of all parties who can be considered as part of the process. These are for example customers, users, workers, owners and suppliers. Quality must be constructed from ground up and upheld with maintenance within certain time frame by following a suitable process of assurance. In order to create quality the strategic goals need to be set and driven by using two different kind of tools. First one is optimization of products and processes and the second one is control and management of all activities using suitable means. This leads to quality assurance which is done in order to fulfill both internal and external needs. In internal assurance the achieved results are assessed and further improvement plans are created. In external assurance the confidence of the marketplace is being achieved. By neglecting the initiatives to maintain and improve the quality of its products an organization may lose large amount of royalties and destroy its credibility among the customers (Thione, Pederneschi, Cirici, Helmprobst, Pecavar, Siegemund, 2000, p. 207-208; Yoo, Park, Kim, Kim, Kim, 2013, p. 3255).

The lack of process models and process descriptions has hindered the efficiency of the certification processes in an organization described in this thesis. Certification process aims to evaluate and verify the products level of quality. Users of the final product have certain expectations of the quality levels concerning the product and the certification process aims to generate these levels of warranty defining (Oh, Park, Lee, Lee, Hong & Wu, 2004, p. 209; Druzhinin, 2001, p.1). The organization has performed third party software and hardware certification activities for a company for many years. Certification requirements have changed over the years and the changes required for certification processes have not been clearly documented and communicated throughout the organization. Increasing number of certification activities have been performed within the realm of tacit knowledge where best practices have been stored only in the minds of the people carrying out the certification. This has led to situation where lots of duplicate efforts are put into the certification process. Many times the process steps go out of synchronization and people have to wait for others or back track their own activities in order to find out which steps have not been properly completed or carried out at all. This kind of confusion increases throughput times and costs and at the same time brings dissatisfaction among the various stakeholders and customers. By modelling the current process a clear understanding of the process flow can be created and the reengineering work for the new more efficient process model can be started. The new certification process aims to be more streamlined and simplified model than the current process and to bring more value to the organization by increasing the satisfaction of stakeholders and minimizing the duplicate effort and throughput times.

The researcher of this thesis was a full time employee of the certification organization where this research was carried out and. As a student of Lappeenranta University of Technology the researcher needed a subject for his thesis work and so he was asked to model the current process of product certification, to find out whether it could be reengineered to be more efficient and to complete his studies by using the research work for his Master’s thesis.

1.2 Goals and definitions

The primary research problem of this thesis is in the form of a question:

"How to reengineer the current product certification process of the organization?"

This thesis aims to present a new reengineered certification process and the road leading to it. The reengineered process tries to rectify some of the problems described in paragraph 1.1. In order to be able to reengineer the processes we must first understand the current processes by carefully studying the inputs and outputs of the current processes and determining all the steps between those. This task is facilitated by creating a detailed process modellings and analyzing the necessary and unnecessary steps and discovering all the possible bottlenecks of the process. After reengineering work is completed a new measuring system is defined which should give up-to-date information for the management of the organization on how the certification process performs.

Certification is a complicated process and strict rules must be followed in order to meet all the demands required by certification authorities. To facilitate this it is important to understand the basics of a process thinking and process management.

For us to be able to answer the primary question selected sub-questions are also researched:

- Why organizations want to model their business processes and which methods are available for use?
- How is the process measurement system designed and how is it used?
- What is process reengineering and how is it used for improving the process efficiency?

Sub-questions and their answers are discussed in theoretical sections of this thesis, which consists of research from literature of business process reengineering, process modelling, process measuring, participatory action research and certification procedures. These answers are then used in empirical part of this thesis where new certification process is reengineered. The completed thesis includes a

modelled and reengineered certification processes with current processes modelled in detail. The new measuring system is also introduced.

1.3 Methodology

This thesis focuses on the current and newly reengineered certification processes of the organization under study. The first task is to understand the big picture current situation and to identify all the dependencies and different stakeholders affecting it. The second task is to search and study previously done researches which might be similar with the current research problem. Third task is to gather research data and analyze the findings and resolve how the organization has reached its current state. The third task is to act out the improvement actions and evaluate whether the new outcomes are more desirable than the old ones (Stringer, 1999, p.18-19; AMK, 2007).

Qualitative research was used as a basis of this thesis. Qualitative research is a constructivist method which values multiple realities that are constantly changing. This requires a researcher to have multiple ways for searching and collecting data. The findings of a qualitative research are generally gathered by using interviews, observations, documents, films or videotapes and even census data previously quantified by other people. Qualitative research seeks to understand the nature of persons experiences and it is highly useful for finding out what motivates people and what are thinking and doing and why they are acting the way they are. Additionally qualitative research may be used in research of substantive areas which are not well known or known at all. Triangulation which was used during the research phase is a strategy where different kind of methods from independent sources are combined in order to strengthening the research by improving the validity and reliability of the research. These methods may include the usage of both qualitative and quantitative methods and data gathering using different means. In qualitative research the usage of triangulation may lead to modification of used theories which can in turn lead to more fruitful result (Golafshani, 2003, p. 603, 604; Mays & Pope, 1995, p. 110; Strauss & Corbin, 1990, pp 10-11; Kankkunen & Vehviläinen, 2009, p. 49).

Participatory action research which was used during this thesis is a qualitative research method. “Formal research operates at a distance from everyday lives of practitioners, and largely fails to penetrate the experienced reality of their day-to-day work” (Stringer, 1999, p. xiii). Participatory action research presents an alternative view to research by taking collaborative approach where all practitioners are seen as equals and they all take part in the research process as full participants (Breu, Hemingway & Peppard, 2004, p. 662). Participatory action research method is presented in greater detail in theoretical part of this thesis in chapter 5.

The data for this thesis has been gathered from databases and using interviews, conversations and perception as a collection method. For this thesis a group of four people from different job levels were selected to participate in the reengineering process and to develop new ideas and to document their current ways of doing the certification tasks. This group was interviewed in non-official manner and conversations were conducted in face-to-face situations and using information technology as a tool for communication. Comments gathered from these people are quoted in empirical part of the study as the process model in some instances was fully created using these comments.

The thesis includes both old and new process models and the two sub-processes embedded into them. The process parts to be measured were chosen by the upper management from the list created by the reengineering team. This thesis does not include the implementation of the new process or the benchmarking of new activities against the old process due to the time constraints of this thesis work.

1.4 Structure of the report

This thesis is divided into two sections. The first section is the theoretical section which is based on previously conducted research of the subject matter. The second section is the empirical section which is grounded on the theory introduced in the first section of this thesis. Chapter 1 gives the general presentation of the nature of the thesis. Chapter 2 presents the ways to improve and innovate the current processes of an organization. Chapter 3 explains why and how the business process modelling should be conducted. Chapter 4 provides information on how to design

and implement an effective process measurement system for an organization to use. Chapter 5 presents the Participatory action research methodology in detailed manner. Chapter 6 sheds light on why and how certification work is carried out in order to improve business. Chapter 7 presents how the modelling and reengineering of certification processes were performed and how the measuring system for the new process was designed. Chapter 8 introduces the findings and the results of the research and Chapter 9 has the conclusions, evaluation and the future recommendations of the research.

2 PROCESS IMPROVEMENT AND REENGINEERING

2.1 General description of a process

Process can be defined as mapped out sequence of acts or functions that furthers a material or line of action from one phase of completion to another one (Ungan, 2006, p. 401). In literature a process is described as a measured set of inter-connected actions or clearly build working procedures which are planned and executed to generate pre-determined output and which generate additional value for a specific market or customer. Process determines how specific tasks are done inside an organization and it defines specific working order of activities and actions across place and time. Processes are seen to bring discipline into organizations working procedures and force the actions taken to be precise. A processes can be seen as a chain of events or activities which have a beginning and an end and have also distinctly defined inputs, outputs, values and customers. Processes are integral assets for getting the job done (Davenport, 1993, p. 11; Martinsuo & Blomqvist, 2010, p. 1; Davenport & Beers, 1995, p. 57; Nickols, 1998, p. 14; Nesbitt, 1993, p. 34; Garwin, 1995, p. 79-88).

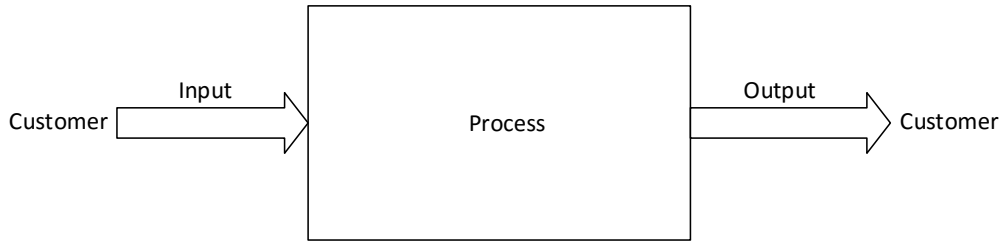


Figure 1: Simplified process picture (Martinsuo et al., 2010, p. 4)

Processes have structural elements which have an important role in process innovation. For process innovation to be effective, the participants and designers need to agree how the work and process need to be structured. A process structure of an organization can be seen as a dynamic view which gives insight on how an organization creates and provides value. In order to achieve its goals an organization should allocate enough resources for the processes and carefully manage and guide them (Davenport, 1993, p. 11; Martinsuo et al., 2010, p. 1)

Operational performance of an organization needs to be managed so that its operations in every day scenarios are handled with efficiency. In order to do this organizations need to concentrate on cross-functional processes which are made of fragmented pieces and are not tight to internal boundaries of an organization. Organizations need to improve work processes which help to increase customer performance. It may be a difficult task to single out organization's key business processes and concentrate on them. Workers of an organization do not usually understand how their work effects the business processes in a larger context. (Davenport et al., 1995, p. 57; Nickols 1998, p. 16).

It may be a difficult task for a person analyzing the process to understand that instead of being stand-alone actions of inter-connected operations processes are structured groups of activities which will lead to desired outcomes creating value to the customer. Processes are chosen selection of bigger "rivers" of operations. It is important to view processes in this bigger context when process borders are created. The creation of these borders makes it possible to handle processes as a group of inter-connected operations (Nickols 1998, p.16; Davenport et al., 1995, p. 57).

Various types of strategic planning is done in almost all of the organizations operating today. The reason behind this is to enable organizations to identify its initiatives or various objectives. Managers of an organization need to able to determine whether the actions done in various business processes support the effort of reaching the planned business objectives and which parts of the processes could be done more efficiently. For this to happen the managers need to implement more efficient ways to embed the process thinking into their daily managing activities (Hacker & Brotherton, 1998, p. 18; Davenport et al. 1995, p. 58).

2.2 Understanding the need for change

According to Grigori (2001, p. 159) it is important to execute business processes with prearranged and high quality for employees and customers to be satisfied. Davenport (1993, p. 12) continue by stating that a process approach to business is usually tagged with strong emphasis on creating better working procedures. For an

organization to be successful it must provide products with high standards or services and use potent processes for generating and delivering them. They continue by stating that companies in the United States of America are much more interested in developing new products than new processes and are spending twice as much money on product R&D compared to process improvements. On the other hand Rohleder & Silver (1997, p. 139) states that various companies are taking actions to improve and reengineer their business processes. Research data indicates that process designing and management technologies are being applied with ever growing volume in both traditional and more recently established organizations for quality improvement and to increase the efficiency of production processes (Grigori, 2001, p. 159).

Processes have attributes such as cost, output quality, customer satisfaction and time. For a process management to be successful these are vital to be known. This information helps to understand the improvement areas and what kind of steps needs to be taken in order to improve the processes. By manipulating these attributes, for example reducing the costs or by increasing customer satisfaction, organizations are able to improve the process itself. This can be done by systematical thinking, focusing on actions which increase value, customer focus, making use of feedback information form business activities and goal orientation. These are central traits of process thinking. By outlining its functions and by improving its processes and organization may implement is strategies and reach higher customer satisfaction and efficiency. The pruning of non-value adding work and efficiency increasing methods are connected to process thinking. Documentation, tools and information systems may all be part of process thinking while they are important means in work automation and in spreading the common procedures. Identification of resources, acknowledging all the major responsibilities and focusing the labor input on critical resources are part of the process modelling and improvement (Davenport et al., 1995, p. 57-58; Martinsuo et al., 2010, p. 1; Davenport, 1993, p. 12).

As customers usually receive the outputs from a process it can be important for an organization to get feedback from them in order to improve the current processes

(Davenport et al., 1995, p. 58). In order to insure that a customer needs are met the processes need to have unambiguously defined proprietors who are responsible for planning them and carrying them out. Defining the owner of a process is a difficult task as processes are usually fragmented and rarely take notice of existing borders of organizational levels. During radical process changes these existing borders must not limit the process owners from taking appropriate actions in their quest for improving the processes (Davenport, 1993, p. 13; Nickols, 198, p.16).

2.3 Categories of process development

Process improvements and changes happening in organizations can be divided into two loosely defined and possibly overlapping categories. Total Quality Management (TQM) also known as continuous improvement compasses step-by-step enhancement of work processes and generated outputs of processes over a time period which is not clearly defined. Process innovation or business process redesign which in literature is also known as reengineering and which is characterized as being radical, IT-led and inspirational approach is usually used in a context where work processes are revolutionarily altered in order to gain better results and is completed under agreed time frame (Buzacott, 1996, p. 768; Melão & Pidd, 2000, p. 109).

Davenport (1993, p. 11) has described the differences between process improvement and process innovation. They are listed in Table 1:

Table 1: Process improvement vs Process Innovation (Davenport, 1993, p. 11)

	Improvement	**Innovation**
Level of change	Incremental	Radical
Starting point	Existing process	Clean slate
Frequency of change	One-time/continuous	One-time
Time Required	Short	Long
Participation	Bottom-up	Top-down
Typical Scope	Narrow, within functions	Broad, cross-functional
Risk	Moderate	High
Primary Enabler	Statistical control	Information technology
Type of Change	Cultural	Cultural/structural

Cultural change is required for both process innovation and process improvement. Cultural shift is felt inside an organization as measurements of results, empowerment of employees and operational performance as a whole are embedded in the new way of doing things. This can lead to cultural resistance where re-engineering efforts are being rendered ineffective. Process improvement can be implemented without resorting to organizational changes but process innovation requires massive change to organizational structures affecting process flows, organizational power and control, management practices and skill requirements. This can be seen as one of the main reasons why process innovation requires long periods of time to be fully completed (Davenport, 1993, p. 13, Melão et al., 2000, p. 114).

Organizations need to be able to do both radical innovation and continuous improvement. Both ways require a solid understanding of processes and how they are stabilized and monitored for best results. This is important because after an organization has completed its process innovation activities it needs to switch its way of doing things towards continuous improvement to make sure that it does not fall back into its old ways of doing business (Davenport, 1993, p.25; Rohleder et al., 1997, p. 150).

2.4 Process reengineering

Process reengineering and process innovation have become a hot topic among organizations driving for better results and performance. As competition becomes

more intense and the pressure surrounding large organizations rises, incremental process improvement is not sufficient anymore. Higher improvement levels can only be gained by radical process change where all work is fundamentally redesigned. This kind of approach is called process innovation and it combines business viewed through processes and key processes which are elevated to better performance by innovation. The idea behind process innovation is to create an ideal process which is not bound by the current process (Davenport, 1993, p. 1; Rohleder et al., 1997, p. 150).

Hammer & Champy (2000, p. 2) explain the definition of reengineering the following way: "Reengineering is defined as the fundamental rethink and radical redesign of business processes to generate dramatic improvements in critical performance measures - such as cost, quality, service and speed." Hammer & Champy (1993, p. 49) continue by stating that "*Reengineering is the search for new models of organizing work.*" At its core business reengineering is a way of discontinuous thinking. This means that organizations undertaking reengineering process must recognize and discard all the obsolete rules and basic assumptions on which the existing processes are built upon (Hammer et al., 1993, p.3).

If an organization is to reengineer its processes it needs to radically rethink its views on how the business is done and it demands lots of time and effort from the management to implement and drive through these changes. As the changes required maybe huge in scale the managers may be too afraid to carry out the needed changes (Buzacott, 1996, p. 768; Rohleder et al., 1997, p. 150). Davenport (1993, p. 8-11) states that as process innovation initiatives are started an organization should not go back to the old process and start fixing it but to build a new process from ground up with no strings attached. Interfaces between product units or functional units need to be improved or deleted when process innovation is carried out. Also sequential flows across functions should be made parallel using fast and extensive motion of information. Objectives of business can be predetermined but the road leading to them should not be set. Planners of the new process need to ask the question: "*Regardless of how we have accomplished this objective in the past, what is the best possible way to do it now?*"

For process innovation to be successful both technical and human enablers are required. Process innovation is usually driven through using change tools specific to it. Information technology is seen as one of the most powerful tools to be used to facilitate process innovation efforts. It enables the use of computers and enhances communication between all involved parties, simulation of processes and benchmarking which are recognized as important means helping the process innovation (Davenport, 1993, p. 13 & 17; Rohleder et al., 1997, p. 150).

Reengineering must be carried out in large steps with all-or-nothing attitude and without biases and trappings of old processes for it to yield influential and effective results (Hammer et al., 1993, p.3; Rohleder et al., 1997, p. 150).

2.4.1 Framework for process innovation and reengineering

A reengineering team needs to understand what the current process does, how it performs and which are the most important issues determining its efficiency. The team needs to build a high-level view of a current process to be able to generate totally new and better way of doing things (Hammer et al., 1993, p.129). Davenport (1993, p.25) presents a framework for process innovation which constitutes of five steps as seen in Figure 2:

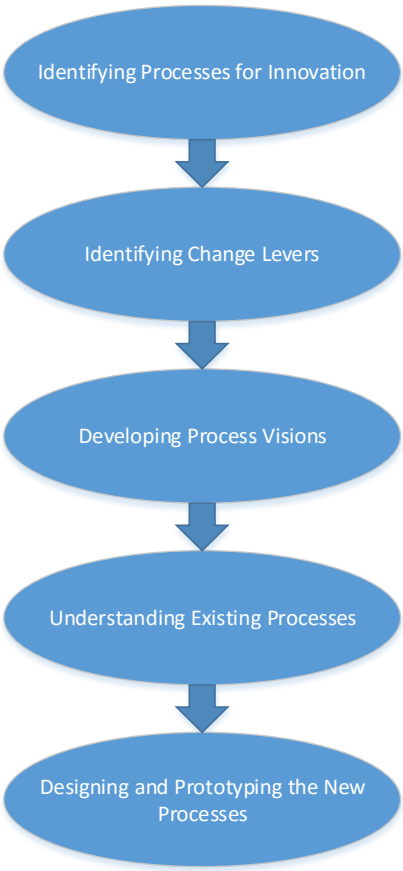


Figure 2: A high-level approach to process innovation (Davenport, 1993, p. 25)

2.4.2 Identifying the process in need of reengineering and levers of change

Davenport (1993, p. 31) states that a process to be reengineered needs to have predetermined boundaries. These boundaries can be difficult to set up and the reengineering team ask and answer some questions in order to complete the task. The team should identify the starting and ending points of the process after which the process owner is not involved with the process anymore. The team needs also to identify the correct point in time after which customers should get involved in the process and on the other hand when does the time window close. Sub-process starting and ending points need to be figured out as well as the position of the process itself: is the process to be reengineered completely embedded within another process? Processes and sub-processes maybe combined but the team needs to figure out if this would increase the process performance or not.

Davenport (1993, p. 31) continues by stating that as an organization starts to reengineer its processes it should keep in mind that processes ought to be simple and not overly complicated. By doing this an organization is able to meet the ever increasing demands of quality, flexibility, low cost and service. Measuring the performance of a clearly structured process is much easier than one with unstructured process. Clearly structured processes have a selection of dimensions which can be measured. These processes can measured in respect of costs and time in association with their performance. The inputs and outputs of the processes can be evaluated by using questions: How useful they are? Are they consistent? How much variability there is? How free are they from defects? (Davenport, 1993, p. 12-13).

Hammer et al. (1993, p. 49) have listed commonalities, characteristics and themes which are found to be important parts of reengineering of business processes. According to them multiple tasks should be united into one and the employees of an organization should be allowed to make decisions. The processes followed by the organizations have various stages which should be carried out in natural sequence. There should be several versions of the single process and the tasks should be carried out at the location most feasible. Minimizing the amount of controls and checks inside the process is important as well as reduction of the amount of reconciliation. Organizations should allocate a single point of contact who in in contact with customer. Also hybrid centralized and decentralized functions should be predominant.

Reengineering work broadens the current scope of jobs from narrow to more wide-angled and multidimensional where people are given more freedom to make decisions and choices concerning their work. Employees are able to focus on meeting the needs of a customer while management offers coaching and mentoring for them. This requires a learning process from the employees as they must train themselves to understand the new work procedures (Hammer et al., 1993, p.65; Rohleder et al., 1997, p. 151).

2.4.3 Developing a process vision

Development of a process vision is a demanding task as no one in the organization has the absolute knowledge of where things are headed, which aspects of the organization will change and how everything will be implemented. Still the organizations need to have a clear process vision as radical change cannot be completed without lucid direction. This is facilitated by understanding how strategy and processes are linked together and how they strengthen each other by containing same kind of topics. Process visions should inspire measuring and be as harmless as possible for the people implementing them. They should also be effortless to distribute across the organization. Customer's perspective should be seen as a key aspect when implementing the process vision. Customers input sets out the objectives of process performance and shows that an organization seeks to have close relationship with the customer. At the same time it shows that an organization is committed to serve the customer using the best possible practices (Davenport, 1993, p. 117-124; Hammer et al., 1993, p.154).

2.4.4 Understanding the current processes

Davenport (1993, p. 133) declares that current process needs to be understood. The reengineering team needs to understand what the process does, how it performs and what are the critical issues affecting the performance. This means that the process needs to be measured before a new process can be designed. Measuring the current process is critical in order to understand how the reengineering work could increase the performance. Attributes of the current and new processes are important to be identified as they may be largely different from one another (Hammer et al., 1993, p.129; Davenport, 1993, p. 133). Davenport (1993, p. 139) continues by stating that there are six key activities which should be carried out in order to understand and improve existing processes. Current process should be depict and measured in terms of process objectives from the new process. It should be assessed in terms of process attributes from the new process. It is important to recognize problems, bottlenecks and short-term betterments of the current process. Finally the present status of organization and information technology should be evaluated.

2.4.5 Designing and prototyping the new process

The final step in Davenports frame work of process innovation is designing and prototyping the new process. The designing activity of a process reengineering is usually done by a team of bright individuals who have a task to check all the available information which has been collected in prior stages of a process and combine the parts into a new process. The participants of this team should include both people capable of creative and innovative actions and members capable of implementing them who are willing to discard their preconceived notions they might have concerning the process. The team should brainstorm alternatives for the new design and asses possible risks and benefits of the new design. (Davenport, 1993, p. 153, 154; Hammer et al., 1993, p.147).

After the team has created and assessed a new design it must be prototyped so that an organization may simulate and test the new process. As the effects of reengineering cannot be estimated accurately, prototyping provides a useful tool to see the results of reengineering activities. Prototyping is an iterative process where information technology, new process and an organization are fitted together by refinement of interfaces between all three. Prototyping is a learning process for users and designers who should not see the need for re-iteration as a failure (Davenport, 1993, p. 154; Rohleder et al., 1997, p. 150).

Davenport (1993, p. 158) states that a successful prototyping opens up the possibility of migrating to a new process. This can be a huge challenge and risk for an organization if done in large scale effort. He also presents alternative ways of migration and suggest piloting which is in smaller scale but completely operational activity. The other possibility is to create a new parallel organization which uses the new process and serves specific customers with specific products (Davenport, 1993, p. 158; Rohleder et al., 1997, p. 150).

According to Davenport (1993, p. 163) it can take several years for an organization to fully implement its process innovation activities. Davenport’s (1993, p.12) studies reveal that organizations haven’t been able to fully complete their reengineering efforts in less than two years. It should be seen as an iterative effort

and not as a sequential process. It takes time for benefits of reengineering efforts to appear and active management work is needed even after process innovation initiatives are completed. The newly designed process should be constantly assessed, measured and improved and if needed – reengineered (Davenport, 1993, p. 163).

3 PROCESS MODELLING

As the worldwide competition grows stronger the revenues of the organizations get smaller and smaller. For an organization to overcome the obstacles of heated competition it must make sure that its business processes are honed to be as effective as possible. Understanding and comprehending the processes is an important factor when efficient process management is the target of an organization. Organizations have many reasons to document their processes. In order to focus its strengths and resources for increasing the business value and to eliminate the factors weakening the business results an organization needs to model its processes. Actions and chains of actions need to be understood and clearly described in order to successfully complete the critical evaluation of business customs. The documentation is used in reengineering, standardizing and describing the processes. Processes need to be documented in order for them to be understood correctly. Process documentation aids the discovery of value adding and non-value adding procedures and also making it easier to simplify them. It may provide a lucid view for process analyzers to discover possible problem areas in a process and present reformation possibilities. It may also reveal unclear or overly complicated processes; faulty outputs of a process or effort which are unnecessarily duplicated in many places (Ungan, 2006, p. 400-402; Martinsuo et al., 2010, p. 1; Biazzo, 2000, p. 111).

For process modelling to be successful it is recommended to be understood how the modelled process fits in the bigger picture among other surrounding processes. After this is done the recognition of all stakeholders as well as inputs, outputs and interfaces is required. Furthermore the resources and support needed for a process to be efficient should be known. Communication between the personnel attending to the process modelling should be facilitated and supported as well as communication between activities needed on organizational levels (Martinsuo et al., 2010, p. 8-9; Luukkonen, Mykkänen & Itälä, 2012, p. 20).

3.1 Process documentation

Nowadays the process analyzing and improving is often done by using instruments such as process documents. Documents can be divided into two groups: process

maps and process diagrams/flowcharts. In the literature studies it has been found that these documents are often either too general or too technical to sufficiently epitomize the process under investigation. Recognizing the wholeness of the processes - process map or process architecture may be included in the process modelling (Ungan, 2006, p. 400-402; Martinsuo et al., 2010, p. 1; Biazzo, 2000, p. 111).

An organization needs to have a clear visibility on its business logic and at the same time evaluate and follow its functions systematically. Process mapping is widely used in visually highlighting the connections between functions, personnel, data and items involved. The documents need to clearly indicate the persons responsible for each of the individual activities of the process. This enables the organization to have enough accurate information about how effectively it carries its business and what are the inputs which affect the business outcomes. This is done by gaining better comprehension of how the processes work. By modelling the processes an organization may visualize its current processes or the ones it aims to have by improving and enhancing its current ones. The method is cheap to perform and it enables organization to acknowledge possible faults and development needs in its current processes (Martinsuo et al., 2010, p. 3; Biazzo, 2000, p. 102; Ungan, 2006, p. 401).

3.2 Detail levels of process modelling

The tasks and contents of a process to be modelled somewhat define how the modelling itself should be done. Using minute details in modelling a process with lots of uncertainties is not recommended and a broader scope in cases like these are much more preferable (Martinsuo et al., 2010, p. 3-4). Nesbitt (1993, p. 37) suggests that the parts of the process which work well do not need to mapped out in great detail. On the other hand the problematic parts of the process need to be analyzed with greater care by going into micro level. Identification of process problems root causes needs adequate amount of specifics which only micro level details can provide. Before the process modelling is started one should always check the contents of the process itself and the level of modelling needed to describe it (Martinsuo et al., 2010, p. 3-4; Luukkonen et al., 2012, p. 28).

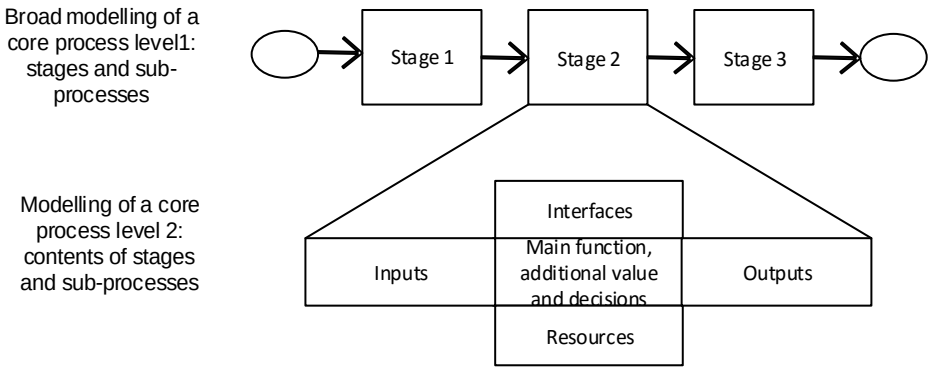


Figure 3: Broad modelling of core process stages (Martinsuo et al., 2010, p.10)

3.3 Flowchart and swimming track methods

Martinsuo et al. (2010, p. 11-12) present different ways to model a process which are:

- flow chart
- task matrix
- "swimming track" chart
- text based instructions

Flowcharting is a popular method to graphically describing a business process. It is easy to use and a potent method for understanding, analyzing and improving work processes and the quality of them. Flowcharting may increase the efficiency of processes by building-up the understanding of how products and services are created. It may also help the auditor's to see if the process flow is logically correct or not. Flowchart documentation describes what is done on a general level and give directions where one should head to seek out more information in the form of written text on how things are done in greater detail. Flowcharting the process may reveal huge differences on how an organization thinks the process is done and on how the process is done in the real-world. It should be started on a theoretical level and only afterwards comparing the results with actual process. Organization can use the flowcharts to review their processes from start to end and find out if some parts of the process are not performing as expected. People throughout an organization are able to understand flowcharts on general level without the need of

a specific education (Nesbitt, 1993, p. 34; Martinsuo et al., 2010, p. 11-12; Babicz, 2000, p. 34-35).

3.3.1 Micro and macro levels of flowcharting

As stated in chapter 4.2 the documentation of flowcharts and process maps can be done in different plains of detail mainly at micro and macro levels. The latter which is also known as “single level process flowchart” includes the modelling of central stages of the process which provide additional value. It should contain four to ten phases and supply no more than two actions for each operation. The interfaces of a process, support, resources and the identification of central decisions are also included in the macro scope of process modelling. According to literature the macro level presents insufficient view of a process to be useful instrument for thorough process analysis and that some parts of critical processes may need more detailed observation where resources are allocated to different tasks. This presents the need of using different flow charts and working instructions when modelling the process in micro levels. Micro view maps out one of the phases from macro plane. Tasks, responsibilities, roles, knowledge, tools and inter-connection of tasks need to be identified and modelled out. The usage of detailed modelling is recommended when a process is followed every time exactly the same way. As process analysis is done in greater depths, the micro view may not be sufficient and it can be transformed into a macro view which then can be dissected in more detailed micro views. If process has variations between different runs it is advisable to use broader process modelling. (Ungan, 2006, p. 402; Martinsuo et al., 2010, p. 10-11; Nesbitt, 1993, p. 36)

Flowchart of a process should be two pages or less in length and preserve a simplistic layout. Trying to add too much information with details too specific increases the possibilities of errors decreases the usefulness of them (Babicz, 2000, p. 36).

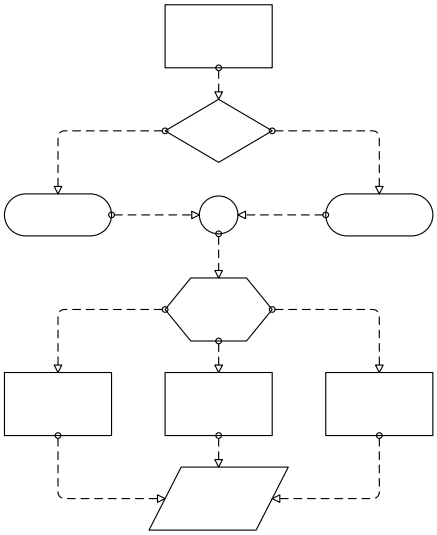


Figure 4: Simple process flowchart (Nesbitt, 1993, p. 37)

3.3.2 Event-driven process chain

Event-driven Process Chain (EPC) is a type of flowchart which is used in business process modeling. It is an intuitive graphical and dynamic modeling language used for modeling business processes and to represent logical and temporal dependencies between activities in processes. It organizes the business resources in sequences of tasks and activities and adds value to the business. EPC is not used in describing processes on a formal specification level but on the level of business logic. EPC consists of two kinds of elements, namely *event type* and *function type*. Event(s) trigger functions and functions create new events. This cycle creates a series of functions and events producing the event-driven process chain. EPC must have one or more start events and a single end event. Function type elements describe the activities carried out during the process. Functions are tasks or activities ideally adding value to the process which are executed in different phases of a business process. Functions are performed by people or IT systems and they have inputs and outputs. Event type elements represents the pre-conditions and post-conditions preceding and following functions. Events can be external changes responsible for starting the process, internal changes happening as process moves forward or final outcome of a process which causes an external effect (Mendling, 2008, p.18; Davis & Brabänder, 2007, p. 105-108; van der Aalst, 1999, p. 4).

The complex routing rules of EPC are defined by three kinds of connector types which are AND, OR and XOR. These connectors are constructed so that they either have several incoming and one outgoing arc (join connectors) or one incoming and several outgoing arcs (split connectors). A syntax rule must be followed as EPCs are created. This rule implicates that events and functions must alternate either indirectly or directly if they are connected through one or several connectors. Another syntax rule dictates that as events are unable to make decisions it is not allowed to use OR- and XOR-splits after them (Mendling, 2008, p.18; Davis et al., 2007, p. 105-108; van der Aalst, 1999, p. 4).

Mendling (2008, p. 18) and Davis et al. (2007, p. 113) describe the informal semantics in EPC in table 2.

Table 2: Rules in EPC (Mendling ,2008, p. 18; Davis et al., 2007, p. 113)

Operator	Following a function (single input, multiple outputs)	Preceding a function (multiple inputs, single output)
AND 	AND – parallel path, process flow divides into at least two parallel paths	AND – trigger, all events must occur and complete in order for following function to be activated
OR 	OR – decision, at least one possible path shall be followed based on the decision	OR – trigger, any one event or combination of events after synchronization shall activate the function
XOR 	Exclusive OR – decision, only one of the possible routes shall be followed	Exclusive OR – trigger, only one of the possible events shall be the trigger

Davis et al. (2007, p. 124) summarize the basic rules of EPC which should be followed as process flow is modelled:

- All process models must contain one or multiple start and end events
- Events and functions must alternate at all times
- Events and functions have only one incoming and outgoing connection
- Rules dictate how process paths split and combine
- Rules dictate the triggering of a function which is preceded by multiple events
- Event cannot be followed by rule
- Only functions take decisions
- Decision taking functions are followed by rules
- The combination of paths following a decisions are dictated by rules
- Real outcomes of decisions are indicated by rules followed by events
- It is forbidden for a rule to have multiple inputs and outputs

According to van der Aalst (1999, p. 15-16) it is extremely important to verify the correctness of EPCs describing the business processes. Erroneous EPCs may create serious problems such as high throughput times, angry customers, low service levels and need for additional capacity. EPCs should be designed so that they always terminate properly. Also any given function described in EPC should be executable by following the proper way through the EPC. After the process is modelled with EPC it should be simulated and verified in order to make sure that the process modelling is done correctly (Martinsuo et al., 2010, p. 7)

3.3.3 Methods for flow chart data gathering

Flowchart data can be collected using two techniques; team method or interviewing. The interviewing method comprises of interviews where individuals or group of people tell the interviewer by their own words how the process works. Actors taking part in the process reconstruction are directly involved in some part of the process and their inputs and answers are used in process mapping. An interviewer writes everything down in minute details and uses the gathered information to build flowcharts. After the process flow is transcribed in a flowchart the interviewer

initiates a second round of interviews to check whether the created flow chart is correctly composed (Nesbitt, 1993, p. 34; Biazzo, 2000, p. 104).

In order to select the correct way to gather information used in flowcharting the complexity of the process and the object of process documentation should be identified. Interviewing technique is not suitable method for processes which are complex, have large scope or have lots of participants. This is due to a fact that group consensus is almost impossible to achieve when complex processes are being analyzed and the inclusion of every ones opinion is a difficult task to perform. Interviewing also takes lots of time and it hinders the regular work of the participants. The group method is a recommended way of flowcharting when more than four people are involved in the process or the process itself spreads across multiple functions. It may require several meetings before the work is completed. The facilitator of the group method must decide in which level the parts of the process are analyzed. (Nesbitt, 1993, p. 34-37; Ungan, 2006, p. 405). According to Nesbitt (1993, p. 37) and Ungan (2006, p. 407) the group method is implemented by identifying and defining the process scope. Next step is to select process owner and team which carries out the flowcharting. The team should then document their knowledge and if needed acquire additional information. After this the team develops a macro view of the process and adds a micro view to parts of the process which need more clarifying. Analyzing the cycle time and costs of the process are additional tasks which can be done if the team has access to this kind of information. The final task for the team is to create a computerized flow chart describing the process.

3.4 Steps to carry out the modelling process

The identification of the starting and ending points or input and output of a process is a good place to start the task of a process mapping. By doing this the inclusion of sub-processes which do not affect the output of the main process can be avoided and this also helps to create joint understanding among all of the participants. It also averts the flowcharting from expanding outside the originally planned boundaries. The next task is to identify all the interfaces, tasks and resources surrounding the process to be modelled. After these are identified one can start back tracking the

process from output to the input direction and map out state-changing activities which are responsible for generating the outputs. The current state of the process (AS-IS) can be modelled from beginning to the end but the target state (TO-BE) should be modelled in reversed order. To do this one should know what needs to be done in order to fulfill customer's needs and what stages are required to be completed in between the starting and ending stage of the process. One should also understand the roles, systems and tools needed to complete the process (Nickols 1998, p. 16; Martinsuo et al., 2010, p. 9-13; Nesbitt, 1993, p. 34-35).

According to Ungan (2006, p. 407) & Nesbitt (1993, p. 35) the second step consists of choosing a "process owner" who aids in selection of process team and supplies managerial support and commitment. The team chosen in this step has participants from different parts of the process and is three to eight persons strong. The participants of this team should ideally be participants in the process or persons closely related to the process and not its managers. They need to have an open mind and innovation skills and are willing to take risks. The members of the team should be respected by the organization and be highly motivated to complete the process achieving best possible results.

When the team first meets, they need to understand the different symbols used in flow charting. For beginners the symbols used should be the most basic and common ones. The positions and departments participating to flow charting should be identified to all participants. After this the flow charting may begin by starting from Macro level and advancing to micro level where needed. Facilitator should control the level of detail used in flow charting and sufficient detail level should be used in problematic areas. The team or interviewer must continue the flowcharting work until a consensus between the members of the team is reached and the final form of mapping is agreed by everyone. After flow charting is done the team should start the process improvement or process innovation process and search for bottlenecks, duplicate efforts and long cycle times and figure out how these instances could be made more efficient. Available tools for this kind of work are fishbone diagrams, cause and effect diagrams, nominal group technique and brainstorming (Nesbitt, 1993, p. 35-38; Ungan, 2006, p. 408).

Adding cost data and cycle time information to the flowchart may help participants to identify improvement opportunities in the process. However these are not mandatory parts of flowcharting. If officially obtained data is not available the time estimations can be created by gathering the minimum, maximum and mode cycle time estimations of macro level blocks from the participants. If account department is unable to provide official cost-data information an estimation of costs can be calculated using time/labor information (Nesbitt, 1993, p. 37).

The final step of the process modelling is creating a computerized models which can be for example flowcharts or data flow diagrams. They are accessible and they can be easily included in meeting minutes or manuals. Various flowcharting programs exists on the market. These programs carry a broad database of flowcharting symbols and automated features. Flowcharts can be drawn on a single page or they can spread out to multiple pages (Nesbitt, 1993, p. 37; Vergidis, Tiwari, Majeed, 2008, p. 69).

4 MEASURING A PROCESS

Previous studies about customs of quality procedures in the firms in United States done by various researchers imply that the techniques which are used to measure the outcomes of all-inclusive quality programs are not properly implemented to this day. As an outcome of this many organizations have a hard time knowing whether there is an improvement in their operational performance or not, which are the key areas where the operational performance needs to be improved and how do the various stakeholders view the organization (Davenport et al., 1995, p. 58-59; Neely, Richards, Mills, Platts & Bourne, 1997, p. 1132).

The relationships of factors influencing the business outcomes can be visualized and studied with greater affect by analyzing the performance of a process or an organization. Measurement of processes gives information which can be utilized in setting business targets, rewarding workers and in analyzing the business results. Progression and improvement of the processes can be checked by using various indicators and meters. For members of an organization to have a clear view of their current business position and the direction where things are going, need to have reliable measurement systems provided by effective strategic management system. An effective measurement system may facilitate the change in organizational culture on how things are done and by doing so shift the focus on performance oriented way of doing things. It should deliver rapid feedback, deliver useful data, be exact and state clearly what is being measured and also be neutral and objective (Martinsuo et. al, 2010, p. 1; Rantanen, 2001, p. 7; Hacker et. al 1998, p. 18 & 22; Lönnqvist, Kujansivu & Antikainen, 2006, p.11-12; Neely et al. 1997, p. 1132).

4.1 Process performance measurement

For an organization to be able to improve the performance of its processes needs to be able to measure them. Performance measurement is a process which aims to define and clarify how effectively certain business operation functions using gathered performance number and indicators from pre-determined parts of business operation. Performance measurement can also be used as a way of communication to clarify which business related areas are important and are in need of special

attention from the workers and staff (Martinsuo et al., 2010, p. 1; Rantanen, 2001, p. 7; Hacker et al. 1998, p. 18; Lönnqvist et al., 2006, p.11-12).

Products, services and employees have a performance which can be measured. They are also considered as process outputs. Quality information is partly build from these measures. Time and costs spent on process actions are important indicators of process performance and they should be always measured. Alongside them the customer satisfaction should be independently measured. Organizations create value for the customers by taking actions necessary to meet the goals and expectations of customers. These actions are defined by processes which the organization has implemented and are now following. As an organization implements its process management program customers should have their voices heard in all the relevant process phases (Davenport, 1993, p. 13; Neely et al., 1997, p. 1132).

Davenport et al. (1995, p. 61-62) state that in the realm of process innovation and process improvement activities it can be difficult task to define process information. Due to this in some cases it is more difficult to create than identify process performance measures. Measures may be tightly connected to institutionalized systems, organizational structures, politics and definition of terms. In the past it has been used mainly in organizations providing service and production outputs but the trend of using it also in information centered expert organizations is rising. Measuring the performance of these kind of organizations and their processes has proven to be more difficult as knowledge and know-how plays a large part of success in these kinds of environments. People in expert organizations are also more independent and self-sufficient than in traditional service organizations. This requires new kind of approach and tools in measuring the performance of the people and the processes (Lönnqvist et al., 2006, p.11-12).

If internal processes are measured to have high quality and performance indicators while customer satisfaction is low it can be an indication of incorrect set of internal factors under measurement (Davenport, et al., 1995, p. 13,62). The success of performance measuring depends on several factors including organizational culture, staff, processes under study and the whole infrastructure of an organization. These

factors need to be carefully considered as performance measurement is planned by an organization (Lönnqvist et al., 2006, p.13).

According to Lönnqvist et al. (2006, p.12) the measuring of a performance in organization is divided in four stages presented in Figure 5. These are:

- planning of indicators: in this stage it is decided what is measured and what kind of indicators are needed in order to get the information needed
- indicators are taken into use: the staff is trained to use the indicators and information systems are updated accordingly
- usage of indicators: processes are enhanced using the data acquired from measurements
- updating the indicators: as business goals and targets may change, it is important to update the indicators when needed

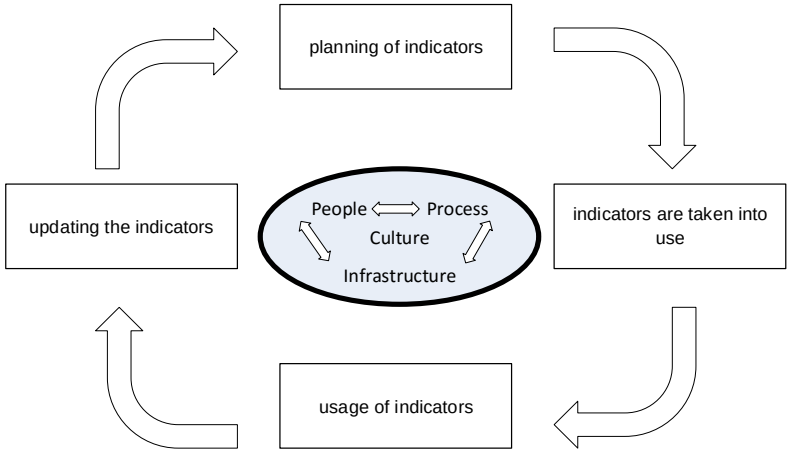


Figure 5: Main stages in performance measuring (Lönnqvist et al., 2006, p. 12)

4.2 Process information

The main output from measuring and analyzing process performance is the creation of much needed information for the managers of an organization who are by using the provided information able to make decisions based on facts. Information needs to accurate and reliable to be useful and can be used in steering the organizational actions towards better and improved way of doing things (Martinsuo et al., 2010, p.1; Rantanen, 2001, p. 7; Hacker et al. 1998, p. 18; Lönnqvist et al., 2006, p.11-12).

The first task of an organization when starting to manage process information is to identify right kind of and useful information. Very often managers and process workers are flooded by too much information that cannot be properly processed during the limited decision making time. Discarding the non-useful data from the gigantic pile of can be a real challenge for them. It is common for business companies to measure sometimes thousands of business components in their daily operations. This kind of behavior generates too much data for the management to be efficiently gone through and used in making business decisions. In the end it may even hinder the making of important business decisions (Davenport et al., 1995, p. 65; Hacker et al., 1998, p. 20). Neely et al. (1997, p. 1131) have the opposite view and they state that one of the central problems in adaptation of performance measurement systems is that they are created to obtain data from far too slender focus area (Neely et al., 1997, p. 1131).

Ideas which are also characteristics of a process but have less structure than measures are valuable collectibles. Ideas constitute for example of possibilities of improvement, customs that are considered to be most useful, innovations of human resource and how technology is and could be used. The target of collecting the ideas is to use them to improve daily working procedures and to distribute them across the organization so that the ideas can be used in processes which share similar characteristics (Davenport et al., 1995, p. 62).

4.3 The role of management during installation

Installation of a measurement system is a difficult task even if the management has the best techniques and tools at their disposal. The lack of leadership or discarded commitment between the design and implementation faces at the management level is the key factor causing the failure of installation. Better measurement systems may be desired by the management but as the first difficulties arise or the management starts to face the resistance for change coming from the workers who are accustomed to do things as they have always done and fear the consequences of the measurement of their work, they halt the implementation plans and back down (Hacker et al., 1998, p. 22; Bourne & Mills, 2000, p. 762).

Hacker et al. (1998, p. 22) and Lönnqvist (2004, p. 6) defines requirements which the leaders installing a performance measurement system should fulfil. Leaders should have positive attitude towards business and employees and the sufficient knowledge about the operations of the company. Leaders must require the use of the measurement system and the employees should learn and use the new system in their daily work and be held responsible for using the system. Follow-up and review meetings should be scheduled by the management in order for them to show that they are committed on using the measurement systems and are driving the business processes toward better performance. They should not let data integrity or availability issues derail the implementation process. As a new system is implemented and taken into use, there can be various issues affecting the gathering of needed output. The data from the measurement maybe missing or distorted and unusable. In face of this the leaders should show persistence and try to figure out how these issues could be solved and show the staff that they are not giving up. Finally they should standardize reporting and presentation. The data gathered from measurements should be presented in unified form across the organization. The results obtained from measurement systems may be affected and have unwanted variation in them if different templates and formats are used between review periods. This leads to confusion and misunderstanding issues and increases the amount of wasted time.

4.4 Planning and implementation of a measuring process

All organizations have different features which and are operating under different circumstances. This has an effect on how the meters are chosen, implemented and used in daily work. As business goals of an organization change so must the measurement system be updated. Unnecessary old meters shall be discarded and new meters implemented and taken into use. Only when meters are up-to-date are they useful and provide usable information for the managers of an organization. Measuring should be based on processes and projects and the information should be used for communicating the strategy of an organization to all relevant people. Measuring should encourage innovations and be easy to use in everyday situations. The measures of an expert organization should include both hard economical and

soft non-economic measures to better aid in reaching the business targets (Lönnqvist et al., 2006, p.34 & 42-43; Bourne et al., 2000, p. 759).

4.5 Performance measure framework

After understanding the reason behind the need of measurement and the direction of improvement needs, quantitative objects may be qualified and set. During 1990s and in the beginning of a new millennium literature has presented various performance measurement frameworks to be used on as basis of measuring the performance. As an organization plans to implement a measurement system it needs to carefully consider which measurement concept best suits its needs. Available concepts are the for example balanced scorecard, performance prism, linking the vision to individual and group activities and the PDSA cycle as a control system. Many of these frameworks puts lots of weight on balanced measuring. “Balanced measuring” is a term commonly used when performance measurement is discussed. It is based on selected measurements covering several different angles of business processes providing information of factors affecting the success of current business done by an organization. All the different angles of success factors are given equal amount of consideration and are seen equally important. These factors include business results, customer satisfaction, the efficiency of processes and job satisfaction of the staff. Balanced measuring is done using hard and soft meters as well as economic and non-economic meters so that a wide-ranged view of the current state of organization and business may be constructed (Hacker et al., 1998, p. 20; Lönnqvist et al., 2006, p.11-43).

4.5.1 Balanced Scorecard

Strategic measuring and holistic measuring are terms used alongside balanced measuring. Balanced scorecard is the most well-known framework used in measuring the organizational performance. It is developed by Kaplan and Norton and it concentrates on four different perspectives where the performance is measured. These are economical, internal processes, learning and development and customer views. Other notable frameworks are Performance Prism by Neely and Adams, Navigator by Edvinsson and Malone and Meritum project (Lönnqvist et al., 2006, p.11-34; Bourne et al., 2000, p. 756).

As a business performance is a complex concept it makes the implementation of balanced scorecard into a demanding process during which time the developers should ask themselves in what way should specific measures of performance be implemented. According to literature poorly designed performance measures may lead to unwanted and falsely applied actions. This can be seen as a result of a method where performance calculations provide distorted data and lead managers to pursue incorrect routes of action (Neely et al., 1997, p. 1131; Neely, Adams & Kennerley, 2002, p. 160).

4.5.2 Performance Prism

Neely et al. (2002, p. 160) state that Performance Prism is a three dimensional highly flexible frame work able to provide narrow or broad focus on business performance. It can be used in designing the measurement system and even in facilitating the organizational performance management initiatives. Performance Prism is built to include five aspects of performance which are interrelated and present some critical questions for consideration:

- Strategies: how to satisfy our stakeholder's requirements as well as our own?
- Stakeholder contribution: What are the critical things we need from our stakeholders?
- Processes: In order to execute our strategies and to meet our goal, what processes are needed?
- Stakeholder satisfaction: who are our stakeholders and what is it that they want from us?
- Capabilities: In order for us to be able to operate and execute our processes what capabilities are needed?

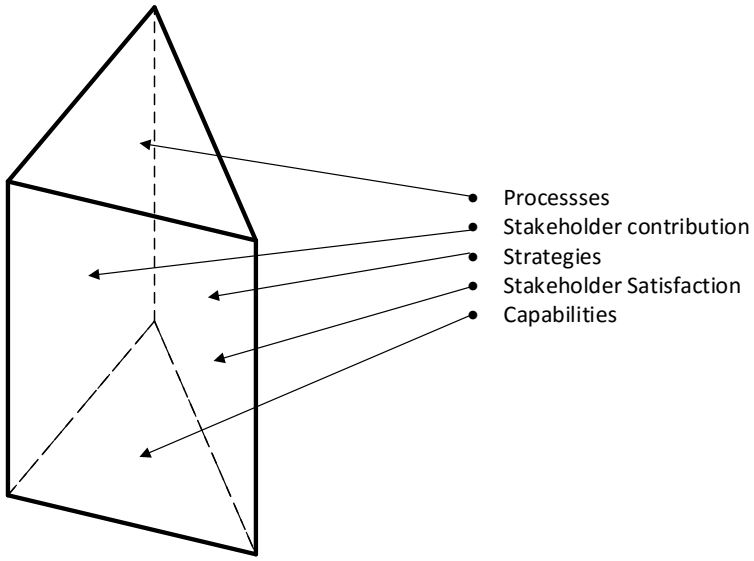


Figure 6: Performance Prism (Neely & Adams, 2002, p. xi)

Whereas the Balanced scorecard focuses on four perspectives of performance which are financial, customers, internal processes and innovation it chooses to neglect the importance of other stakeholders for example regulators, suppliers, communities and employees. As an organization chooses the framework which to follow it needs to decide which perspectives of performance are most valuable to it (Neely et al., 2002, p. 159-160; Kaplan & Norton, 1996, p. 9).

The developing of Performance Prism should be started by identifying the stakeholders of an organization. Bourne, Franco & Wilkes (2003, p. 16) argue that organizations are created in order to satisfy the needs of the stakeholders. These stakeholders are probably a combination of investors, customers, employees, suppliers, regulators or from various other groups. Organizational management needs to decide which stakeholders are more important than others and which needs are critical to be satisfied. This leads to first perspective of Performance Prism which is stakeholder satisfaction (Neely et al., 2002, p. 166).

Stakeholder contribution encapsulates a key message which is that for every stakeholder there is something what an organization needs from them. Same thing is true the other way around: stakeholders need something from an organization.

This equation is valuable for an organization to understand as it is an excellent learning exercise for the business units of an organization. After the needs of the stakeholders are understood the strategy of the organization can be developed to answer these requirements (Neely et al.,, 2002, p. 167-168; Bourne et al., 2003, p. 16).

According to Neely et al. (2002, p. 169) the third perspective of Performance Prism is strategies. This perspective tries to answer the question: *Which strategies should the organization follow in order to provide satisfaction for the stakeholders?"* They continue by stating that a measurement system designing process is often started at this step but it should not be the case. Strategy should be firmly in place before measurement system is designed. Measures should be consistent with the strategies of an organization in order to promote desired behavior from the employees.

Processes are the thing which makes an organization to work. They are also the fourth dimension of Performance Prism. Some of the aspects of process performance are quality, quantity, effectiveness, efficiency, time, timeliness, ease of use and money. An organization needs to be able to measure its processes in both micro and macro levels (Neely et al., 2002, p. 171-175; Kueng, 2000, p. 72).

The fifth perspective of Performance Prism is capabilities which potential customers usually find to be the most interesting perspective. It consists of practices, infrastructure, technologies and people. Each capability requires skills different from one another (Neely et al., 2002, p. 177-178; Kueng, 2000, p. 68). When combined these five perspectives deliver an extensive integrated framework which can be used in organizational performance measuring. Performance Prism framework is comprehensible and fluid to use when easy articulation of business operations model is needed (Neely et al., 2002, p. 160-161).

4.5.3 Elements of efficient performance measurement framework

Neely et al. (1997, p. 1132) and Kueng (2000, p. 82) have reviewed literature in their own work and determined how a good performance measure framework should be build and which elements are essential to it. The conclusion of their studies shows that firstly the name of the measurements should be distinct. There

should be no chance of misunderstanding of what is measured and why. A measure has to have a clear purpose and the reason why it has been chosen and the reason should be explained. It should be related to business objectives of an organization and these objectives should be recognized. Managers should have a clear target in mind of what they wish to achieve by improving the performance of a process. The reason behind measuring is to gain knowledge whether the performance is increasing or not and if the target set out in the beginning is reachable. The formula which dictates how performance is measured is one of the hardest elements to specify because it dictates how people may behave. Correctly chosen formula could promote good business practice or better customer service. The frequency of measuring and reporting the results are the function of how crucial for business the taken measurements are and how much information is available. Data collecting should be a simple, non-time consuming task. This can be facilitated by automating the data collection or by minimizing the amount of data needed for measuring. The collector and reporter of measurement information should be appointed. The origin of the information should be defined in order to obtain consistent comparable information over long periods of time. As data is gathered and analyzed, appropriate actions must be taken. The person responsible of these actions should be appointed. Whether the performance of a process is acceptable or unacceptable there should be a clearly defined management process which should be followed. Management loop should always be closed or there is no reason to make measurements at all.

4.6 Measurement system implementation

The measurement system implementation process is unique every time. It may include different phases and its durations may vary. Sometimes the process is simple and easy to complete but in other occasions it is a time-consuming effort by being a multi-layered demanding process Lönnqvist et al. (2006, p.103-115; Kueng, 2000, p. 81).

The implementation is often facilitated by a consult who is recruited from outside of an organization. Organizations may also appoint a person responsible for the process inside the organization who oversees the process from start to finish. Organization places a task force who decides which success factors need to be

measured and which measures are used. As the new measurement system is taken into use in daily work more people from the organization are introduced to the new system and the consultant's role is minimized (Lönnqvist et al., 2006, p.99).

A model in Figure 7 which is combined from the researches by Lönnqvist et al. (2006, p.103-115) and Kueng (2000, p. 82) describes how to develop a performance measurement system for an organization. The model is divided into five phases which are:

- start of a process: there must be a reason to measure. Senior management gives endorsement and support for building the measurement system. Resources are allocated and time tables are agreed upon.
- defining of targets: strategy of an organization needs to be understood.
- defining the success factors: which factors are most critical? Selected success factors must complement each other.
- defining the measures to be used: measures need to be tied with strategy and to provide information.
- defining the usage principles of measures: as measures, users and situations vary the usage principles of measures need to be clearly defined. The frequency of measurements, the collector of data, the source of data and target values need to be defined before advancing the implementation process.

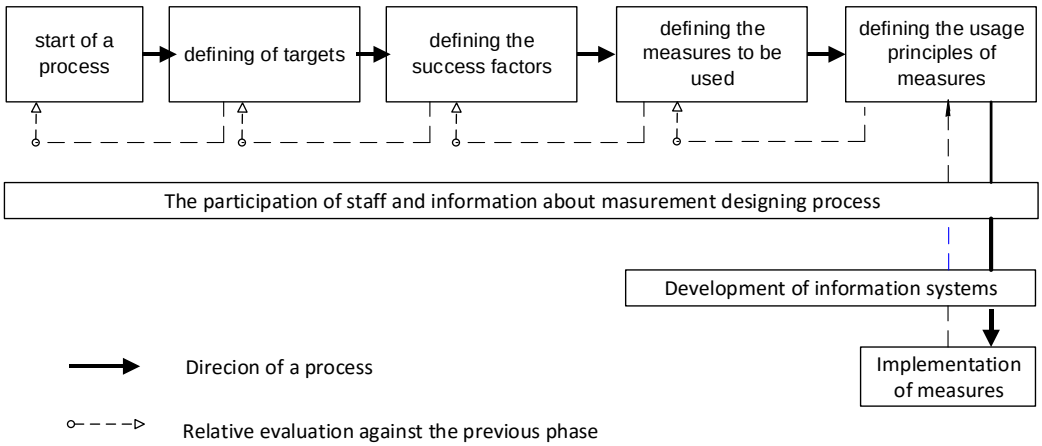


Figure 7: Designing process of performance measurement system (Lönnqvist et al., 2006, p. 104)

In addition there are two phases running concurrently with the five already established phases which are involving and informing the staff and improvement of information systems. The phases may overlap partly. The process itself is iterative and may require back tracking if previous phases have not been executed thoroughly enough.

Globerson (1985, p. 639) has created similar kind of performance measurement system guide lines. He states that every organization should create a performance criteria system by recognizing a multitude of objects to be measured. To do this an organization needs to choose a set of objects to be measured and measure the chosen objects. They should set and follow standards during measurement and implement a feedback loop so that if the actual performance of the process does not follow standards, correct actions can be taken in order to rectify the situation.

4.6.1 Start of the process

The measuring process is started by mapping out the needs of an organization and by identifying a process which performance is to be measured. The next steps compose of choosing the criteria to be assessed and forming the standards to be followed. Also the frequency of measurements should be decided. A time table is planned and a target group of individuals is selected. This phase is crucial for the success of the process as it has great impact to the outcome of the whole measuring process. The costs of measuring can be minimized and the whole measuring process can be more effective if the designing phase is done with care. The requirements and timing of a measuring process are affected by the scope and frequency of intended measurements (Lönnqvist et al., 2006, p.85; Globerson, 1985, p. 639).

4.6.2 Defining the targets

Management of an organization needs to have a consensus about the vision and strategy of how to develop the business and this vision needs to be clearly illustrated to all members throughout the organization. Organization may have a vision of how it wants to look like in the future and the strategic means to achieve this vision. The measurement implementation team needs to achieve a joint understanding of this vision in order to build the best possible measurement system to facilitate the organizations strategy (Lönnqvist et al., 2006, p.106; Kaplan et al., 1996, p. 19).

4.6.3 Defining the success factors

Lönnqvist et al. (2006, p.22) state that every organization needs to identify the success factors which are seminal for its business success and strategy. These factors are measured when organization performance needs to be graded. The success factors can be categorized in many different ways. The most traditional way is to categorize them into economic and non-economic success factors. An example of these is shown in Table 3.

Table 3: Success factors (Lönnqvist et al., 2006, p. 22)

Economical	Non-economical
liquidity	Customer satisfaction
profitability	Quality
Economic growth	Delivery time
Manufacturing costs of a product	Productivity

4.6.4 Defining the measures

A success factors performance can be described by using specifically defined practice which can be called a measure. Measurement system consists of strategically chosen measures which may evolve over time when measures are added or removed from it. Measurement system which is effective should link the vision of an organization to the daily activities done in various processes inside the organization (Lönnqvist et al., 2006, p.29; Hacker, 1998, p. 21).

Like success factor the measures can be categorized in many ways. The following list (Lönnqvist et al., 2006, p. 30-31; Kujansivu, Lönnqvist, Jääskeläinen & Sillanpää, 2007, p. 168; Flapper et. al., 1996, p. 28) presents some common categories which are:

- financial measures: used in steering the business decisions and are fairly easily collected from financial statements
- non-financial measures: are not based on financial information and describe different parts of organizational actions and processes including customer satisfaction and delivery times
- hard measures: are based on unambiguous input values like business transactions or repetitions

- soft measures: cover views, feelings and attitudes and are collected using different questionnaires
- objective measures: are based on quantitative information derived from organizational actions
- subjective measures: are based on estimates of the current status of a success factor
- direct measures: a success factor is such that it can measured directly
- non-direct measure: a success factor cannot be measured directly and instead something else which links to it is measured

Selected measures should include characteristics validity, reliability, relevancy and usability. Validity indicates the ability of a meter to measure the correct success factor whereas reliability describes whether the results received are consistent or not. Relevancy seeks to understand whether the meter used is relevant for the task. Usability describes the easiness and cost efficiency of the meter (Lönnqvist et al., 2006, p.32; Neely et al., 2002, p. 45).

An organization needs to create a selection process for the measurements needed to build the measurement system most suitable for an organization. Organizations select measures which are easy measure far too often and do not select the right ones which might be harder to measure. The measurements which are linked to success factors have a relative weighs which have a total sum of 100. Assigning the weight for the measurements enables managers to have a clear understanding which measurements are most critical for the process to be efficient (Globerson, 1985, p. 640-642; Neely et al., 2002p. 34). Globerson (1985, p. 640-642) presents three alternatives for measurement selection which are:

- pair comparison
- graphical
- simultaneous comparison

Table 4: Assignment of relative weights using 'simultaneous comparison' method. Modified from (Globerson, 1985, p. 642)

Success factor to be measured	Relative weight
Efficiency	30
Percent of defects	20
Satisfaction	10
Cost per item	30
Response time	10
Total	**100**

In pair comparison managers need to compare measured success factors by pairs using relative weights. The sum of weights needs to be 100. Graphical comparison sees measured success factors assigned to a scale divided in ten parts where the left side of the scale has value “not important” and the right side has value “important”. The third alternative simultaneous comparison has all the possible measures in one table, where manager assigns weight percent for each measure so that a sum of these measures is 100. In Globerson study it was discovered that managers preferred the simultaneous comparison technique which implies that a discriminative power of this technique is seen as the most important feature in this kind of selection process. The findings of Globerson were also re-enforced by previously done studies which had yielded similar kind of results.

4.6.5 Defining the usage principles of measures

If measures are considered to be used as a tool for managing the organization many things need to be considered and important question must be answered. A compilation of questions presented by Kujansivu et al. (2007, p. 176) & Neely et al. (2002, p. 35) were gathered here. The things which for example need to be considered are the reasons behind selected measure and why organization wants to measure it. Organization has to appoint a person responsible for acting upon the results of measure. It is also important to understand how the results are reported and what is done after this new knowledge is gained. The source of data needs to be known and the person who is in charge of collecting the data must be nominated. The frequency of the data gathering activity must be set as well as the frequency of the data reviews. Lastly the connection between measures and reward systems has to be decided.

The measures definition template by Neely et al. (2002, p.35) is presented in Table 5

Table 5: Measures Definition Template (Neely et al., 2002, p. 35)

Measure:	
Purpose:	
Relates to:	
Metric/Formula:	
Target Level(s):	
Frequency:	
Source of data:	
Who measures:	
Who acts on data (owner):	
What do they do:	
Notes/comments:	

Globerson (1985, p. 640) presents the findings from previous studies done by Berezi 1978, Eilon 1979, Hurst 1977 and Westwick 1973 which support the findings of Lönnqvist et al. (2006) and adds new guidelines for organizations to consider when creating a performance criteria. Organizations objects must guide the performance criteria selection and organizations doing the same kind of business can be compared by using performance criteria. The reason behind performance criteria's need to be clear. Information gathered from measurements and the procedures used in calculation of results need to be understood without confusion and organization has to have power to control the units which are measured. Choosing of the performance criteria's are done under discussion of everyone involved (managers, customers, employees). Subjective performance criteria's are not as useful as objective performance criteria's and if the performance is the same, the value of the performance criteria's shall be the same or have negligible differentiation.

4.7 Data gathering and reporting

The implementation of a measurement system includes modification of current information systems so that required data may be collected more efficiently and

with lesser effort. The measures need to be tested and the staff needs to be trained to use the new system. Gathering and reporting of data are both part of the testing process. The staff needs to understand the meaning of measuring and how it might affect their daily work. They should understand that performance measuring is essential for improvement of the current business processes in their organization (Lönnqvist et al., 2006, p.118-119; Kueng, 2000, p. 82).

The source of an information is a method which is used to collect the needed data from a measure. Intellectual capital is much harder to measure than concrete business and other physical information. For this reason it is extremely important to select and implement suitable means of information gathering methods at the same time when measures themselves are implemented. The first step in implementing a measure is to decide what or who to measure. The next step is to figure out how the needed information can be extracted from the target of measurement. The data can be collected as part of the process which is called the build-in approach. The other method is initiative approach where data collection must be initiated whenever the data must be acquired (Lönnqvist et al., 2006, p.69; Globerson, 1985, p. 644).

Reporting of measurements is a central part of the whole measurement system. It is vital to be known why the reporting is done, who does it and to whom are the reports delivered. Reporting can be carried out with various ways depending on who are in the target group. Organization management need different kind of reports for the basis of their decision making than customers or shareholders. One-time investigations of measurement can be done manually but reporting in performance systems which need to produce data in frequently should be automated (Lönnqvist et al., 2006, p.134; Bourne et al., 2000, p. 761).

Literature studies indicate that people tend to change their behavior while trying to make sure that performance measurements yield positive results even though it might require unsuited actions to be taken by them (Neely et al., 1997, p. 1131; Lönnqvist et al., 2006, p. 11). For this reason the staff needs to be aware of the measurement goals and results. This helps manager to motivate staff and steer the staff's actions towards desired working procedures. A worker needs to understand

the key areas which affect the outcome of his/hers performance and clear measures and targets need to be assigned for worker to follow (Lönnqvist et al., 2006, p.134).

For measurement reports to be useful the presentation of results needs to be simple. Usage of pictures, graphics or numbers is recommended as it makes the results easy to understand. The results should be presented in familiar surroundings and the stakeholders need to be able to access the results at any given time. Measurement data should be collected and presented in the most cost efficient way possible (Lönnqvist et al., 2006, p.135; Neely et al., 2002, p. 54)

5 PARTICIPATORY ACTION RESEARCH

Stringer (1999, p. 5) states that research is strict and methodical study that is done in order to help people to better comprehend situations and actions that are seen problematic. Research is composed of a problem which is to be researched, a process where information is gathered and an explanation given to people which facilitates the understanding of the problem and its essence. Activities carried out to solve the problem under study may possibly be included to research.

Participatory action research is one of the educational directions of action research. The fundamental difference between action research and participatory action research is that where action research concentrates on doing research on people the participatory action research is about doing research with the people. The aim of both action research and participatory action is to study and alter current ways of doing things and at the same time its purpose is to solve problems which may be found from technical, social, ethical or professional areas. Both methods are used in order to help people from organizations to better comprehend the situation surrounding them and to tackle obstacles they may face in their daily activities. These research methods create a model of how to overcome problems in certain situations by inquiring useful information and applying academic theories (Stringer, 1999, p. 9-10; Tappura, 2009, p. 9; Breu et al., 2004, p. 662).

As stated before the participatory action research is one of the directions of actions research. Both are used in order to reach similar goals using similar methods. In following paragraphs the researcher of this thesis will use the phrase action research as it is used in majority of the reference documents used in the theoretical part of this thesis work.

5.1 Characteristics and methods of action research

The key thing in action research is to activate the people who are the owners of research problem and who are the owners of the to take part in the research and for to be involved in the process by doing more than just record the events happening (Saaranen-Kauppinen & Puusniekka, 2009, p.41; Stringer, 1999, p. 7; Breu et al., 2004, p. 662; Walter, 2009, p. 2).

Some characteristics common to action research are focus on the problem, the active roles of participants and facilitator during the change process, focus on practicality and cooperative relationship between facilitator and people or actions under study. Every stakeholder whose work is affected by the research and who have a desire to solve the problems under study should participate actively in the process. They should be involved in all the phases of the process including data collection, information analyzing and in theorizing the problem under investigation. By participating actively and reflecting the situation together the stakeholders are able to create better comprehension of the problem under investigation and they may share their varied knowledge with others. This enables them to generate various solutions to overcome the problems they are facing and to enhance the quality of their work in their organization (Stringer, 1999, p. 10; Breu et al., 2004, p. 663; Walter, 2009, p. 3).

The possible target of an action research can be almost any feature which is related to human life. It is widely used in educational research as well as indigenous research focusing on problems on community level. The initiative for action research may come from an organization that wants to find solution to a problem or it may be born from problems discovered from previous academic researches (Saaranen-Kauppinen et al., 2009, p.41-42; Walter, 2009, p. 3).

Action research is based on teamwork and cooperation. The researcher who is empowered as a change-effecting practitioner cooperates with the workers who are titled as knowledge creators. Data collection and knowledge acquisition is done as a collective process. It uses surveying and exploration as tools to provide methods and to undertake systematic actions to settle and solve particular problems. Action research endorses participatory and consensual conducts which help people to systematically explore issues and problems, create refined views of the status of things and to form different schemes on how to solve current problems (Stringer, 1999, p. 11 & 17; Breu et al., 2004, p. 663).

The methods and techniques of action based research observe and pay attention to the people's culture, emotional lives, interactional practices and history. This is beneficial on both theoretical and practical level and develops expertise and insights

in a way which would not be possible by using different research methods. The techniques used in action based research are very common in social and behavioral sciences but they are also extremely usable in other fields of science. Action based research is accessible to both professionals and to common people (Stringer, 1999, p. 17-18; Walter, 2009, p. 6).

The routine of action based research is divided into three basic actions namely look, think and act.

- Look focuses on data gathering and on building "the big picture" of things.
- Think tries to answer the question "what is happening here" by exploration and analyzing the findings.
- Act has four actions which are plan, implement, evaluate and learn. If evaluation leads to an assessment which deems the actions taken to be correct, these actions are then implemented in the planning phase of the next cycle

These actions are in constant motion of recycle and as participants go through these steps they are constantly observing, reflecting and taking action according to their findings trying to improve the results from the previous cycles (Figure 8). After action has been taken the participants review and look at the situation again and all the steps are gone through again. This cycle is continued until the problems are resolved or the objectives of the research are reached (Stringer, 1999, p.18-19; amk.fi; Walter, 2009, p. 4; Baskerville & Wood-Harper, 1996, p. 238).

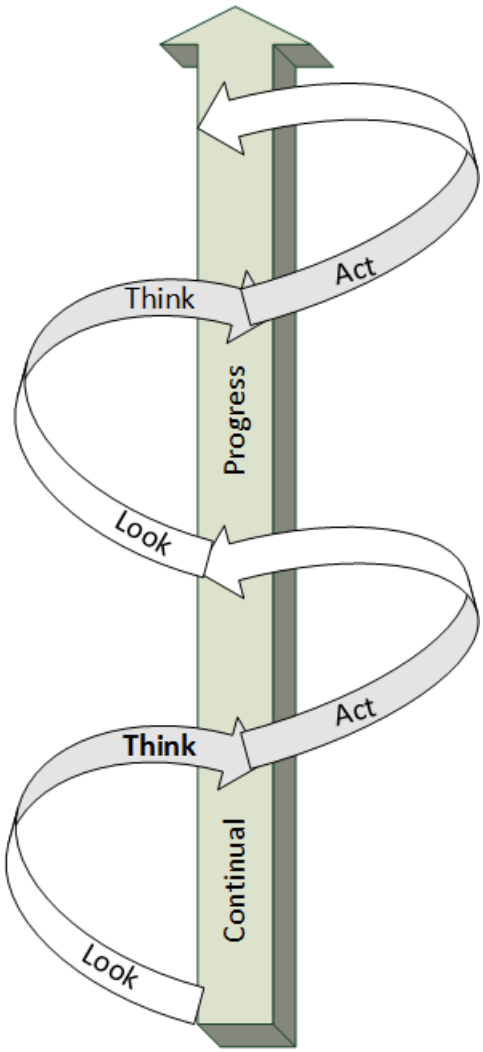


Figure 8: Action Research Interacting Flow (Stringer, 1999, p.19)

5.2 Roles and tasks in action research

The role of a researcher who works closely with the participants in action base research is not so much an expert who conducts the research but a resource person. His or her task is to facilitate the change, associate and consult all the parties who are part of the research project. Researcher or the facilitator should be the catalyst of the whole process, who stimulates people to change and help them to create their own analysis about the situation under development. Researcher's task is to help the others to see all the possible courses of actions which can be taken and to see the possible outcomes of these actions (Stringer, 1999, p. 25; Walter, 2009, p. 2).

Participants of an action research project need to familiarize themselves with the complexity of the situation they are trying to improve. Facilitator helps the participants to see the big picture of things, to define all the stakeholders affected by the situation and to understand the research context. As the learning is an ongoing process in action research the participants are constantly gaining new knowledge and the organization learns more about its environment and nature (Stringer, 1999, p. 44; Baskerville et al., 1996, p. 238).

The building of the big picture is conducted by gathering information using stakeholder and participant interviews, by participating in every-day-work and by analyzing gathered information and constructing and reviewing reports. The researcher should communicate all the findings to participants and stakeholders using meeting minutes, bulletins or interim reports (Stringer, 1999, p. 67 & 88; Tappura, 2009, p. 14).

Problem resolving can be started after everyone understands why the organization wants to change, what the underlying problems are and how all the details surrounding the problem are situated in the bigger picture. First action of the resolving process is to determine the boundaries of the research and to priorities projected actions and to clarify the goals and objectives which are targeted by these actions. Resources, timetables and persons responsible should be determined at this point. After planning phase is completed the decided actions are implemented and evaluated. The evaluation phases includes the describing of what has been done and achieved and what needs to be done in the future to further improve processes (Stringer, 1999, p. 134 & 165; Baskerville et al., 1996, p. 238).

By experiencing the action research process the participants learn that the process is not trimmed and groomed activity which can be strictly followed in step-by-step manner. The process will require backtracking, repetition of processes and planning. Re-evaluation of interpretations and organizational actions are also characteristics of action research. Action research can be seen as a complicated process embedded with multiple ways to reach the goal but in the end the participants will have clearly defined target ahead of them and they will constantly

be aware of their current location on their journey towards their destination (Baskerville et al., 1996, p. 243; Stringer, 1999, p. 19).

6 CERTIFICATION OF PRODUCTS AND SERVICES

As hardware, software and communication level complexity increases and computers and software have reached a critical role in modern societies the engineers of today face an ever-growing challenge of creating reliable, secure and safe ICT systems. These systems need to be verified thoroughly by the developers before they are submitted to customers by manually reviewing the system or testing it. In occurrence of a system failure the safety aspect is critical so that dangerous behavior of a system or software may be prevented. Classified information needs to be protected accordingly and this is done by taking proper security precautions. Systems also needs to function correctly and expectedly (Heck, 2006, pp 1; Moraes, Durães, Martins, Madeira, 2007, p. 179-180).

Dependable systems can be created by assuring that every critical function is determined and defined precisely and fully and that these functions are implemented in the correct way. Heck (2006, p. 2) presents three external factor which are needed in creation of dependability:

- correctness: the functionality must follow the specification
- robustness: usage of a product in a way which does not correspond to the specification must not create damage
- security: antagonistic use carried outside of specification must not create damage

6.1 Reasons for certification

Reliability and safety are usually tested and verified during product certification. The certification of consumer products and industrial goods has gained importance as product safety, consumer interests and protection of environment have received more attention from legislation by tightening the requirements and standards. Manufacturers may want to certify their products in order to aid their marketing efforts or to have a written statement which declares that they are committed in producing products with certain quality. Certification can be used as a tool for informing the customer that the product has certain functionality and characteristics or to gain permission from government to sell their products as the law may require

products to be certified. Certification is also used to declare that clearly formulated, accessible regulatory documents are available for all interested parties. Consumers are interested in the quality of the product and have certain expectations of the quality levels concerning the product. Buyers have greater interest to know, which components are used, where have they been assembled and developed and in what kind of conditions they are manufactured. The may base their buying decision on whether the product is certified or not. The certification process aims to generate certain levels of warranty (Druzhinin, 2001, p. 13; Oh et al., 2004, p. 209-210; Moraes et al., 2007, p. 179-182; Vertinsky and Zhou, 2000, p. 231-232.

6.2 Characteristics of a certification process

Certification is a complicated process where specified standards must be followed. These standards set out the rules for documents, product requirements and test validations which are used in the testing and verification process. Products can be tested against standards or by assessing manufacturer's quality system and processes. Independent third party test centers and laboratories which are not the creator or the recipient of the system or product to be certified have gained powerful authority at both national and international level. The need for these rose from ever growing lack of confidence from customer side that manufacturers could produce promised quality products and follow strict safety requirements. A third party may provide complete and objective statement of the systems performance and produce legal recognitions which declare that a process, product, service an organization complies and conforms to specified set of requirements and pre-determined characteristics declared in specifications. By doing this the certification authority states that the manufacturer has followed and fulfilled quality properties recognized in a given standard. Certification authority needs to be convinced by petitioner that all the necessary steps to fulfil the required requirements have been taken and design conditions must be carefully constructed (Moraes et al., 2007, p. 181-185; Gigante & Pascarella, 2012, p. 208; Oh et al., 2004, p. 210; Druzhinin, 2001, p. 13-15; Mashkov & Golikov, 2002, p. 51; Heck, 2006, pp 1).

Certification systems are unique and have their own management systems procedural rules. Certification maybe voluntary or obligatory depending on legal

standpoint. Certain products are required to have technical compatibility with each other and this can be assured by running necessary certification procedure. Voluntary product certification is usually done by third-party accreditation peers who make sure that an assessed product complies with appropriate industry standards (Druzhinin, 2001, p. 13; Thione et al., 2000, p. 208).

Product certification requires certain technical competence and satisfactory facilities for testing. It also has significant sectoral characteristics. Testing, measuring and analyzing are experimental tasks which can be seen as integral parts of product certification. These task require certain amount of technological knowledge of the products under assessment as well as essential production processes. It can be said that expertise and testing laboratory culture are profound to product certification tasks (Thione et al., 2000, p. 208).

Certification should be based on measurements, where a product is assessed objectively by evaluating its measurable attributes against agreed industry. Testing is an important part of certification process and is carried out by following known standards and using standardized test methods. It is performed on products in order to assess their quality and in making sure they comply with characteristics and properties described in documents of technical standardization (Wassyng, Maibaum & Lawford, 2010, p. 258; Druzhinin, 2001, p. 14).

6.3 Certification of software products

Software products have been certified in Europe by independent testing laboratories since early 1990s. United States has adopted certification process only recently. According to Oh et al. (2004, p. 210) software certification has two main branches which are process maturity assessment of an organization and product assessment.

Process maturity assessment of an organization is built upon a presumption that organizations which have more efficiently organized groups of people and possess high-tech methods of software engineering are able to create products with better quality. In order to get certification from independent certification body these organizations need to prove that they have efficient quality management system which is strictly followed. The certification of quality management system provides

a guarantee for the clients that an organization follows specific standards and rules of operations. This kind of approach to certification does not ensure the quality of the final product (Oh et al., 2004, p. 210; Thione et al., 2000, p. 208).

Product assessment concentrates on the quality of the product itself and is more technical perspective to quality where-as management system certification focuses on the managerial processes in providing quality. Product is checked against various specifications, source code and user manuals by testing it using pre-determined suitable techniques and accessories. Certification can be a hybrid of both process maturity assessment and product assessment. Software certification requires an evaluation of multiple different quality features which may be unique for certain software product. This makes certification process a situation-dependent task which requires substantial know-how and experience about the topic under testing and evaluation (Oh et al., 2004, p. 210; Thione et al., 2000, p. 208).

Certification authorities require evidence that the target of the certification conforms to all the needed requirements and base their decision upon the evidence presented to them. Certification process provides an economical alternative for consumers and whole industry to gain standardized and valid information regarding the products. The information provided by the process is based on scientific or professional consensus of different parties involved in the process. Usually the certification process is driven by regulations and political aspects where economical stakes are high (Wassyng et al., 2010, p. 258; Vertinsky & Zhou, 2000, p. 234).

7 EMPIRICAL PART: MODELLING AND REENGINEERING THE CERTIFICATION PROCESS

The main goal of this thesis is to reengineer a certification process which is one of the processes of a multi-national company manufacturing software and hardware products. The request to reengineer the process was initiated by the senior management of the organization responsible for certification process as it was suspected that the current process was not functioning in the most efficient way possible. Senior management wanted also to gain a clear process map of how things are done currently in certification and how much leaner and simpler the reengineered process would be. After development of a reengineered process the senior management also wanted a measurement system to be built so that they would have up-to-date information of how the certification process performs and how the whole company could benefit from the measurements done during certification process.

The researcher and writer of this thesis acts as one of the team members of the reengineering team as he has gained extensive knowledge of the current processes by working under certification organization for several years. This academic research is done under supervision of Lappeenranta University of Technology department of Industrial Management.

7.1 Background of the thesis work

The research process started in spring 2015 as the researcher approached the senior manager of the certification organization and asked whether there was a need to do some kind of research inside the organization which could be used as a basis of a thesis work. Different possible research subjects were discussed and together it was decided that a process reengineering research would be the most suitable and beneficial subject for both parties. It was agreed that the researcher would first contact his university and acquire Non-disclosure agreements from all of the persons involved and study the available books and publications in order to gather information on how the research should be conducted. The time schedule was agreed and the deadline of the research was set to the end of 2015. In the same meeting it was agreed that the researcher would have the support from the

management and the reengineering team would consists of the key people needed to complete the process the best way possible.

In summer 2015 the organizational restructure process was initiated inside the company which had major impact on the certification organization. The agreed schedule of the thesis work changed so that the empirical part of the research needed to be completed by the end of September and some of the key personnel agreed upon earlier became unavailable to participate in the reengineering process. As time to complete the research became limited all the steps of the reengineering process had to be executed with haste.

A meeting was arranged with the researcher and one of the senior managers of the organization where the reengineering team was chosen. As the researcher was unable to have all the needed key members of the organization to be included into the reengineering team it was agreed that parts of the process modelling and reengineering would solely be done by the researcher himself. The reengineering team consisted of five members – two project managers and three certification engineers of which the researcher was one of them.

7.2 Product certification process

The product certification process modelled and reengineered in this thesis is divided into one main part and two sub-parts. The main part which is called a project management process has two sub-processes – a work request process and a report request process. As not everyone from the reengineering team knew all the parts of the process the team was divided into two sub-groups and the certification process was modelled and re-engineered with project managers while the work request process was modelled and reengineered with certification engineers. The report request process was modelled and reengineered by the researcher himself as he was the only one in the team who had the full knowledge of how the current process functioned.

The certification process described in this thesis is valid for all the products which are certified by the organization. The process starts when a product is planned and a customer commits to acquire the product. The process has lots of stakeholders

affecting it. These were not singled out in the process modelling. As stated in chapter 6 the certification is affected by different specifications, operator requirements, customer requirements, laws and partner solutions it would have an overly complicated task to model the involvement of all these different parties.

7.3 Start of the modelling process

The modelling process started by acquisition of theoretical research data on how the process modelling should be done. The library databases of Lappeenranta University of Technology, Tampere University, Tampere University of Technology and Tampere University of Applied Sciences were used in order to gather sufficient amount of theoretical data on which the thesis work could be based on.

The next step was to find out whether there was an existing process model which could be used as a basis of the modelling process. The organization had gone through several restructuring phases during the past ten years and it was discovered that some of the data describing the current certification process had been lost during the transitions and changes. The researcher was able to find only one document which described the current product certification process. The process was described in macro level and did not reveal individual stages of the process and what was actually done in them.

Various modelling schemas as presented by Martinsuo & Blomqvist (2010, p. 11-12) were studied and Event-driven process flowchart was chosen because the organization needed to understand how the certification process operates on the level of business logic and how the tasks and activities performed add value to the business. According to Mendling (2008, p.18) EPC is correct tools to be used under these requirements. The EPC's general level of description was enhanced by written text describing in greater detail how each of the functions and events was carried out. EPCs are also easy to understand and people throughout an organization are able to understand flowcharts on general level without the need of a specific education (Nesbitt, 1993, p. 34). The researcher was also familiar with the tool as he had used it during his academic studies in Lappeenranta University of Technology.

The performance measurement framework selected for this research was Performance Prism (as presented in chapter 4.5.2). Its five dimensions and aspects were seen as most informative and useful for this kind of research. As stated before the product certification process has many stakeholders who play critical role in the successful implementation of the process. The stakeholders contribute critically important factors for the process and the quality and timeliness of these factors set the stage for the efficiency of the product certification process. These stakeholders have also various needs which the certification organization needs to fulfil. This requires specific strategy and variety of capabilities from the organizations part.

7.4 Commonalities in Certification Process Modelling

Before every process modelling described in this chapter the participants of the process modelling identified all the process stakeholders, inputs, outputs and interfaces as suggested by Martinsuo et al. (2010, p. 8-9). Following the theory from chapter 3.4 the participants gained understanding of roles, systems and tools needed to complete the processes. During the first meeting the researcher presented the EPC flow charting method to the other team members by identifying the different symbols and their meanings as instructed by Nesbitt (1993, p. 35-38).

The non-mandatory cost data and cycle time information presented by Nesbitt (1993, p. 37) were not available at the time of the modelling process and the teams did not find them to be important aspects for the modelling so these are not included in this thesis work.

As a final step in making of each of the process models was the creation of computerized process models. Microsoft Visio was used in forming the EPC flowchart as the researcher had the program already installed on his computer and had familiarized himself on how to use the program during his previous studies.

7.5 Current Report Request process modelling

The Report Request process modelling was created first as the researcher wanted to practice the modelling before presenting the EPC method to the other team members. The modelling was first done by using “French lines” as the researcher wrote down the Report Request process in text format using short sentences

describing the different actions and events of the process. As Martinsuo et al. (2010, p. 3-4) pointed out the problematic parts of the process need to be analyzed in greater care. Due to this fact the researcher decided to model the Report Request process in micro level to have a better understanding of which actual steps of the process were unnecessary or repetitive work. Modelling the micro level did not present any problems as the researcher modelled the process alone and did not have to reach a consensus with other members of the team. The rules of EPC did not allow the process to be modelled as the researcher initially envisioned it and some remodeling work had to be done based on theory. The resulting process model had simplistic layout and was under two pages long as suggested by Babicz (2000, p. 369). After modelling was done the researcher contacted the project managers and reserved a time slot when the modelling of the Project management process would be initiated.

7.6 Project management process modelling

Before the Project management process modelling was initiated the researcher presented the modelled Report Request process to the project managers. This was done as part of the introduction of the EPC modelling method and to provide a general idea and guidelines on how to model a process. After the rules and guidelines were established the process borders were agreed upon and the non-inclusion of report request and work request sub-processes was agreed upon. As the certification process has many stakeholders it had to be decided which ones would be presented as individual actors in the process model and which ones should only be mentioned in general terms. It was also discussed on how the project management should be seen in the process model as they are seen as the customers of the certification test team but on the other hand the development program sees them as part of the certification testing organization.

7.6.1 Current project management process model

As the researcher had no previous knowledge of the Project management process a mix of interview and team methods presented in chapter 3.3.3 was used in to gather the needed information of how the current process is done. According to theory interview method is not suitable for complex processes with large scope. It was

used in conjunction with team method in order to clarify all the details of the process so that the researcher could have better understanding of it. The interview part was done in very informal way where the researcher asked the Project managers to discuss freely of how they see the Project management process and what are the logical events and functions of it. From then on the researcher participated only by listening to the project managers and documenting the facts presented to him. The researcher interrupted the discussion only to make clarifying questions when something which he did not fully understand was discussed upon. The discussion between project managers bounced back and forth as they added details, changed the sequences of events and actions and challenged each other opinions on how the Project management process is actually carried out. A macro view of the process was developed first and micro parts were added to the parts which were most critical and presented to be a most problematic areas of the process. As mentioned before the micro views of the process were difficult to create because there are many small variables inside the process. For example the test software of automated testers is constantly evolving and the test categories evolve as new test cases become available or old ones are removed from the requirements. By removing a feature from the product might open several new test cases which have not been tested before. This may cause the finding of several new errors and possibly affect the time schedules.

After the meeting ended a new meeting time was agreed upon where the results of the first meeting would be discussed.

After the meeting the researcher started the modelling process using the documentation gathered from the first meeting. It became evident that the researcher would be unable to create a complete process model based on the documentation as some of the key information was missing and some of the data was not completely understandable by the researcher. The process model was sent to the project managers so that they could study it before the next meeting.

During the second meeting the first draft of the process model was inspected and the missing and incorrect parts were added and fixed. Project managers admitted that their description of the process was lacking and that the first draft of the

modelled process helped them to see what was missing and what parts of the process they had overlooked. After the meeting the researcher created a second draft of the process model and sent it to the project managers to be reviewed. The third meeting was reserved.

In the third meeting the current process was finalized and some spelling errors were corrected.

7.6.2 Reengineered project management process model

After completing the modelling of the current process a process reengineering was started. The researcher presented the theory behind the reengineering process to the team as described in chapter 2.4. Project managers had a fairly clear picture of what could be improved in the current process and which stakeholders should carry out their task in improved manner. As before the research participated only as an observer of the discussion and documented the reengineering ideas of project managers.

7.6.3 Selecting the process performance measures

After reengineering discussion the process performance measuring was discussed. The researcher presented the theory behind the measuring system creation as described in chapter 4 to the team and the selection of suitable measures was started.

In chapter 4 the understanding of success factors is discussed upon. Due to this the success factors of business were discussed within the team. Product certification aims to provide quality for the customers with fast response times. The people inside the organization need to understand what is required in order to fulfil the certification requirements and what are the correct specification and the work procedures needed to perform certification successfully. Certification organization must provide assistance to all the stakeholders and customers as they might not have the correct up-to-date information of the certification needs.

The team was unable to determine suitable measures which would directly inform how well the reengineered process functions. The product certification organization was seen as an information centered expert organization where people’s knowhow

and tacit knowledge is critical for the success. Processes in this kind of environment can be measured in macro level but performance measuring which concentrates on smaller parts of the process are much more difficult to develop. This was due to a fact that the process had so many stakeholder that there would be small micro level variations between different process runs which could have large impact on how the process performs in general. The through put time measuring was one of the ideas discussed but it could also have drastic variations depending on how factors not the under control of certification organization would affect it. The team had to consider also the fact that people tend to change their behavior in order to yield positive results from the performance measurements. This kind of behavior was seen as problematic and the measures chosen for the reengineered process should avoid the possibility of this kind of behavior.

Three measures were chosen to be presented to the senior management of the organization. As instructed in chapter 4 the team evaluated the validity, reliability, relevancy and usability of these measures and concluded that these were the best possible measures to be used in measuring the new process. After the meeting the researcher finalized both of the process models and formed the tables for chosen measures.

7.7 Work request process modelling

The modelling of the current work request process started as the researcher sketched the process steps using bullet points. The researcher was familiar with the process as he had participated in it for several years. After forming the text version of the process the researcher used Microsoft Visio to create an EPC model of it. The first draft was sent to the team which consisted of people responsible for testing activities and a meeting was scheduled after one week.

Before the work request process modelling was initiated the researcher went through the work request model with the team and introduced the EPC modelling method to the reengineering team members to give a general idea of what the general guidelines of the process modelling would be. The rules of EPC were

discussed and the different meanings of the figures used in modelling were clarified. After the introduction the first draft was inspected and the process was discussed.

The team method described in chapter 3.3.3 was used to build knowledge of how everyone saw the process and in building the common view of it. The researcher wrote down the agreed changes and improvement ideas raised by the discussion. The reengineering process was also initiated during this meeting. The researcher presented the theories behind reengineering to the team as described in chapter 2.4. All the ideas presented and agreed upon were documented and later to be added in the reengineered process model.

After the meeting the first draft of the current process model was altered according to the meeting notes and a reengineered process was modelled. The new models were sent to the team for inspection and the second meeting was arranged.

During the second meeting both of the processes were fine-tuned and spelling errors were fixed. After agreeing that the process models were accurate enough the researcher presented the theory behind the measuring system creation as described in chapter 4 to the team and the selection of suitable measures was started. As with project managers it proved to be difficult to come up with measures which would be beneficial and which would actually improve the way of doing things inside the organization. The researcher presented the three measures created during the discussion with project management and it was agreed that these were probably the most reasonable and informative measures to be used. After the meeting the researcher created the finalized versions of the process and sent them to the team for final inspection.

7.8 Reengineered report request process

The final stage of the modelling process was the creation of reengineered report request process. The reengineered project management process and reengineered work request process needed to be finalized before the report request process could be reengineered as there were many dependencies between the processes. The new process became short, lean and very efficient.

7.9 Presenting the results to the senior management

After all the six processes were modelled and the measures were finalized the researcher presented the results to the senior manager of the organization. The results were approved and seen to be informative and helpful. The researcher asked for the senior manager to assign weighted percentage for each of the measures as instructed in chapter 4 using simultaneous comparison method. By doing this the measures would be put in the order of importance and if the management should decide to implement the measuring system the order of implementation would be clear.

7.10 Completing the thesis work

By this time all the data needed had been gathered, processes modelled and the measures defined. The research of the thesis continued his work by verifying that the theoretical and empirical part were in harmony and that the empirical part was done according to the theoretical frame work. The results of the research were written open and the path leading to them clarified. Finally the conclusion and recommendations were added to this work.

8 RESULTS

As a result of the research work done for this thesis a product certification process was modelled and reengineered. Also three measures were designed to be used with the reengineered process. The product certification process was divided into three parts, to a project management process and into two sub-processes which are Work Request Process and Report Request Process. Each of these three parts have a current version and reengineered version and the reengineered processes are presented in their own chapters followed by a dedicated chapter for the measures.

8.1 Reengineered Project management process

Reengineered Project management process (Figure 13) starts when Project management receives information that a product is being manufactured. Project managements assigns a Project manager to the product who is responsible for overseeing that the product is certified according to standards, time schedules are being kept and that customers receive the product in time with all the features requested by them.

After Project manager is assigned to the product he contacts Development program for additional details. A product has features, customer(s) and a time schedules and possibly variants. Project manager requests this information from the development program and uses this information to build an understanding what kind of product is being developed and how he may facilitate the certification process. Software and hardware providers have certified their outputs according to specification and issued a statement that all the different parts may be combined in order to make fully functional product.

Project manager requests feature reviews in order to determine which kind of tests are required in order to fulfil certification criteria. Reviewers go through all the software and hardware documents and check them against certification documents. After reviews are completed Project manager receives information concerning testing areas which need to be tested.

At this point of the process a mature hardware and software are required. Project manager checks the availability of mature software and mature hardware with Development program and creates a Work request after both software and hardware are available.

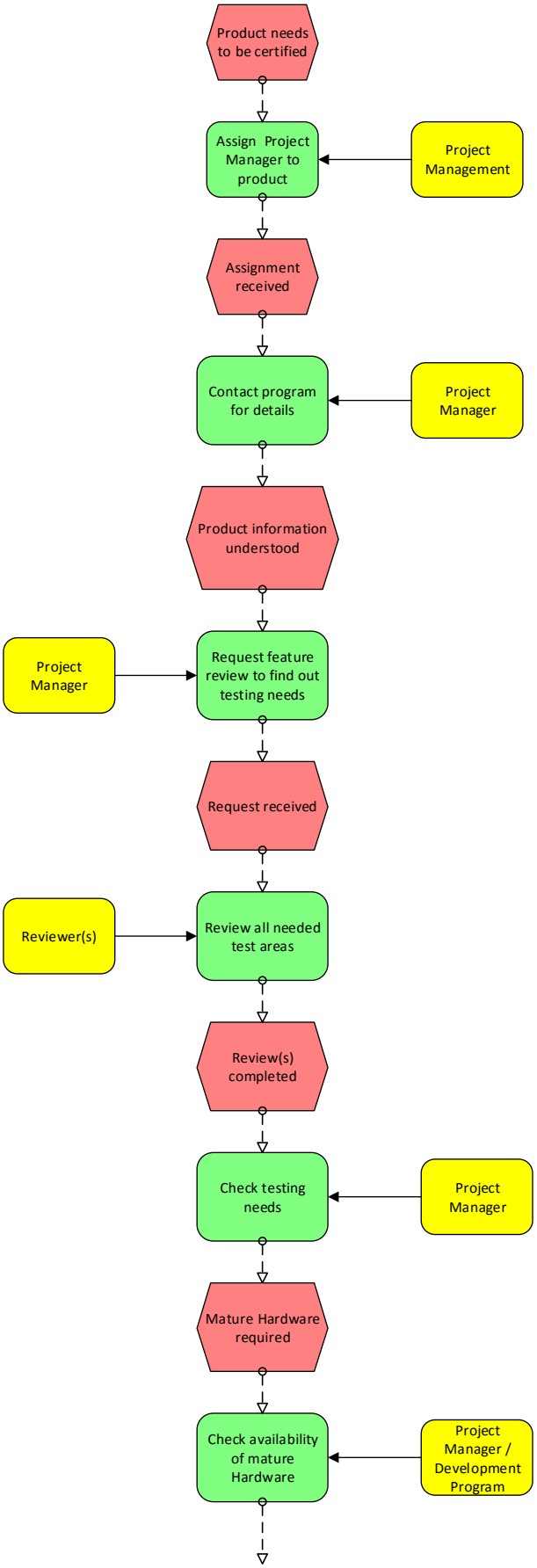
Process moves to a Work Request Process sub-process and returns back to the main process after correct set of functions have been completed.

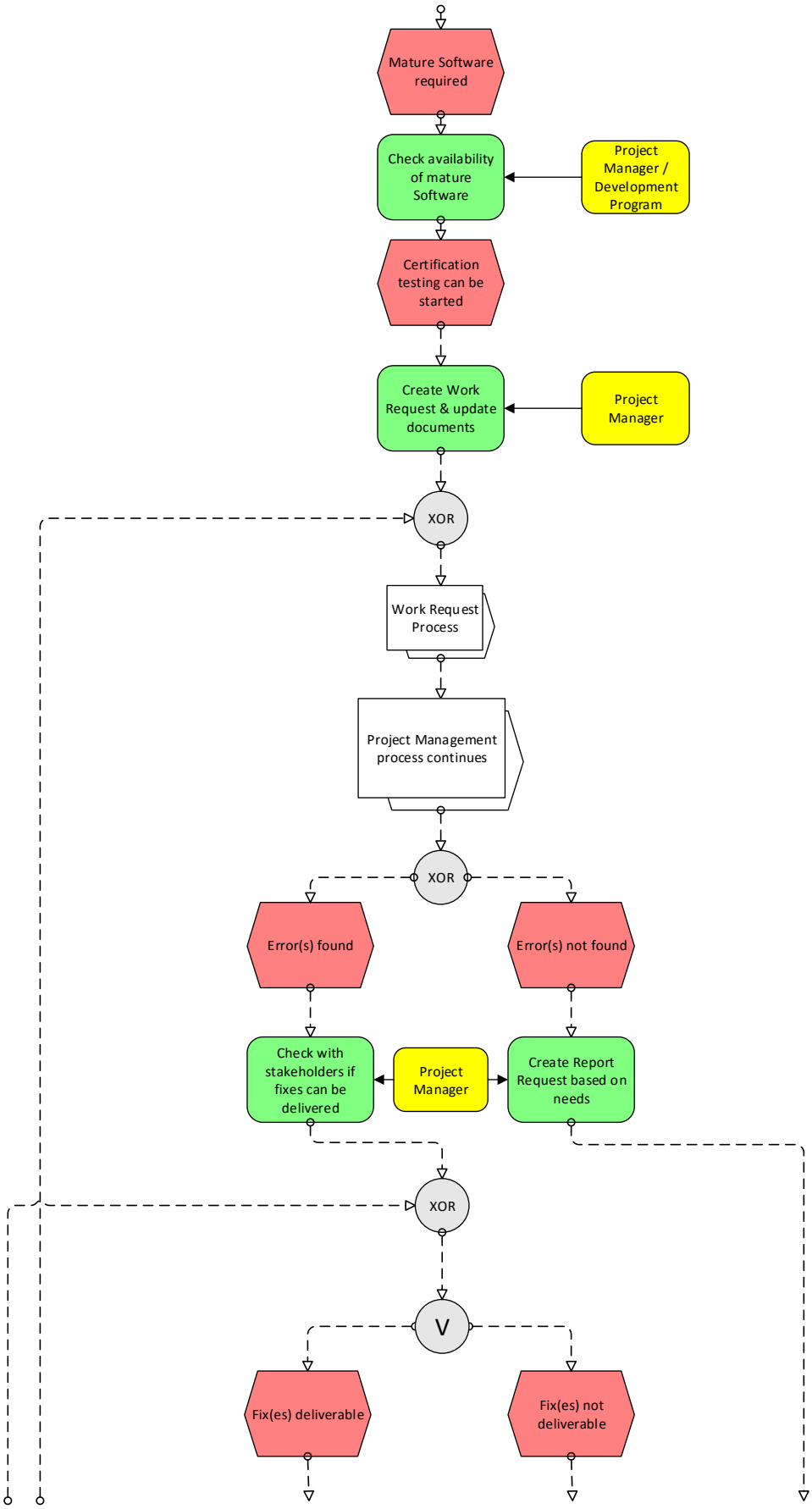
There are two outcomes from the testing efforts – errors are found or tests are completed without errors. If errors are found and the errors are valid certification blocking errors Project manager checks with stakeholders whether fixes can be delivered in given time frame. This time frame is affected by time schedules of the product. Fixes can be deliverable or be non-deliverable. Fixes that are deliverable follow their own process branch where Project manager oversees that errors are fixed according to specification and apply pressure for developers to meet the demand dates. Once errors are fixed and software containing the fixes is released Project manager issues a new Work Request for certification laboratory and updates software documents to have correct updated information.
If fixes are not deliverable within given time frame Project management needs to request waivers and/or exceptions to be able to proceed with product certification process. Waivers need to be approved by Certification Authorities. If waivers are not approved Project manager needs to check with stakeholders once again when fixes could be delivered. After this the process returns to the state where it is decided whether fixes are deliverable or not.

After waivers are approved by authority, all required test cases are done and no errors remain open a Project manager issues a Report Request.

The second outcome from the testing efforts is No error(s) found. After receiving this information a Project manager issues a Report Request. On this point process paths are joined by XOR and process continues.

At this point a process jumps to Report Request sub-process. After required functions in Report Request sub-process have been completed the process returns to the main Project management process. Project management gathers all the reports and documents and uploads them to Certification Authorities. After this a certification round is completed.


Product needs to be certified
Assign Project Manager to product
Project Management
Assignment received
Contact program for details
Project Manager
Product information understood
Project Manager
Request feature review to find out testing needs
Request received
Reviewer(s)
Review all needed test areas
Review(s) completed
Check testing needs
Project Manager
Mature Hardware required
Check availability of mature Hardware
Project Manager / Development Program


Mature Software required
Check availability of mature Software
Project Manager / Development Program
Certification testing can be started
Create Work Request & update documents
Project Manager
XOR
Work Request Process
Project Management process continues
XOR
Error(s) found
Error(s) not found
Check with stakeholders if fixes can be delivered
Project Manager
Create Report Request based on needs
XOR
V
Fix(es) deliverable
Fix(es) not deliverable

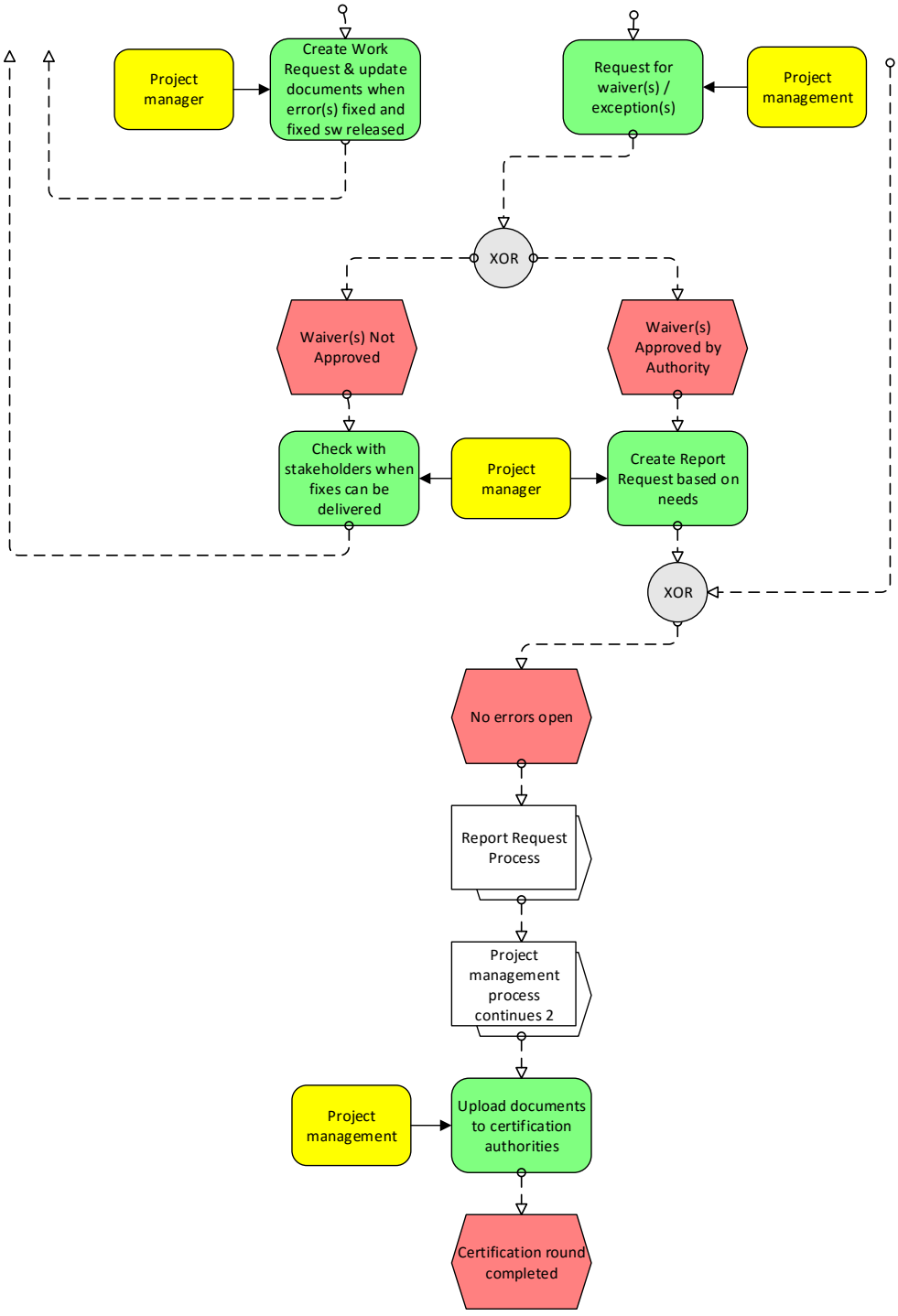


Figure 9: Reengineered Project management process

8.2 Reengineered Work Request process

Reengineered Work Request process (Figure 14) is a sub-process of the Project management process. Process starts when a Work Request is received by Work

Request handler. He processes the request and checks whether hardware to be tested is available. If hardware is not available the Work Request handler contacts Project manager and asks for hardware.

After hardware is available the Work Request handler checks which areas need to be tested and allocates correct test sets to Testing Responsible(s) and creates work space in IT tool.

Testing responsible initiates testing procedures after receiving the allocation and after testing is completed uploads the test results to IT tools. Process continues by two different paths where other one returns to the Project management process and the other one to error handling.

If errors are found the Test Responsible reruns the tests again with tracing enabled and verifies that the test fail every time. After fail is reproduces and log files are successfully captured the Testing responsible saves the time used for testing so that test equipment usage may be tracked, creates an error report using given template and informs Project manager and Work request handler so that they may act accordingly.

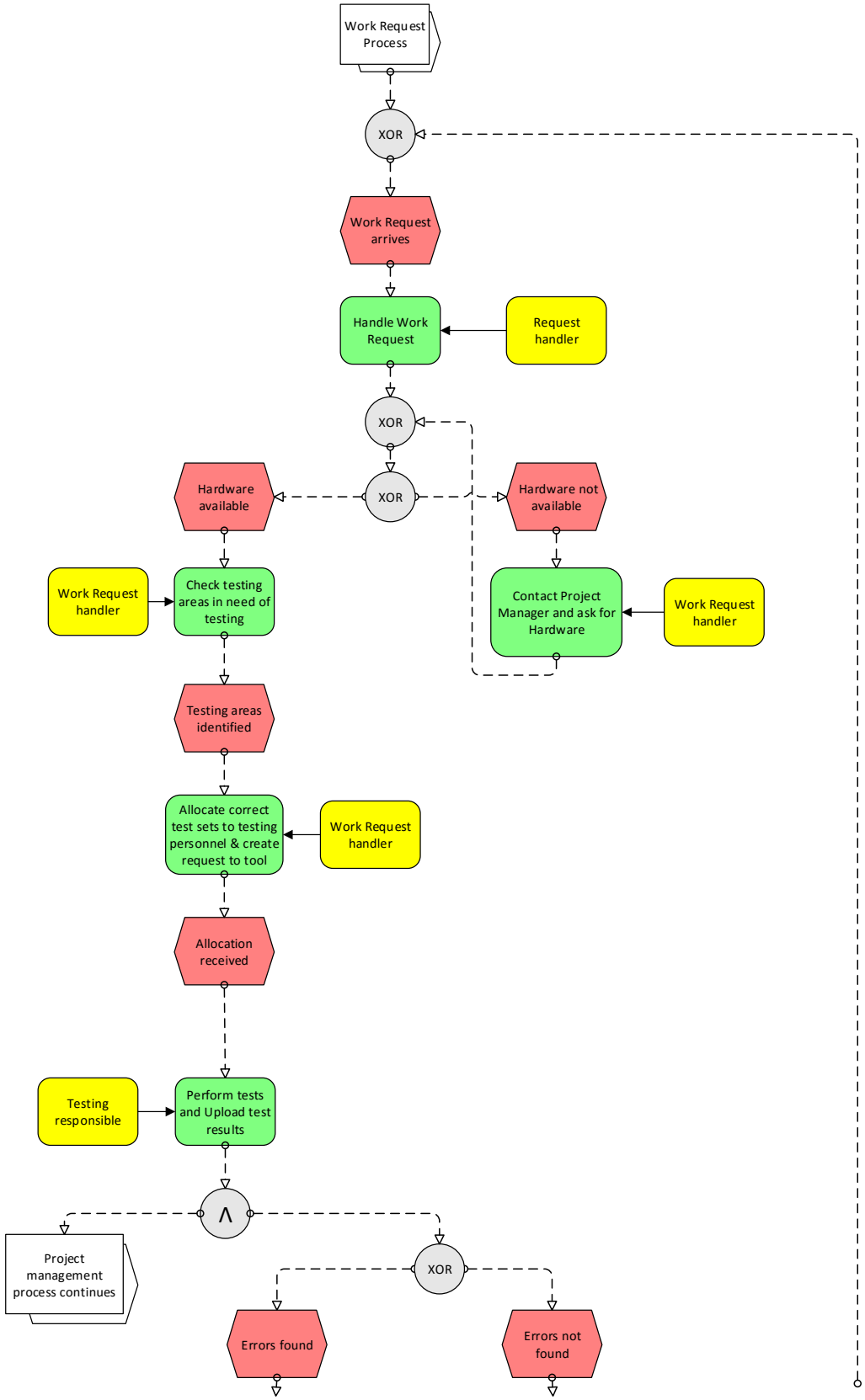
At this point the process splits into two concurrent paths. One path defines how errors are handled and the other one demonstrates how Error Manager follows error process, provides statistics to management and provides assistance to all stakeholders if needed.

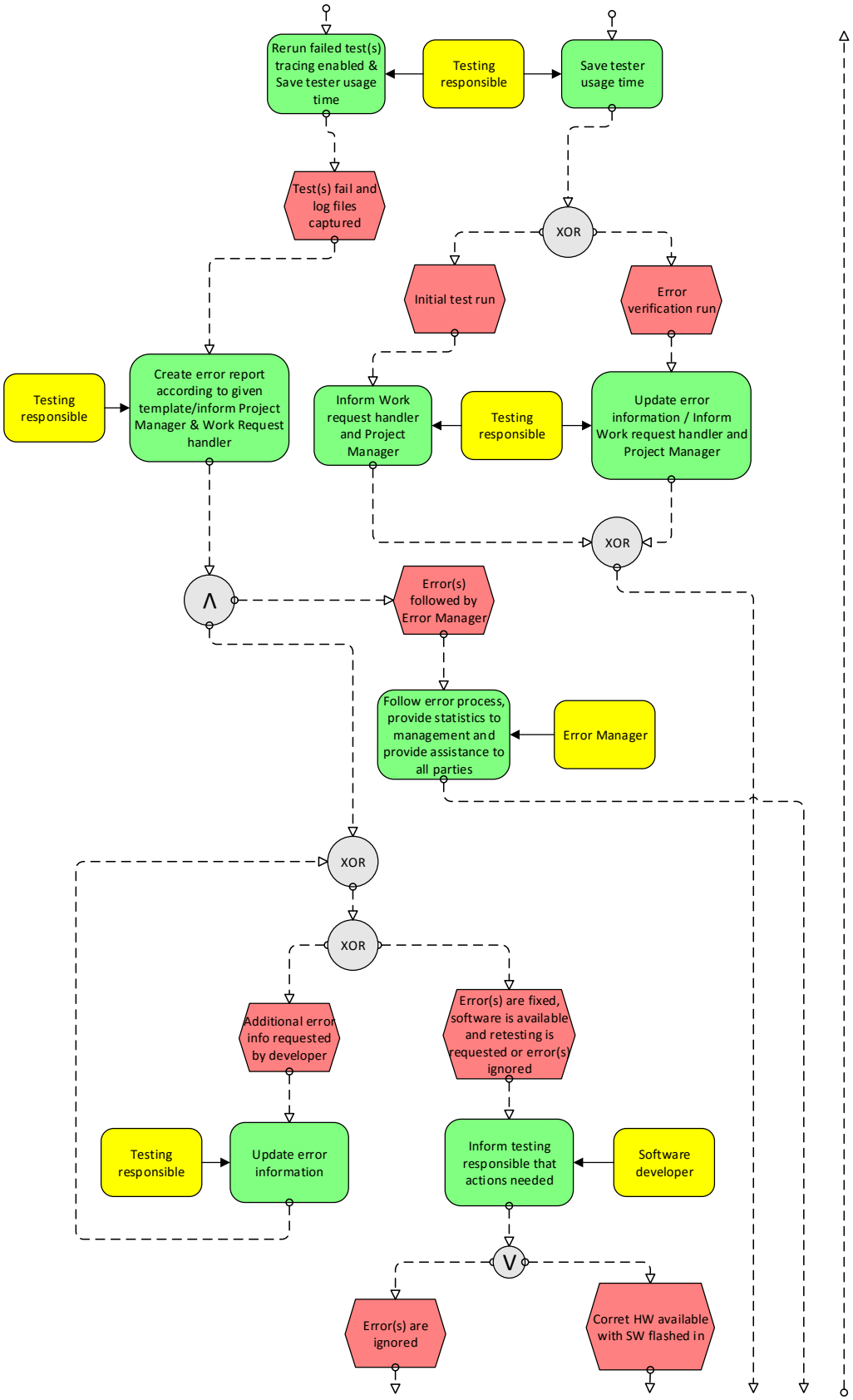
After error is created the developer may ask additional information from Testing responsible who then provides it. If error includes all the needed parts the developer takes error under investigation. Error status is constantly visible to Testing Responsible and all the communication is done directly between Testing responsible and the developer. If errors are found to be valid and they can be fixed in given time frame a new software is created and retesting is requested in the form

of Work Request by Project manager. If errors are ignored the Testing responsible has to agree to close before this can be done.

If errors were not found during testing round the Testing responsible saves the time used for testing so that test equipment usage may be tracked. After this the Testing responsible informs Work Request handler and Project manager. If test run was error verification round the Test Responsible updates error information accordingly.

After testing is done and no errors remain open the Testing responsible creates an official report of the certification testing activities he has carried out and uploads them in IT tool. After every Testing Responsible persons have completed their report writing and report uploading tasks the Work Request handler updates Work Request status to Done and Work Request process is completed.


Work Request Process
XOR
Work Request arrives
Handle Work Request
Request handler
XOR
XOR
Hardware available
Hardware not available
Work Request handler
Check testing areas in need of testing
Contact Project Manager and ask for Hardware
Work Request handler
Testing areas identified
Allocate correct test sets to testing personnel & create request to tool
Work Request handler
Allocation received
Testing responsible
Perform tests and Upload test results
Λ
Project management process continues
XOR
Errors found
Errors not found


Rerun failed test(s) tracing enabled & Save tester usage time
Testing responsible
Save tester usage time
Test(s) fail and log files captured
XOR
Initial test run
Error verification run
Testing responsible
Create error report according to given template/inform Project Manager & Work Request handler
Inform Work request handler and Project Manager
Testing responsible
Update error information / Inform Work request handler and Project Manager
XOR
Λ
Error(s) followed by Error Manager
Follow error process, provide statistics to management and provide assistance to all parties
Error Manager
XOR
XOR
Additional error info requested by developer
Error(s) are fixed, software is available and retesting is requested or error(s) ignored
Testing responsible
Update error information
Inform testing responsible that actions needed
Software developer
V
Error(s) are ignored
Corret HW available with SW flashed in

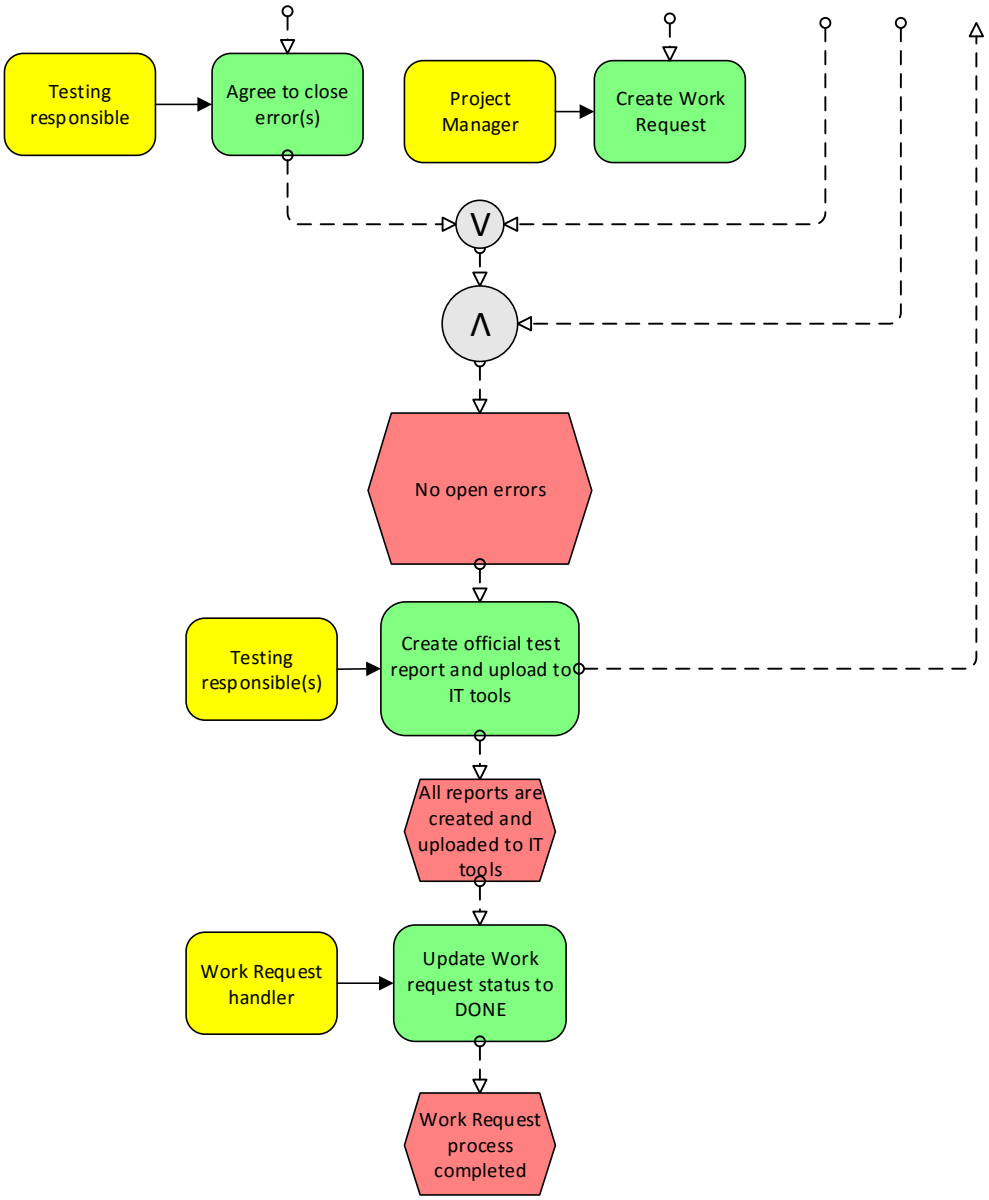


Figure 10: Reengineered Work Request process

8.3 Reengineered Report Request Process

Reengineered Report Request process (Figure15) is a sub-process of Project management process and it starts when Report request arrives to Report Request handler. Report Request handler checks whether report is needed or not. If report is not needed he updates all Report Request documents accordingly and process ends. If report is needed Report Request handler creates combines reports from all test areas into one master report, uploads it to IT tools and updates Report Request

documents. Once these steps are done the process splits into two paths one leading back to Project management process and the other completes the Report Request process.

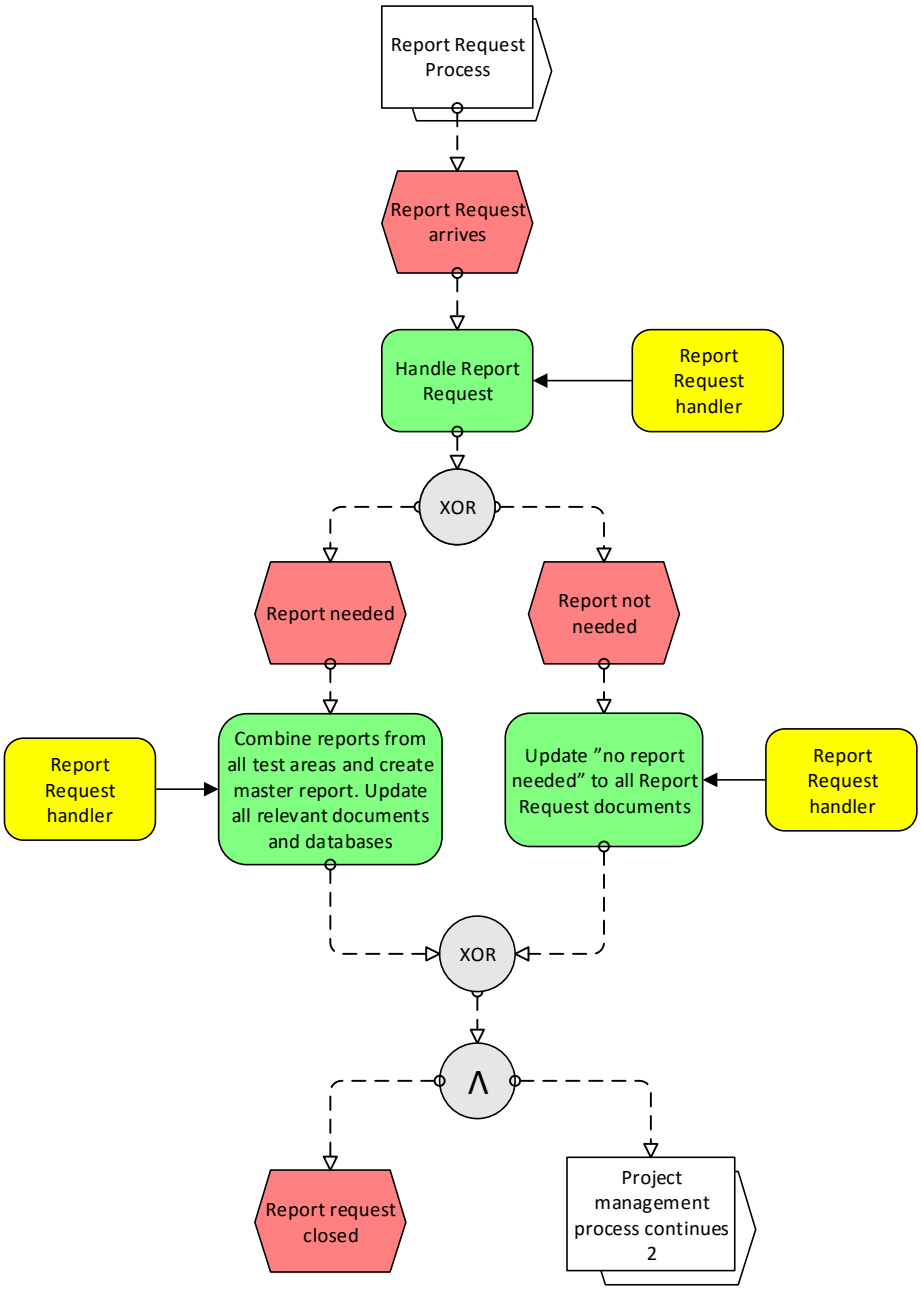


Figure 11: Reengineered Report Request process

8.4 Designed measures for the product certification process

Three measures were designed to be used with the reengineered processes. These measures do not measure the performance of the process but give general information on how the performance of various stakeholder affect the process and

how the maturity of the certified products evolve over time and is the direction of the company correct one or in need of steering.

Table 6: Measurement for the amount of waivered test cases

Measure:	Amount of waivered test cases
Purpose:	Discovery of product maturity
Relates to:	Conformity
Metric/Formula:	Amount of test cases deviating from specification
Target Level(s):	0
Frequency:	Once per SW approval
Source of data:	Report team / IT tools
Who measures:	Project management
Who acts on data (owner):	R&D
What do they do:	Improve specification compliance
Notes/comments:	Errors which cannot be fixed in certain timeline

The amount of waivered test cases is used in order to discover the overall maturity of the product. In order to be certified a product needs to conform to several requirements and pre-determined industry specified test cases need to be passed. Target level of waivers is 0 and the waivers should only be used as a last resort. The reporting team provides the information to project managers if there are test cases which cannot be successfully completed. These waivers are results of errors which the developers have not been able to fix in certain time line. These errors should be fixed by the developers before the next certification round initiates.

Table 7: Measurement for the amount of errors after initial test round

Measure:	Amount of errors after initial test round
Purpose:	Discovery of product maturity
Relates to:	Conformity
Metric/Formula:	Amount of test cases deviating from specification
Target Level(s):	0
Frequency:	Once per SW approval
Source of data:	IT tools
Who measures:	Error Manager
Who acts on data (owner):	R&D
What do they do:	Improve software maturity
Notes/comments:	Valid errors fixed in certain timeline

The amount of errors after initial test round is used in order to discover the overall maturity of the product and to check how well the product is implemented according to specification. The target level of errors is 0 and the frequency of this measurement is once per SW approval. The error managers collect this information from the IT tools and developers provide fixes for these errors. The errors calculated by this measure have to be valid and fixed in certain time line (not waivered).

Table 8: Measurement for the time used in fixing errors

Measure:	Time used in fixing errors
Purpose:	Discovery of how much time is spent on error fixing compared to the time used in whole process
Relates to:	Time usage of developers
Metric/Formula:	Days/Error
Target Level(s):	1 week
Frequency:	Once per SW approval
Source of data:	Error reporting tools
Who measures:	Error Manager
Who acts on data (owner):	R&D
What do they do:	Use information to calculate how much time each section of the process consumes
Notes/comments:	Valid errors fixed in certain timeline

Time used in fixing errors provides information for the senior management on how long it takes to fix an error compared to the whole certification process. This measure is calculated by how many days an error is on the responsibility of a developer. The reporting tools can be used as a source of this measure. Developers should concentrate on creating quality software with speedy delivery. The data can be used by project management as a defense if a development program demands to know why certification process takes longer than expected as usually the error fixing is the factor which prolongs the certification process the most.

The following table of measures was provided for one of the senior managers and he was asked to assign correct weight percentages for each measure. Due to the time constraints and the fact that the researcher’s employment ended the percentages were never received.

Table 9: Simultaneous comparison of measures

Measures	Relative weight
Amount of waivered test cases	-
Amount of errors after initial test round	-
Time used in fixing errors	-
Total	**100**

9 CONCLUSIONS AND RECOMMENDATIONS

In this chapter the research questions set in chapter 1 are answered and the conclusions and findings of the research are presented. The research is also evaluated by determining the reliability and validity of the methods used and the results gained. The final part of this chapter covers the future recommendations given to the certification organization based on the findings of the research.

9.1 The research questions and conclusions

In the introduction of this thesis a research problem was set and it was supported by three sub-questions. The main research problem of this thesis was:

"How to reengineer the current product certification process of the organization?"

The sub-questions which were researched were

- Why organizations want to model their business processes and which methods are available for use?
- How is the process measurement system designed and how is it used?
- What is process reengineering and how is it used in process efficiency improving?

The theoretical part of this thesis was written to answer these questions. The reasons behind the need to model business processes was discussed in chapter 3. The designing and implementation of process measurement system was described chapter 4 and the reengineering of organizations business processes was discussed in chapter 2.

As a summary if an organization wants to reengineer its processes management and the employees selected to carry out the reengineering process must commit themselves to the project. The work load of the team must be managed so that the members have enough time to do the reengineering process thoroughly. If the reengineering team members have to perform their daily routines in addition to the reengineering the process will suffer and the quality of results will decline. During the research of this thesis the reengineering was done "on the side" of regular

working hours and some members were in a hurry to leave the meetings and continue with their daily tasks.

The reengineering team should know the current processes extremely well in order to improve them. The team should also be large enough and filled with people who are inventive and who are eager to improve the ways of the old. There were only five participants in the reengineering team described in this thesis. The lack of knowledge of report request process hindered the results somewhat. Also the time schedule of this project was very tight compared to the schedules described in the theoretical part of this thesis where reengineering process was said to take minimum of two years.

Modelling of the old process was very important step in the reengineering process and without it the consensus on how the things were done in the organization could not have been reached. The modelling of the old process made it easier to reengineer the new process as the bottle necks of the current process became visible and understandable.

The reengineering part of the thesis was difficult and would have required more time and effort. As stated in theoretical part of this thesis reengineering is done to drastically change the old ways of doing things. This thesis is more about improving the current process even though the research goal was to reengineer a new process. This is partly because the time available was so limited and partly because the reengineering team didn’t have visionary and inventive members.

The measures developed for the reengineered process do not provide data of how well the process performs. The organization had already different measurement system in place measuring satisfaction of employees and capacity usage so the measures developed for this thesis had to cover different areas. The new measures provide data on where the company is generally going and how much effort is put into quality increasing efforts. The organization should commit itself to gathering the designed measures for at least two years and to see if the quality of products is increasing or decreasing.

9.2 Evaluation of the research

Qualitative research can be assessed based on factors which are vividness of description, methodological suitability, theoretical logicality, analytical accuracy. The vividness of description means that a researcher must portray the reality as accurately and vividly as possible and as a result make the report to rich, creative, and bold. A report must have context specificity in order for a reader to be able to compare the results with previous researches. Methodological suitability implies that a researcher should understand the meta- and methodological theories used in his research and that a researcher should only use the original sources from theoretical literature. The method used in research should be suitable and correct. Methodological suitability consists of several stages requiring punctuality and accuracy. A researches must describe the methods and instructions used in analyzing stage in great detail. Analytical accuracy requires that a reader is able to follow the whole analyzing process from beginning to end and that the researcher is able to keep the whole process logical and clear. The results of the research should be based on the whole research data available and not on partial usage of gathered data. Theoretical logicality means that a researcher has been able to use the theoretical literature in the way which leads to well-grounded and logical wholeness on which the empirical part of the research is based on (Kankkunen et al., 2009, p. 161; Whittemore, Chase, & Mandle, 2001p. 529).

Based on literature the reliability of a qualitative research can be evaluated based on four criteria which are transferability, credibility, dependability and verifiability. In order for research to have credibility the results of the research must be depicted clearly and the strengths and restrictions of the research can be understood by the reader. The selection process of participants, the background information of research process and the methods used for data gathering must also be clearly described. The reader must also be able to follow how the analysis phase is carried out and whether the results are valid or not. The categories and concepts used in research must be based on theoretical and empirical data and they must cover the whole research area (Kankkunen et al., 2009, p. 160; Morse, Barrett, Mayan, Olson & Spiers, 2002, p. 15).

Validity is defined by determining the truthfulness of the research results and by deciding if the research really measures the thing it was originally planned to measure and how congruent the research findings are with the reality. Researches may test the validity of their research by searching the answers from the research of others or by asking a series of questions related to validity and by using the generalization to see if the results can be applied to some other situations. The validity of the research can be viewed in the light of reader or user generalizability where it is the task of the user to discover whether the findings of the research can be applied to other situations (Golafshani, 2003, 598; p. Merriam, 1995, 53-58).

The validity of this research can be decided by checking whether the research questions were answered in a meaningful way. In chapter 9 the answers to the research questions were given and the path leading to the answers was constructed using detailed instructions. The results are transferrable on a macro level to other situations as reengineered processes should be leaner and shorter than the original ones and the modelling of processes can be used in various scenarios to improve the understanding and communication concerning the processes.

Literature presents various strategies which can be used to strengthen the reliability and validity of the research. Methodological coherence means that the research questions must match the method used which in turn matches with the data and analytic procedures. The researchers has to collect sufficient amount of data samples from different sources using triangulation and to demonstrate that saturation point has been reached. Data gathering and analyzing should be done concurrently because the reliability and validity of the research are improved with iterative interaction. Researcher must use theoretical thinking to come up with new ideas and he must confirm them by using old and new data. Theoretical thinking is not achieved by cognitive leaps but with small steps. Theoretical understanding evolves as a research moves forward. Theories tend to develop during the research (Morse et al., 2002, p. 189; Whittemore et al., 2001, p. 553)

The research method used in this thesis was participatory action research which is qualitative in nature and because of this interviews and verbal communication was used in data gathering. Everyone from the reengineering team participated in

research and tried to provide insight of how things were done and what could be improved. Triangulation was used to gather the data. Interviews and team methods were available as well as literature reviews from previously done researches. Data was gathered and analyzed at the same time and whenever it became apparent that some information was vague or missing more data was gathered using the methods described earlier. As research advanced the researcher acquired better understanding of the theories behind the research and switched the scope of data gathering accordingly.

The reliability of this thesis was increased by going through the results with the reengineering team and by reaching a consensus that the results appeared to be correct and in line with every ones views. As Report Request process was modelled and reengineered by the researcher without any input from other team members it can be viewed as being the least reliable part of this thesis. Saturation point was not reached as inputs for the research concerning Report Request process were limited.

The research was documented using detailed descriptions and another researchers are able to start similar kind of researches in different organizations by following the instructions laid down in this thesis. Comparing the results described in this thesis with the results from similar kind of researches from different organizations is not feasible as every organization and their processes are unique. The strengths and restrictions can be found from chapter one were restrictions are stated. The background of the researcher can be seen as a strength as he was part of the organization where the research was done and had extensive knowledge of the processes from time period of several years. The selection process of participants and methods of data gathering are described in detail. The empirical part of the research is based on theoretical part and all the methods used in research can be traced back to the theory presented in this thesis.

9.3 Future recommendations

According to senior management of the organization the results of this thesis were beneficial and could be used in the future one way or the other. After the organization restructuring work is completed the organization should concentrate

on improving its processes by assigning a reengineering team which would have at least 10 members and allocate resources and time for the reengineering process to fully complete. The managers of the organization should understand the importance of product certification and the quality assurance provided by it and get fully behind the reengineering effort. Reengineering cannot be completed in as short period of time which was allocated to this research.

New process measures should be included in the current measurement system and the current measuring questions should be altered to be more informative and more in line with personal development, satisfaction and meaningfulness of work procedures.

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