TURUN KAUPPAKORKEAKOULU
Turku School of Economics

PRODUCT CERTIFICATION PROCESS ANALYSIS AND FURTHER DEVELOPMENT
Case: TCC Nokia Radio Access certification

Master´s Thesis
in Information Systems Science

Author
Jukka Björn

Supervisors:
PhD Reima Suomi
PhD Jarmo Tähkäpää

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ABBREVIATIONS

AE	Application Enabler
AMD	Automotive Directive is for products and systems intended for fitment in vehicles and it covers only the legal EMC (electromagnetic compatibility) aspect of the automotive directive.
CS	Chipset Solutions
EMC	Electromagnetic Compatibility
FCC	Federal Communications Commission
GCF	Global Certification Forum
HW	Hardware
IC	Industry Canada
ODM	Original Design Manufacturer
OTA	Over the air
PTCRB	Personal Communication System Type Certification Review Board
RF	Radio Frequency
R&TTE	Radio and Telecommunications Terminal Equipment
SAR	Specific Absorption Rate
SLS	Security, Location and Smartcards
SW	Software
WiFi	A term developed by the Wi-Fi Alliance to describe wireless local area network (WLAN) products that are based on the Institute of Electrical and Electronics Engineers' (IEEE) 802.11 standards
WiMAX	Worldwide Interoperability for Microwave Access
WM	Wireless Modem

1 INTRODUCTION

1.1 Background for the research

In today's competitive business world enterprises must continually improve their product and service quality in order to stay ahead of the competition. During the last decade many organizational efforts have been undertaken by modern companies, wherein the concept of a process-centered company has received a lot of attention. Kueng (2000, 67)

The mobile devices are becoming more and more complex. Type approval and certification requirements and activities related to mobile devices are constantly growing as the features of the devices are developing and their amount is increasing. Also the specification work behind the features is under perpetual development.

Product certifications in Nokia are done via Global Product Certification Process which enables Nokia to self certify products in many areas and thereby reduce time to market. Certification services are offered locally in most of the Nokia sites by Certification Specialists. An independently assessed and accredited Test & Measurement service provides the Radio Access (RA) evidence, RA being only part of the product certification, to support submissions to external authorities and internal conformity declarations enabling market entry for Nokia products. The mobile device certification has been divided into two separate schemes on the grounds of their technological characters; Radio Access and Radio Spectrum scheme. The technologies belonging to the Radio Access part of certification are explained in more detail in chapter 4 which focuses on the process descriptions and walks through the whole process.

This mobile device certification and type approval activity in Nokia is organized in a process organization including customers, owners for different processes, management of the processes and laboratories conducting the testing activities and managing the test results as well as maintaining information about the requirements and materials needed. As the ever demanding business world requires this organization too needs to be able to meet the demands of the future and is constantly trimming the processes and the organization. The commission to conduct this research was received from an organization called Testing and Certification Center (TCC) with a target set in certification process description creation, analysis and development. TCC is the in-house body responsible for certifying Nokia products and providing in practice the earlier mentioned Test & Measurement services.

1.2 Aim and research problems

This thesis includes a review of scientific literature of the process theory, different process views and descriptions of it as well as information about how can the theories be used in real life organizations. It also includes a collection of some of the researchers' studies about process measurement and process development. One chapter is devoted to information system purchasing and development issues because it became evident during the research that IS purchasing and development may provide solutions to develop and alleviate the bottlenecks of the certification process.

The scope of the thesis is set to study process theory, its typical use and how the theory can be utilized when modeling and developing the case study organization's activities what comes to mobile equipment certification, testing and the development of the whole activity. Also the analysis and development of the information systems in use in certification testing is within the scope of this study.

The research questions of the thesis are:

1. What kind of process there is in place at the moment regarding Nokia Product Certification in Radio Access area and what are its weaknesses and bottlenecks?
2. How can the process be developed in order to better meet both the current and the future ever growing demands what comes to Product Certification activities in Radio Access Testing area?
3. What can be done to the information systems in use in Radio Access certification to enable them to better support the process and its development and how to harness the IS suppliers in this?

1.3 Research methods and collecting the data

Where quantitative research methods were originally developed for studying natural phenomena in natural sciences, the qualitative research methods were developed in the social sciences to help in the research of social and cultural phenomena. Among the qualitative research methods are e.g. case study research, action research and ethnography. Typical sources of data for qualitative research include analysis of documents and texts, observation and participative observation, interviews and researcher's conceptions (Myers 1997, 241–242.)

Hirsjärvi, Remes and Sajavaara (2005, 125) define the case study research strategy as having detailed, intensive knowledge about a single case or small group of cases having some relation with each other. Yin (2002, 23) approaches the subject by stating that a case study empirically investigates a contemporary phenomenon within its real-life

context and is used especially when the boundaries between the phenomenon and context are not clear.

Case study allows an investigation to preserve the holistic and meaningful characteristics of real-life events such as organizational and managerial processes, individual life cycles and international relations (Yin 2002, 23). Experiment, survey and history are other research strategies defined by Yin (2002, 15). Case studies can be descriptive, explanatory or exploratory in nature, and they usually answer to questions such as “how” and “why”. These descriptions of the case study strategy support its use for this research. Furthermore, Yin’s (2002, 40) statement to use a single-case study when a critical or a unique case is tested against well-formulated theory, support the use of single-case study strategy. The research was conducted in a real-life and unique process organization which also supports the use of case study and its single-case type. The object organization of this study was selected naturally because the researcher worked at the time of the research for the case organization.

Documents and texts as well as the researcher’s conceptions of how things are truly done were the sources used when forming the picture of the current status what comes to the product certification process in Radio Access. Granfors (1982) states that there are four different states of researcher participation in his own research:

- Observation without actual part taking
- Participatory observation
- Action research
- Hidden observation.

According to Eskola and Suoranta (1998, 98-99), participatory observation means the collection of material where the researcher takes part, in one way or another, in the operation of the organization under research. This type of observation differentiates from the every-day observation in three ways which are valid in this research. Firstly, the researcher has to concentrate also on his daily routines in the community and can not focus merely in observation, as is the case in the normal full-time research. Secondly, the researcher stores the observations in systematical way. And thirdly, the researcher presumably has the required skills to conduct the observation and the analysis.

The three main organization charts used in document analysis are shown in Appendices 1 to 3. On top of these organization charts numerous written process descriptions and guidelines located in the company intranet pages were used in forming the holistic picture of the process (shown in Appendix 4). This process description was used as a baseline for discussions when conducting the theme interviews among different process stakeholders. Totally, ten people were interviewed, all involved in different parts of the process. This strategy to have all the stakeholders interviewed was selected in order to get as thorough and comprehensive picture as possible from all the

process angles. The process chart was updated according to the received feedback during interviews in order to better correspond the real-life. The interviews were also used to collect information about the development needs and ideas, process bottle necks and the most typical problems encountered in the RA certification process.

All interviews were done individually in order to get interviewees' isolated and honest opinions about things and not to compromise them with other people's opinions or presence which may cause problems in group interviews. The interviews were recorded with the interviewees' consent to back up the written notes done during the discussions. The specialists interviewed were acquainted with the interviewing colleague enabling honest and relaxed discussions and profound dialogue. According to Eskola and Suoranta (1998, 86) in theme interview the themes and fields are predefined but the exact form of questions and their order are not fixed. Hirsjärvi et al. (2005, 197) continue that theme interview is widely used type especially in qualitative research because it corresponds to the foundation of the qualitative research. The base questions used in the interviews are presented in Appendix 6. The questions were made in the form which acted as a basis for the discussions and they were specified or expanded more if found necessary. Theme interview was the type selected for the interviews in order to have more room for maneuvers and capability to steer the discussions because of different interviewee backgrounds and knowledge of the process parts. The questions were divided into two sections. The first section was to canvas how the process was experienced in operation and the other section was to find out if the people had some ideas of how to improve the process.

According to Hirsjärvi et al. (2005, 218) the validity of the research can be focused better by using several research methods. This use of multiple research methods is called triangulation. Eskola and Suoranta (1998, 68) argues that by using only one research method it is difficult to have extensive picture of the research subject. Furthermore, one method only provides a view from one angle and remedy for this is to use multiple methods. Out of the four different types of triangulation presented already in 1970 by Denzin, the best fitting type for this research was the method triangulation. In this research the different data collection and research methods were the earlier presented document analysis, participatory observation and interviews.

1.4 Structure of the thesis

The thesis is divided into two main sections discussing the research object. The first section, having two separate chapters two and three, constitutes the theoretical and scientific part of the research. The second section, including two succeeding chapters four and five, forms the empirical part. The other chapters of the thesis, including the

introduction, result and conclusion presentation and the summary, bundles up the whole written part of the research.

Chapter one introduces briefly the research object and the case organization. It also justifies the research by setting the background to it; organizations need to constantly improve their operations and processes to stay ahead of the competition or simply in order to survive. This chapter introduces the aim of the research as well and presents the essential research questions based on it. Also the research strategy and methods chosen for this study are presented along with their justification. In the last sub-chapter the summarized structure of the thesis is described.

Chapter two, first of all, defines the concept of process by introducing its different definitions among academic researchers. Different process types are presented as well as the usual process problems experienced in different organizations. The chapter also presents methods of process performance measurement and concludes with the introduction of process development and improvement.

In chapter three the information system (IS) development and procurement what comes to the case organization requirements is presented. The chapter includes researchers' conceptions and guidelines about the effects and characteristics of IS and the selection between own system development and procurement. It also reviews the planning of the information systems in organizations and presents the scientific view of the IS purchase preparation.

Chapter four includes the introduction of the case organization and its function. The whole certification process is walked through with the parts included in the scope of the research by presenting and combining the data from different sub-process descriptions and using the results of participatory observation. Also the most critical and error-prone or promising development parts of the process are presented.

In chapter five the material gathered from the interviews is introduced. The impressions and opinions of the different stakeholders about the current RA certification process are presented. Also the process bottle necks and weak points according to the interviewees as well as the development ideas are shared.

Chapters six and seven include the result review and analysis of the research. Also the answers to the research questions are formulated and the requirements of further studies considered. Chapter seven wraps up the whole study and summarizes the most important findings of the research.

2 PROCESSES AND THEIR DEVELOPMENT

2.1 Process definitions

A Process (lat. Processus – movement) is naturally occurring or designed sequence of changes of properties or attributes of an object or system (Wikipedia, 2008.) Muller (2007, 1) states:

> *A process is an activity which takes place over time and which has a precise aim regarding the result to be achieved. The concept of a process is a hierarchical which means a process may consist of a partially ordered set of sub processes.*

Collins English dictionary (2000) defines process as: "A series of actions that produce a change or development" or when used as a verb the description is: "to subject a routine procedure". There are many different definitions for processes and process development in the academic literature and they are somewhat overlapping. (process redesign, process re-engineering, process innovation, process management etc.). The views about processes among scholars and researchers are listed next in order to provide some examples of how differently and then again similarly they see this challenging type of organizing things in companies and organizations.

Earl (1994, 13) defines the process:

> *"it (the process) focuses on activity and is an organizational unit of analysis or frame of reference. Essentially a lateral or horizontal organizational form, process encapsulates the interdependence of tasks, roles, people, departments, functions etc. that is required to provide a customer with a product or a service."*

Garvin (1998, 33) argues that: "Processes, when described in the broadest sense, are collections of tasks and activities that together – and only together- transform inputs into outputs". Hammer and Champy (1993, 25) think that business process is a collection of activities that has one or more kinds of input and creates an output that has value to the customer. Vanhaverbeke and Torremans (1999, 42) emphasize further the customer part by stating: "Processes are at the very heart of every organization because they are the means through which companies create value for their customers. Big processes like development of a product or manufacturing almost always draw on multiple functional skills." They continue by stating that business processes are central to the functioning of an organization and have long been neglected in managerial studies mainly due to the fact that departments in companies are structured in a

functional or product oriented way. Laudon and Laudon (2000) use processes as means to link strategy to operational activities. Davenport and Short (1990, 12) define business process as series of logically combined tasks which are carried out in order to reach a predefined business outcome. Harrington (1995, 36) has the same value-adding view as he defines the process as an activity or series of activities which by adding value to it, provides an output.

Rummler and Brache (1995) state that processes are cross-functional, covering the space between the boxes on the organizational chart and often falling into the cracks between different functions. The term process can be used as a complementary word to business process (Kueng 2000, 70).

2.2 Processes and their challenges

2.2.1 Process usage

Process-based companies have become fashionable during recent years because they are a powerful answer to the problems which functional and product-oriented firms face (Vanhaverbeke & Torremans 1999, 51). In fact the way companies organize themselves and do business has become obsolete. The traditional procedures, functions and hierarchy served corporations well when the environment was fairly stabile but current continuously changing environment requires more flexible and adaptive capabilities and radical change in how things are done. (Cross, Earl & Sampler 1997, 401.) Process perspective enables a convenient, intermediate level of analysis in the organization by combining and integrating the trees (individual activities and tasks) and the forest (the organization as a whole) whereas in many other methods of studying organizations that part has been a problem. (Garvin 1998, 34.)

By its nature the process perspective provides a suitable and intermediate level of analysis for the operation of the organizations. It helps in opening the black box of the organization in a way that takes both the individual tasks and the organization as a whole under the scope. A process perspective enables the required integration ensuring that the realities of work practice are linked explicitly to the overall functioning of the organization. (Garvin 1998, 34)

2.2.2 Process types

Vanhaverbeke and Torremans (1999) divide the processes into *value adding processes* which create value to the external customers and *enabling processes* whose customers are within the organization e.g. IS and HR (human resource) processes. Garvin (1998) places these processes among work processes in their model and names them as *operational processes* and *administrative processes* but they are based on the same meanings. Hammer and Stanton (1995) knits these processes together by stating that although the enabling processes do not create value to the customer, the value adding processes can only achieve competitive edge if they are supported by agile enabling processes. Next the Garvin process categorization is described in more detail.

There are three categories of organizational processes according to Garvin (1998):

1. *Work processes* focus on accomplishing tasks by linked chain of activities cutting across departments and functional groups. In this category there are two different process development movements; the quality movement which argues for incremental improvement and the reengineering movement calling for radical change in the functions of the organization.
2. *Behavioral processes* focus on ingrained behavior patterns which reflect an organization's typical way of acting and interacting. They profoundly affect the form, substance and character of work processes by shaping how the behavioral processes are carried out. This category has three segments: decision-making, communication and organizational learning process which all involve the collection, movement and interpretation of information along with forms of interpersonal interaction.
3. *Change processes* focus on sequences of events over time. These sequences, or processes, describe how individuals, groups and organizations change, grow and develop. Change processes can be autonomous, where the entity evolves naturally and of its own course, or they can be induced where the direction of the change is predetermined and inevitable. Moreover the change processes can be incremental or revolutionary depending on their required impact to the organization.

Vanhaverbeke and Torremans (1999) distinguish two (2) more types of processes on top of the *Customer processes* and *supporting processes (staff and service processes)*, described earlier. 1) *Development processes* such as product development and technology innovation which allow organization to work effectively on a longer time horizon. Customer and development processes form the basis on which the organizational units are centered. 2) *Planning and control processes* include processes that are linked to the execution of the customer and development processes and processes which assure that the separate parts of the organization function as whole. The

latter part is extremely important because there lays the biggest resistance towards change which requires different role of management and its supporting staff.

Earl (1994, 7-8) has divided the processes to *Core processes*, *Support processes*, *Business Network processes* and *Management processes*. The *Core processes* relate straight to the value chain and *Support processes* have internal customers acting as back-up for the core processes and can therefore be considered as being in analogy with the previously introduced value adding and enabling processes. *Business network processes* reach beyond the organization boundaries into customers, suppliers and partners and the *Management processes* are used for planning, controlling and organizing the resources of the organization.

2.2.3 Problems related to processes

There is a natural law that if processes are not continuously and incrementally adjusted and improved, they will deteriorate to a point where they stop functioning. In order for a process to exist, one must identify why the process is required and why people should be involved. If the need for a process cannot be identified, incremental improvement is not required, and there is no need to involve people, as the process has any reason to exist. The same principles of a process theory exist among different kinds of processes. If e.g. the pressure in a water pipe is increased, the flow will increase to a certain point. After this point no further increase in flow is experienced irrespective of how much pressure is applied. Instead, the temperature increases and as this happens, the pressure will also increase. Without control reducing the pressure, the process will destroy itself. The same process phenomena can be seen in a business process. If the pressure on employees is increased, the workflow increases to a point. Behavioral instruments indicate that once a certain rate of workflow is achieved no further increase in flow is experienced, irrespective of how much additional management pressure is brought to bear. Instead, behavioral temperature increases and as that happens, it further increases the pressure. Without control to reduce the pressure, the workers will destroy the process. (Van der Merwe 2002, 407-409.)

According to Kiraka and Manning (2005, 288-289) process-based perspective is a challenging way of managing organization and the winnings of transforming it do not come easy. In fact there are many potholes along the way and many organizations have made only partial or marginal improvements, some have failed completely, because of these problems. The problems have been traced to two main issues. One is the difficulty of identifying the processes and the other is the managing and the redesigning work itself.

The reasons for organizational process identification difficulties are because they have often unknown quantities, have no names, and are not presented in the organizational charts. The processes are also cross-functional, spanning the white space between the boxes on the organizational charts and therefore it is advised to view an organization horizontally in order to truly understand the way how work gets done. On top of those, processes usually have no defined boundaries making them difficult to identify. Next three components of organization are presented which help in identification of processes. (Kiraka & Manning 2005, 289-291.)

- Clearly defined strategy as processes have strategic relevance. Processes are the way through which the strategy is implemented.
- Clearly defined end-users. Processes are set to produce value to the end-user.
- Resource base which is either existing or potentially available.

If some or all of these components are not clearly stated, the process identification becomes increasingly complex and uncertain.

Crabtree, Rouncefield and Tolmie (2001, 164) note that there are remarkable situated work practices, where the processes are produced, making it difficult to identify processes. Sometimes organizations draw charts of their processes attempting to identify a definitive way to conduct a particular activity. However, such a perception becomes obsolete as organizations realize that the best practices come from ad hoc action considerations and work practices not fitting to well-designed process chart. This means that numerous contingent considerations such as costs, increases in workload or the number of managers concurring with the particular process exist in arriving at a process. Managers need to define the processes in their organization, based on their existing and tried work practices.

Kiraka and Manning (2005, 290-291) continue by stating that the issues causing problems in managing and redesign work are because of insufficient emphasis on the critical role of stakeholders determining process initiatives and outcomes. They emphasize the internal strategic and management capabilities and decisions in process organizations but also point out the existence of external factors that affect the process outcomes and determination. A holistic approach is needed towards process initiatives involving elaborate planning and critical conceptualization.

2.3 Process performance measurement

Regardless of the dramatic changes in the business environment, performance measurement systems have been partially neglected: management assess enterprise performance mainly through financial measures leaving the non-financial aspects such as customer and job satisfaction out of the equation. Furthermore traditional

measurement systems fail in distinguishing control from improvement or relating performance to the process. According to Kueng (2000, 67-69) in order to address these problems many scholars have developed their own approaches and techniques to measure process performance. These techniques are presented shortly next.

- Balanced scorecard (BSC). A strategic management instrument clarifying and translating vision and strategy, communicating and linking strategic objectives and measures, planning and setting targets and enhancing strategic feedback. It is a tool for describing an organization's overall performance across a number of measures on a regular basis. BSC is focused on organizational units, not on business processes.
- Self-assessment. This method offers benefits such as objective identification of current strengths and improvement areas, provides useful analysis of organization's capability and helps in creating a vision to counter organization's tendency to skip from one initiative to the next.
- Workflow-based monitoring. Workflow systems support automatic or semi-automatic process instance execution, communication between process actors and coordination between process activities. As a by-product, a mass of data is collected and it can be exploited by automated evaluation. Workflow-based monitoring concentrates on business processes and has a character of real-time reporting.
- Statistical process control (SPC). SPC uses statistical methods of measurement and analysis of variation in the processes. Possibilities to make reliable predictions about e.g. product quality have become an important tool of competing.
- ISO9000 certification. Guarantees that enterprises execute their business processes in a specified and controlled manner.

The modern performance measurement system should focus on processes and not on the whole organization and it should evaluate the performance holistically by measuring both quantitative and qualitative aspects. In the Figure 1 some of the different measurement approaches are presented in terms of scope and focus.

	Focus on Corporations or Business Units	**Focus on Business Processes**
Wide-angle lens (quantitative & qualitative aspcets)	Self-assessments Balanced Scorecard	Process Performance Measurement System
Zoom (mainly quantitative aspcets)	Traditional Controlling (e.g. ROI)	Workflow-based Monitoring Statistical Process Control (SPC)

Figure 1 Different performance measurement approaches (Kueng 2000)

Process measurement is a necessity for modern process-oriented organizations although there is not any universal set of indicators that can be applied to all business processes. Performance indicators must be process-specific and derived from both strategic and enterprise-wide goals and process goals. The measurement itself does not show the actions that are to be taken to improve the processes but it gives the process a clear direction, identifies areas of weakness, evaluates the process performance comprehensively and assesses the impact of previous process changes.

2.4 Process development and improvement

Many continuous process improvement initiatives put emphasis on process improvement. The whole organizations are looking for, and implementing, improvements to all work processes. These improvements tend to be small and focused on improving the existing system. Valiris and Glykas (1999, 66-67) state these improvements as being incremental and focusing on simplification by eliminating non value adding activities in order to achieve lower throughput times and best re-allocation of resources. The same researchers name the more dramatic mode of improving the

processes as radical mode and state that the redesign and rebuilding of the processes will usually emerge from the application of industry best practices, achieved with the use of benchmarking. The process reengineering is based on the premises that the companies need major breakthroughs in performance in order to leapfrog their competitors. The differences between improvement, redesign and reengineering are presented in the Figure 2.

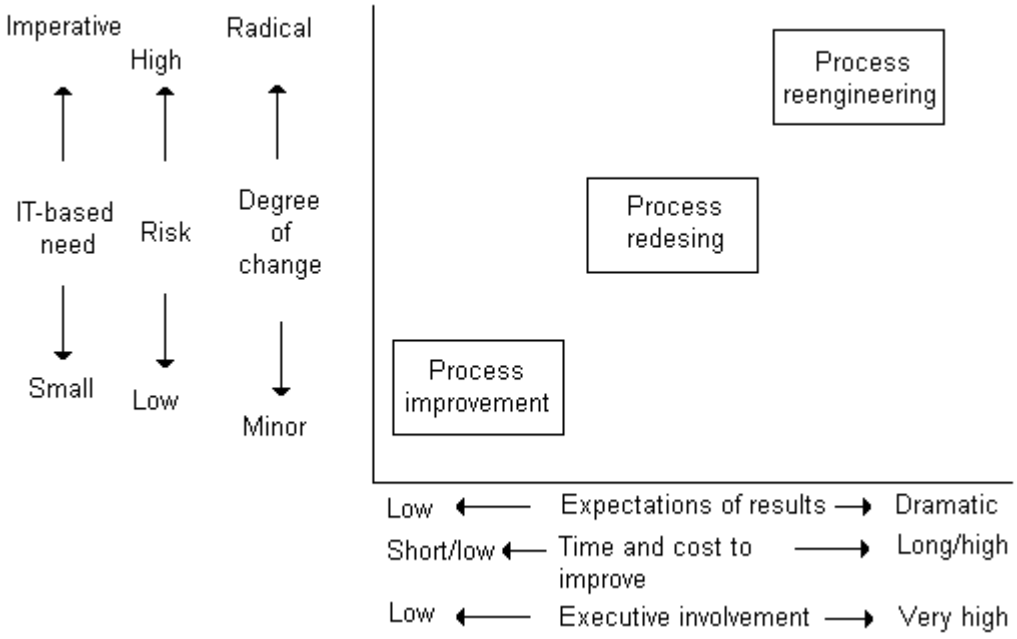

Figure 2 Differences between process improvement, redesign and reengineering (Macdonald 1995)

It is noteworthy that when the process improvement approach requires minimal investments and contribution, the results are not expected to be high. Furthermore, the investment requirements and risks are higher with redesign and reengineering approaches but at the same time the results are expected to be much better and change more radical.

A method of analyzing and designing the work flows and processes within and between organizations is called Business Process Redesign or Reengineering (BPR). Macdonald (1995, 21) states that the BPR is a common-sense evolution in an umbrella philosophy used for all business improvement initiatives, Total Quality Management (TQM). BPR uses the new tools of information technology in business process reengineering. Teng, Grover and Fiedler (1994, 95-97) continue and state that information technology can be used to improve organizational efficiency and effectiveness by eliminating administrative intermediaries, delays, redundant processing steps and by providing improved access to information. BPR strives for optimal use of

technology to support business tasks and facilitates a more rational and natural alignment between IT and organization.

According to Shin and Jemella (2002, 353) BPR brings fast and radical changes to business processes. They categorize the process development projects to three parts: quick hits, incremental improvement and reengineering. *Quick hits* have typically low risk level and their goals are easy and fast to reach. Nevertheless, the quick hits have big influence on the morale and motivation of the process development team to continue the project. *Incremental improvement* focuses on small issues which provide little but important improvements. *Reengineering* on the other hand aims for radical business results with breakthrough thinking. This form of organizational change is described as a dramatic process transformation.

The reason behind the need to reengineer the processes in the organizations rises often from the management's concern about the significant gap between actual and desired business results. After the management's initiative to make radical changes to the processes, the problem solving can begin but not without true commitment and sponsorship of the management to the endeavor. Shin and Jemella (2002, 353-360) segments the BPR methodology to four phases: energize, focus, invent and launch. Their outlook is introduced next.

The first phase, *energizing*, is about taking the initiative and mobilizing the reengineering for action. In this phase the executive sponsorship is solidified, the project organization established and the commitment to initiate the project is made. The deliverables of the energizing phase include a justification and reasoning for the reengineering, the definition of project organization and plans about the project and the communication.

The second phase, *focus*, includes a careful study of the current process, organization and the technology as well as the financial components. The deliverables of the phase are process diagnosis, the entry points from where the most gains and benefits can be derived in reengineering the process and the quick hits found. In this phase the management and staff is interviewed in order to find out the weighting of the three major ways the organization is competing in the market; cost, value and competence. Also the feedback from the customers is collected to see how they see the organization and what would they want to be developed. A major aspect of the focus phase is the simultaneous assessments of the process, organization, financial aspects and information technology. Process assessment includes the analysis of the process and search for improvement opportunities such as redundancy elimination, cycle time reduction, error elimination and standardizing. The information technology assessment covers the identification of IT that will provide significant business value to the organization such as the value of the new information technologies, identification of the

information technologies and the organizations readiness to use them and elimination of the low value information technologies from further considerations.

The next phase, *invent*, is about determining the look the business system should have. Almost half of the project time should be spent on this BPR phase. In this redesigning phase there are two components: how the goals set by the executives are met and how to fundamentally rethink the work gets done in the organization. The redesign is done in two sequences; brainstorming by using out of the box –thinking and setting the ideas to the reality.

The last phase, *launch*, represents the culmination of the BPR process. It identifies the tangible and intangible benefits of the development and evaluates the risk factors of the project. The risk factors entail the review of the project possibility to get done and the technology proposed. The goal is to identify the projects with high net benefits and with low risks.

Valiris and Glykas (1999, 66) present their view of the redesign process split in five phases:

1) Setting the business vision and objectives
2) Identifying and focusing on the core business processes that support the set objectives
3) Modeling and analyzing the business environment
4) Streamlining
5) Controlling and improving constantly the previous steps.

They also introduce two perspectives in BPR; Management accounting perspective and Information system development perspective shown in the Figure 3.

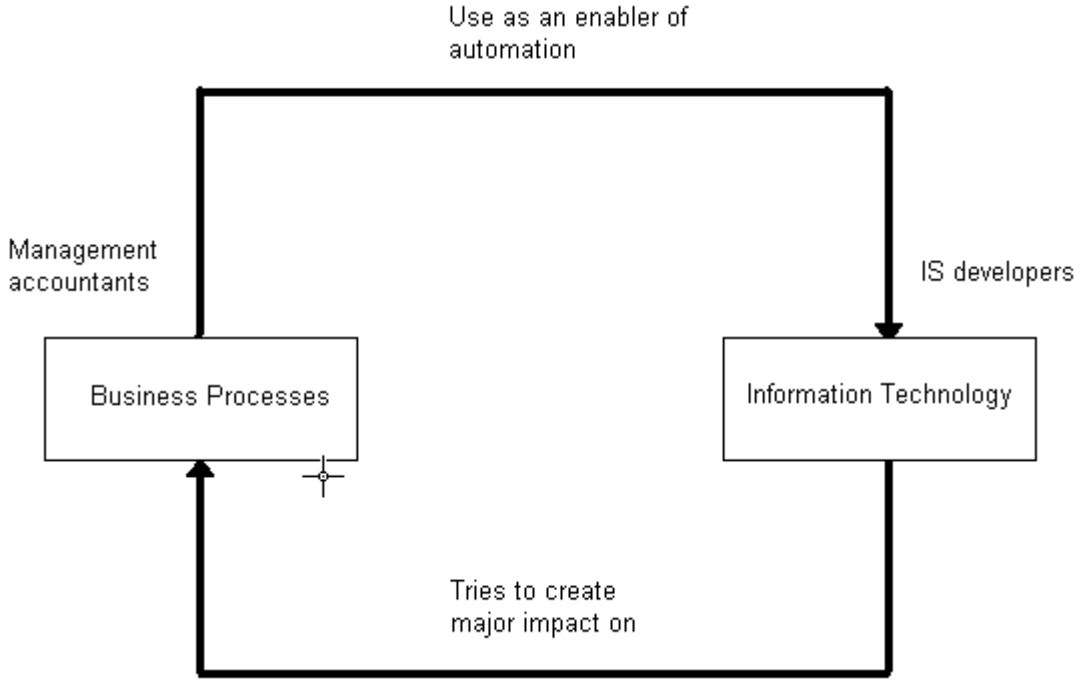

Figure 3 Two approaches in BPR (Valiris and Glykas, 1999)

In the management accounting perspective the analysts use IT as an enabler for attempting to reorganize the business process whereas in information system development perspective the IS developers need to understand and possibly reorganize the processes to enable the biggest possible impact of the introduction of IT. Redesigning can be achieved in two modes: incremental and radical. These modes presented by Valiris and Glykas deviate slightly from the definition of Shin and Jemella (2002), presented earlier in this chapter. Valiris and Glykas state that the incremental improvement is about improving the processes by simplifying the existing parts usually by eliminating non value adding activities in order to achieve lower throughput times and best allocation of resources. And according to them the radical redesign mode is about the application of best practices achieved by means of using benchmarking. Furthermore, the radical redesign will challenge the existing organizational framework and might require the introduction of new technology despite the impact this might have on the behaviors and attitudes of the personnel.

3 INFORMATION SYSTEM DELIVERY

3.1 Acquiring or developing information system

There is an ever-increasing amount of different software products in the market for various purposes with which enterprises can empower their operation. There also is a big bunch of enterprises offering tailored solutions for specific information system needs. Nevertheless almost without exceptions, implementation of ready-made, off-the-shelf software products need some degree of customization and tailoring from the supplier in order to get them function properly in their real environment. It is therefore difficult to make a difference between using ready-made software and operating with a development project. (Kettunen 2002, 37-39.) The so-called packet solutions offered by the software vendors provide options to run the basic operations of businesses. This means that their functions are standardized and they are not suitable for every organization without some degree of alternation of the system or the business processes. (Forsman 1995, 86-90.) It should be noted though that no matter how attractive market purchasing may seem, the limitations of it should be correctly understood in order to maximize its advantages (Saarinen & Vepsäläinen 1994, 188).

Usually choosing between these two options is based on the costs, lead-time and customization as well as the tailoring needs of the system. Simple answer to which solution to use is impossible to give because some functionalities can be covered using ready-made softwares and some specific needs require tailored development projects. (Kettunen 2002, 37-39.) According to Saarinen and Vepsäläinen (1994, 187) a system, which is company-specific and holds high uncertainty, should be developed internally in order to enable specific knowledge and intensive interaction between developers and users that they require. With more standard requirements of the information system it is preferred to use outside consultants or software vendors having knowledge and experience about similar types of systems.

Sometimes software packages are not so easy to implement as the vendor’s marketing material suggests because they have made assumptions about the management philosophy and business practices during the development. By accepting this fact and planning actions accordingly during the implementation the problem can be kept under control. (Laughlin 1999, 33.) The truth is that there is no single best package solution. There might be three to four packages that can offer 80-90% of all the information and transactional needs but none can offer 100%. (West & Shields 1998, 5.) More than finding the best package, it is all about selecting a strategic business partner. It is a way of being ready for the future needs in addition to the current ones. The most

important point is to get top management committed to this process. It is about having management's commitment to technology, which enables the change in organization, and letting the vendor drive the technology decisions rather than requiring that own IS (Information System) department make these decisions. "The senior management team must accept the fact that the enterprise will have to conform to the application and endorse the implementation. If it can't, then it should abandon the effort". (Laughlin 1999, 33.)

The product selected has a crucial role in driving key business and technology directions for a long time and it will be a technology enabler of the company. That is why these issues should be addressed in the strategies of the organization at the top levels. The vendor of the system will become a strategic partner of the organization for years so the selection should also investigate and evaluate the vendor's capability to support the future needs of the organization and drive the use of the future technology in order to support business processes. (West & Shields 1998, 7.) IS–strategy planning produces a portfolio of IS, that assists organization in executing its business plans and realizing its business goals. IS planning is identifying the most valuable IS projects. Organizations seek applications that provide higher payback, strategic significance and are in line with the organization's competitive needs. (Salmela & Spil 2002, 443.) Rapid technological development in many fronts has made it less feasible for the companies to keep in-house all the technological expertise they need to compete. To solve this challenge, companies are increasingly turning to outsourcing – using outside suppliers for IT related services that were previously supplied internally. The spectrum of products and services ranges from routine articles like computer supplies and software licenses to highly specialized and customized development projects. Similarly, the gamut of different possible supplier relationships ranges from purely transactional, price-based interactions to highly interdependent partnerships and alliances. In order to maximize the business value of purchased IT products and services, powerful supplier management strategy has become a critical component of the information management function. (Heckman 1999, 142.)

3.2 The effects and characteristics of the IS

IT purchasing effects reach usually throughout the whole organization. Therefore it is difficult to clarify the direct affects not to mention the indirect ones. A system serving only one department in the enterprise may have effects on how the whole company and its customers and suppliers operate. (Karvinen, Reponen & Vehviläinen 1994, 27.) Leading enterprises are aware that wisely executed IT purchasing is a strategic business activity and when properly organized, it can enable businesses to acquire IT assets and

services in a more efficient and cost-effective way. Costs can be reduced and the speed of implementing IT projects and initiatives increased. Well-executed IT purchasing can provide organizations competitive advantages to capitalize the opportunities in reducing costs and making implementation more efficient. In the past, technology products were purchased directly from vendors and the focus was on adhering to purchasing rules and procedures with the primary goal of biggest possible discounts. (Mac Neela, Mein & Disbrow. 2004, 4.) From suppliers point of view the cooperation with the customer was cut down to minimum and to a ready-made software delivery process. Cost efficiency won the reasonable thinking of making profit. (Ahlstedt 1996, 22.) When IT infrastructures became more complex, thinking of the need of services and integration come in to play when buying IT products. Seamless integration of products into firms' infrastructure was the aim and handling the purchases this way is still common in many companies. (Mac Neela et al. 2004, 4.)

The purchasing approach is set to change again and there will be more strict focus on acquiring technology through long-term relationships with a few vendors. There has been a trend for many years to reduce IT suppliers but now enterprises are moving to strategic purchasing by consolidating their technology suppliers and the relationships with the remaining ones will be more critical. This means that IT buying behavior will have to, and has already, changed. IT purchasing departments are regarded as low-value, administrative cost centers in many firms and IT buyers seen as procedural obstacles rather than value adding contributors to IT buying processes. Difficult economic conditions have led the enterprises to reappraise the role of their IT purchasing aiming only on cutting costs and not increasing business value. When IT purchasing evolves towards buying relationships it must also change into value adding strategic activity. Purchasing organization's goal would shift from getting the biggest discounts from vendors to choosing the right vendor relationship. (Mac Neela et al. 2004, 4).

It is typical for information system purchases that they are originally intended to be only minor investments but soon realized to be line decisions for long-term cooperation. The same applies with their life span. Typically the quickly done investment decision on information system, originally planned to be used only a few years, is still in use after 15-20 years. Therefore the most practical way is to be prepared for quite short life span but aim to use the investment as long as possible. (Karvinen et al. 1994, 28.)

Information system is a sociotechnical entity, which means it is an arrangement of both technical and social elements. New information system is much more than just new hardware and software; it includes also changes in jobs, skills, management and organization. It is not wise to install new information system without thinking about the system users' needs. When designing a new information system the organization is actually redesigned. Systems can be technical successes, but organizational failures

because of failure in the social and political process during the development of the system. (Laudon & Laudon 2002, 305.)

IT-professionals and their customers need to establish ways to communicate with each other in order to make sure that the investments are successful. It is easier said than done because the ability to understand customer needs is one of the biggest weaknesses among IT-professionals. It is vital that the communication starts from the very beginning of the information system purchase process and continues all the way through the endeavor. (Karvinen et al. 1994, 28.)

3.3 Information system planning

Information system purchases should be based on determined work with enterprise IS-strategy as a guideline. IS-strategy defines central teleinformatic solutions of the enterprise, their use, development plans, resourcing and barometers measuring efficiency and success of the operation. When building an information system, there are two possible starting points. In the first alternative the organization has a certain need for an information system. To fulfill this need, the requirements should be defined and using the requirements as a framework, the information system project is started. In the other possible starting point the organization wants to explore more extensively its current teleinformatic status. When a company starts doing this it is good to be open for all thoughts and suggestions. The goal is to define information system aggregate needs for the problem from the development point of view. As a result of the planning, there are a bunch of problems and suggestions to be solved with particular information systems. With the first starting point the enterprise has a clear view on what kind of systems are required and what is their execution priority. The planning is then done by focusing on only one, beforehand defined, information system purchase. This can be done if the organization has a clear IS-strategy with defined information development needs. (Kettunen 2002, 53-54.) The objective of four cycles –model (Salmela & Spil, 2002) presented in chapter 3.4 is to establish a continuous business planning process and to make sure that all critical aspects of IS planning are addressed periodically. This cycle-model can be used also when planning information systems.

Forsman (1995, 51-57) divides the information system needs into two different sections; external and internal pressures. These pressures come from the circumstances in which companies are operating. The environment is constantly changing and the company is adjusted to it accordingly. The operation has to be kept modern and the business competitive. The most important external pressures are competitiveness and information technology development. Competitiveness requires that the central operations are at least as well handled as they are handled by competitors. Following the

information technology development progress is also vital in order to be able to boost operations when new, more efficient and vast applications are introduced in the market and to turn them again to competitive advantages. New information system solutions are coming to market in a continuous stream and the only sure way for the companies to keep up with the development is to constantly follow the progress from the core process point of view. This requires constant, own development effort, sometimes with lower, sometimes with higher profile. The most important internal pressure stems from the need to be profitable. It is vital for the company to find development ways for internal functions and for that information systems offer good possibilities. Examples of internal pressures driving for new information systems according to Forsman (1995, 54) are:

- Increasing working safety by eliminating dangerous or mundane jobs
- Demanding faster information flow in the organization
- Opening process bottle necks
- Decreasing labor force
- Improving employee motivation.

Rather typical starting point of information system project is the need to change the existing system. That need could be either internal or external. An example of this situation could be a payroll system, which needs to be changed because of changes in legislation or labor agreement contracts.

3.4 Phases of information system purchase preparation

3.4.1 The importance of the different phases

It is important to prepare the ground for the purchase project thoroughly because if the organization has not defined sufficient internal requirements for the system, the phase of asking competing quotations from suppliers will probably fail. This is because the quotations will be inaccurate and incomparable in order to make the right purchase decisions. Also the project schedules and budgets are in a risk to be overrun if this phase is overlooked. This phase model describes the tasks to be done before the actual information system building up begins. (Kettunen 2002, 65-67.) The right order of executing things is crucial for the system's success. If these tasks are done in a hurry and some phases skipped, the outcome could be fatal. There is an old saying in IT-business stating that all the tasks during the development phase of system work must be gone through and it is cheapest to do them in the right order (Forsman 1995, 71.) Usually information system projects are old system upgrades, further refining

developments or replacements, having plenty of more information available about the requirements than with completely new systems. The information system purchase preparation starts from realizing the need for the new system analyzed in Chapter 3.3 and then carefully planning the background tasks before starting the build-up project. The project-planning preparation model includes phases described in the Figure 4.

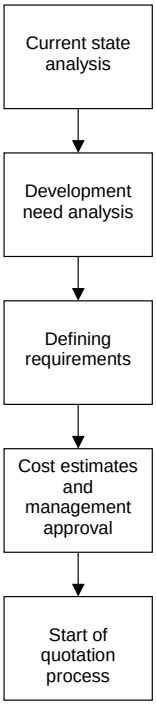

Figure 4. Phases of Information system planning process (Kettunen 2002, 67)

This model of Kettunen applies also if the organization has detected their information system needs. In that case, phases starting in chapter 3.4.4 described next and onwards are to be followed. Next phases are based mainly on Kettunen (2002, 68-80) and supported with Four cycles -method of Salmela and Spil (2002) and views of Seilheimer (2000) and Saarinen and Vepsäläinen (1994).

3.4.2 Current state analysis

Before starting a new information system purchase process the analysis of the current state should be done. As a result there is a short and compact description of the current environment in the organization. It gives, among other things, important information to suppliers about the environment and development needs of the infrastructure. Current state analysis includes information about data management organization and resources, current teleinformatic architecture and softwares, lists of hardware components and

servers, information about telecommunications and their suppliers, outsourced activities and system integration needs. (Kettunen 2002, 68.)

Salmela and Spil (2002, 448) use, in the first cycle of their Four cycles -model for formulating information system strategies, three planning tasks that are applicable also when doing analysis in the starting point of information system purchasing process:

- Result evaluation of the previous planning
- Scope setting for planning and objective selection
- Participant selection and planning approach adjustment.

In this first cycle of agreeing on planning objectives and stakeholders, managers are asked to critically assess the achieved results with the current information system. It is important to define the groups that need to be informed, interviewed or trained regarding the new information system.

3.4.3 Analyzing development needs

In every organization there are many teleinformatic development needs, which usually are limited to certain departments of the organization. These development needs should be considered bearing the whole organization in mind. When analyzing the requirements it is important to focus to think them through solutions. Solutions for the problems that are discovered should be written down during analysis but the focus should be in analyzing the problems and the development needs. After the analysis is ready, the software products in the market or the solutions offered for found problems are mapped. It also is important to think when there is a need to use own software development instead of commercial softwares. (Kettunen 2002, 69.) Differences between these two approaches are presented in the start of this chapter.

Salmela and Spil (2002, 452) define in the second cycle of their Four cycles – method, three planning tasks:

- Review of existing plans, documents and sources of information
- Analysis of business and technology issues
- Alignment of IS plans with business objectives.

This cycle is about aligning business and information objectives. Seilheimer (2000, 290) enlarges the issue by stating that this information analysis is to identify the problems that need to be solved and the decision rules and the assumptions that need to be utilized. In the analysis the solutions to be considered and data needed to be gathered are identified also and the presentation method of the way the information is presented to managers is thought through.

3.4.4 Defining requirements

It is natural that defined requirements depend on the viewpoint of the definer. Usually these requirements are divided into two main divisions: requirements defined by the customer and requirements defined by the supplier. Customer defined requirements include current teleinformatic infrastructure, functional objectives of the new system and exclusions. It may also include non-functional objectives like performance, maintenance capabilities or support availabilities. Supplier defined requirements are usually sharpened with teleinformatic solutions like servers, softwares etc. and focused with functional requirements. Defining the requirements is the most important phase effecting to the success of the information system project. Without thorough requirement definition of both parties (customer and supplier) and their approval, the projects have small chances in fulfilling the goals. (Kettunen 2002, 73-74.) Forsman (1995, 92) adds that when defining the requirements, it is useful to have users, representative from organization management and IT-experts involved in the process.

The importance of defining the requirements is emphasized because based on those, the suppliers prepare their quotations for executing the project. The better-defined the requirements are the better and comparable quotations can be expected from suppliers. Based on these quotations the customer makes the decision which supplier to choose. Usually the requirement document acts as a guiding document describing issues included in the system. Other things requested on top of that are to be invoiced separately. Based on the problems detected and goals identified in the current state analysis and different departments' needs of the system, the requirement document is written. (Kettunen 2002, 73-77.)

Salmela and Spil (2002, 453) define in their third cycle, IS resource analyzing and IT infrastructure of formulating information strategies, three planning tasks to be considered:

- IT infrastructure planning
- IT organization planning
- Preliminary project portfolio development.

Saarinen and Vepsäläinen (1994, 190) identify generic systems to be either routine systems common to many organizations with stabile requirements, standard applications, which have some variety and dynamics in their requirements or speculative investments with highly specific needs and requirements.

It usually is rather time-consuming to define the requirements and using consultants in this is usually recommended. When using consultants it is important to be prepared for supporting them along with supervising and controlling their operation in order to make sure that things go as agreed. The consultant should have special knowledge about

the technological field concerned but at the same time be independent of the suppliers in the business. (Kettunen 2002, 73-77.)

3.4.5 Cost estimates and management approval

After defining the requirements the organizations usually have a very accurate view on what kind of system to build and what acquisitions to be made. A precise budget cannot be done because there are no quotations yet. Price spread can be estimated rather accurately by using earlier teleinformatic purchases within the organization, consultant estimates, experiences of partners from similar systems and preliminary price inquiries from suppliers. In principle all the company's investment alternatives compete of the same scarce financial resources and therefore IS investments should be evaluated based on the expected yields compared to other sectors' forecasted offerings. (Forsman 1995, 57.)

Kettunen (2002, 77-79) states that, when estimating the total costs of the information system the construction costs, implementation costs and costs of system use are to be taken into account. Usually the major part of the total costs consists of the post implementation costs like user training, maintenance costs, external service costs and further development costs. Once the total costs have been calculated, the estimates of the system benefits and yields are to be defined. Based on them the payback time and profitability can be calculated. Often the benefits of the new system are very difficult to calculate monetary wise because the technology is more of an enabler than enhancer of the operation. Forsman (1995, 59-60) presents three more investment profitability calculation methods in addition to payback time. They are annuity method, internal interest method and present value method.

Management commitment is an absolute must in information system projects because it tells how important and useful the IS-projects are to the organization and that management sees and appreciates the business advantages they create. If the management is not interested enough in the project, there is a risk that the resources assigned for the project are inadequate or they are moved to another, more important use during project execution. Also during cost reduction activities the low priority projects are killed. One way to have management involved in the project is to have a company's management team member assigned to the project management. (Kettunen 2002, 79.)

The fourth cycle of information strategy development that can be used also in here consists of organizational implication identification, decision-making criteria definition and final decision authorization. The primary objective is to reduce potential conflict that might risk the implementation of plans. (Salmela & Spil. 2002, 455.)

3.4.6 Starting quotation process and selecting the partner

Kettunen (2002, 79-80) states that the start of quotation process requires time and careful preparation. Usually it takes longer than planned. Pre-elimination of the suppliers should be done first and the candidates chosen to which the invitation for tenders is to be sent. Forsman (1995, 95-97) adds that the difficulty with information system quotations is that they have to be similarly constructed in order to be comparable. If supplier quotations deviate from each other in their functionalities and extent, their comparison is impossible. Therefore a good background work in defining requirements is important. When the quotation process is done well it acts as a fruitful platform for efficient cooperation between the chosen supplier and the customer.

When determining which vendor to choose it is wise to search the company's financial results either from financial magazines, if it is a large company or incase of a small company, from financial data serving organizations. (Bannister 2004, 301.) More information on evaluating and selecting the business partner can be found in the next chapter.

3.5 Software vendor evaluation

3.5.1 Evaluation principles

Small companies and departments of bigger companies, due to their limited human, technical, and financial resources, usually tend to purchase packaged software, like accounting and inventory control packages, and the amount of investments are comparatively small. The manager of the department or the small company has a dominant role in collecting relevant information, discussing with potential vendors, doing selection analysis and finally making the selection decision. (Chau 1995, 72). Enzweiler (1995, 39) continues that there are a lot of different software products for all purposes in the market but the problem lies often in finding the best product for the particular purpose. Because of the big supply in the market, organizations should focus on finding the right product with the right features and scalability for their needs. The major problems according to Enzweiler (1995, 39) are:

- How to identify vendors worth evaluating
- How to identify the best software
- How to find the need of modifications
- Vendor terms are a mess, what are their true meanings.

These problems can be solved either by using effective evaluation workplan explained in the next chapter or using software consultant (Enzweiler 1995, 39). Traditional capital budgeting techniques like cost benefit ratio, net present value and payback period are generally not used when small businesses are evaluating their purchases. Instead the important factors in the owner's/manager's mind while choosing the packaged software may have descriptive variables like those related to the software, the vendor and the opinion given by the other concerned parties. (Chau 1995, 72).

3.5.2 Evaluation workplan

The first step is to create a team responsible for the software selection; other team will be responsible for the implementation. Four different tasks belong to the software selection stage; defining critical vendor requirements, defining critical software requirements, identifying the short list of vendors that are acceptable and selecting the software by evaluating the short list (Enzweiler 1995, 40) or giving points to the software based on the quotations, vendor abilities and skills as well as related hidden costs (Kettunen 2002, 113).

Usually teams in organizations are using RFPs (Request for Proposals) to document their requirements and obtain vendor information. Vendors are asked to compare the business requirements with their functionality and the team's most important responsibility is to find out which softwares are able to satisfy the requirements without heavy reprogramming. Most softwares today are designed to be flexible so that there is no need for reprogramming if only minor adjustments are needed to be done i.e. changing report formats and other forms or styles of displaying things etc. They can be tailored by altering the parameters in the software. Software functionalities throughout the industry are currently in a level that exceeds most of the organizations' requirements because software development has been going on over 20 years now and a lot of changes for a vast base of customers have been made. Software's technical design determines the platform on which the software runs. Client/server softwares are designed for open systems, meaning that there is vast variety of companies offering solutions to choose from. (Enzweiler 1995, 40.)

The problem usually is to locate the system supplier candidates. The buyers do not necessarily know the specialist suppliers and therefore can't ask quotations from the right companies. Therefore a background check is needed. One good source to find information about system suppliers e.g. in Finland is Tieke's (Tietoyhteiskunnan kehittämiskeskus ry.) Pertti-databank. It is a database for IT-product- and service suppliers and subcontractors. Other sources of finding potential suppliers are of course the Internet and IT-magazines. One very good way to make contacts with different

companies is IT-seminars because there, it is possible to discuss and network with different company representatives. (Kettunen 2002, 105-106.)

3.5.3 Critical vendor requirements

According to Kettunen (2002, 122) the purpose of defining critical vendor factors is to develop evaluation criteria that have quantifiable measures to find an acceptable business partner. The buyer needs to make sure that the software satisfies the requirements after the vendor is accepted as a business partner. There are a number of risks involved in choosing a partner and the biggest is the long-term viability of the partner. These factors help in quantifying the amount of risks the organization is willing to take. The factors that are useful to consider according mainly to Kettunen (2002, 122-123) are:

- Vendor history. If the vendor is quite new in the market there can be a risk of them promising something they can't keep or they may not success at all (Enzweiler 1995, 42). It would be good if the system being sold is on the core of the suppliers business so that they have the world class competence and resources enabling them to support and develop the system further (Kettunen 2002, 122-123)
- Vendor size. Revenue, number of employees and customers give information on how big resources the company has to serve their customers and how they have succeeded in it in the past
- Financial stability. In addition to customers served in the past, vendor's predictions about the future provides information on what to expect from them
- Channels of sales. Channels of purchase may play important role in some cases when choosing a vendor. Possible sales agents have their own pros and cons
- Service for implementation. Possibility to use vendor's staff in implementation may be of big importance to some organizations (Enzweiler 1995, 43)
- Change and Risk Management. The proper preparing for risks and how to handle them is vital and a good supplier have those issues under control in their plans (Kettunen 2002, 122-123).

In this phase a lot of the costs of the software are determined. Large vendors with big offices, large sales and marketing staffs, specialists and software developers cost the most. Small vendors use third parties to handle parts of their functions like sales and implementation services. (Enzweiler 1995, 43.)

3.5.4 Critical software requirements

The critical software requirements includes three issues; functionality, flexibility and specifications. Functionality comprises of sophistication and integration of the software. Sophistication means the level of functionality for which size of businesses the software is designed for. Level 1 is for small businesses and it runs on one PC and/or LAN. Level 2 is for medium-sized businesses and Level 3 is for large businesses running on mainframes. By integration it is meant what is the width of vendor's product line and what functions are needed in the system e.g. budgets, general ledger, HR, logistics etc. so it categorizes the level of integration between different functions in the software and in the organization. (Enzweiler 1995, 43.)

Flexibility requirements mean simply the number of editable parameters in the system and tools available to customize the software. The more parameters there are to change, the more flexible the software is. Especially client/server softwares are known for their unlimited flexibility and every requirement unique to a business is driven by parameters. Different tools are used to customize reports, queries, forms etc. and tailor the software during implementation as well as maintain the software once it is in operation. (Enzweiler 1995, 43.)

Specifications consist of the platform specifications the software is designed to be run on like OS, network, servers, database etc. (Enzweiler 1995, 44). According to Gell, Madjaric, Leodolter, Köle & Leitner (2002) in addition to requirements mentioned above there are a few more data processing issues regarding software evaluation that needs to be assessed. These include data protection, general quality issues, reliability and performance as well as software maintainability.

3.5.5 Identifying and evaluating the short list

The vendors who satisfy organization's critical factors and critical requirements are acceptable business partners. They are the ones who are in the short list. Usually only two to three vendors make it this far and the evaluation team can be sure that every potential business partner is in the list. Next, the objective is to find out how the softwares satisfy the organization's functionality and flexibility critical factors. Best way to do it is to get an evaluation copy of the software and install it. If the evaluation copy is not possible, then vendor demonstration is an alternative. When using the demonstration it is useful that the vendor walks through the whole implementation work plan and shows all the parameters to be set up. It takes some time and probably is a bit boring but it is the way to see if all the requirements are satisfied. All user defined parameters required in the set up and other tailoring options need to be documented in

order to be able to evaluate the training and implementation effort. In the demonstration or using demo version of the software the performance can also be evaluated. (Enzweiler 1995, 45.)

It is also possible to use sample processes run on a full version of software and by that way pinpoint the possible needs to customize the product and evaluate it in real environment and use. (Gell et al. 2000). Site visits to organizations using the same software the same way is also suitable way of evaluating the possible live operation in customers own organization. By meeting the vendors' local or regional support office, the support after the sale can be evaluated. The references can be checked to verify software release quality, support for regulation changes, training and hotline support. It is recommended to also meet the vendor's senior management team to find out the objectives of the firm, R&D effort, forecasts of the company growth and the financial state along with contingency plans (Enzweiler 1995). Because people are doing all the evaluation, all the decisions are not done purely by rational measures. There also are emotions and people chemistry involved. (Kettunen, 2002, 120.)

3.5.6 Evaluating vendors and softwares based on the quotations

When quotations are asked from the vendors they are first evaluated after their return deadline based on the issues in the call for bids. Assessment criteria can be e.g. (Kettunen 2003, 113):

- Vendor know-how on the subject
- References and their statements
- Ability to deliver and control of schedules
- Project management
- Quality system
- Quotation quality and sophistication
- Comprehension of the problem
- Experience of the customer's line of business.

The solutions offered in the quotation are assessed by giving points to different features like (Kettunen 2002, 115):

- Problem solving capability
- Innovativeness
- Database technology
- Platform technology
- Software language
- Data security

- Maintainability
- Performance and scalability
- Estimated amount of work needed
- Software prices
- Price of project work
- Price of maintenance.

In addition to details presented above the information system prices need to be estimated in more detail because of the software variants and human labor costs required to operate and maintain the system (Enzweiler 1995, 45).

In most cases the selection and implementation of software is a major investment and therefore the software decision should be the right one. By defining vendor's critical factors and software critical requirements, collecting software and vendor information, categorizing information using critical factors and requirements and then focusing on thorough evaluation of the short list can be made sure that the software selection decision has been rightfully informed. (Enzweiler 1995, 45.)

4 RADIO ACCESS CERTIFICATIONS

4.1 About Certification

Organization called Testing and Certification Center (TCC) is responsible for certifying and testing the products of Nokia Oyj, a global equipment manufacturer in telecommunications. Certification, what comes to information technology domain, means a formal process of assuring that a product is qualified in terms of its specific functionalities or features. Certification programs are often promoted or supervised by some certifying agency, such as a professional association (www.whatis.com 2008.) Certification, putting it in general terms, is about assuring the conformance, e.g. by means of testing against specific requirements. A certificate is issued as an indication of conformance to the requirements and used as a license to sell the product in particular regions. As an example, a CE-mark, which can be found on nearly all the products on the market, is required in order to access the markets of European Union. A certificate may also be applied for in order to prove the quality of the product and, hence promote the product. Generally can be stated that certification is a means to standardize the products in the market for the benefit of the consumers who are selecting their products from huge global supply. In this chapter the Radio Access product certification process is outlined by means of analyzing the process descriptions of different stakeholders and using participative observation about the actual day-to-day functions. The product certification from the viewpoint presented in this study consists of Radio Access and Radio Spectrum parts. The feature and technology split between these two certification testing parts is described chapter 4.4.

At this point it should be noted that the views of the stakeholder's about the process are somewhat diverse and dependent of their perspective. Nevertheless, these views are used to the appropriate extent in creating an upper level process summary as seen in Appendix 4. Furthermore, the figures provided in this chapter are taken from the different process illustrations presented in appendices but manipulated in order to give clearer conception of the parts introduced.

4.2 Product Certification Process

The purpose of the Product Certification Process is to describe how to certify Nokia products (excluding network infrastructure) according to relevant certification requirements and how to maintain the certification when updates are made to already

certified products. The global directive, Approvals and Certification in Nokia, provides information about the certification and approval requirements, decision-making authorities and related budgeting practices in Nokia. Description of the Product Certification Process (PCertP):

> *"Product Certification Process ensures that all external and Nokia internal certification requirements relevant for all products are met in an efficient manner in terms of quality, time, competence and cost" (CertMT website 2008).*

The PCertP is to make sure that the required products are certified in time, the quality of the products is high and they meet the set requirements. It also describes the handling of the products and PCertP non-conformities as well as includes development schemes for the process itself to cover new certification requirements. Furthermore, the PCertP is an independent part of the Product Verification Process in the Nokia Product Development process and Nokia Quality System having the Full Quality Assurance Approval as its basis. (Global Product Certification Process in Nokia, 2007.)

The Product Certification Process is organized in sub-certification processes which handle the specific certifications e.g. certain market area or feature certifications. These sub-processes are managed by corresponding Competence Forums covering the different schemes. The different Certification schemes are described in the next chapter 4.3.

4.3 Different Certification Schemes

In order to cover all the different certification schemes regarding Nokia product certification, the handling of these distinct schemes have been arranged in a Competence Forum setup. The purpose of these forums is to bring decision making closer to a level where the operative work is done. Competence forum participants work actively to find solutions to open issues related to their certification scheme by means of having regular meetings. Forums also concentrate on new technologies Nokia is planning to introduce and investigate the effects they may have on forums' certification areas. In addition, the forums share information between each other about new and future technologies. It is among the different forum's responsibilities to prepare requirements and changes in certification policies as well as notify interest groups, i.e. labs and product programs, of the related certification requirements. The forums take proactively care of training and information sharing inside and outside of their organizations about issues related to their own certification area.

The forums established currently (status of January 2008) are presented in Table 1 with parts within the scope of this study marked in bold.

Table 1 Competence Forums

Competence forums
R&TTE / AMD forum
GCF / PTCRB / WiFi / WiMAX / CCX forum
FCC (Federal Communications Commission) / IC (Industry Canada) forum
Bluetooth forum
Battery certification forum
SW Application Certification forum
China forum
Japan forum
Country Specific Certification forum

Out of these competence forums only R&TTE, GCF / PTCRB, China and Japan forums have actions related to Radio Access part of certifications. Furthermore, China and Japan certifications are not included in the scope of this study.

The R&TTE (Radio and Telecommunications Terminal Equipment) directive is a regulatory scheme and by meeting its requirements the product is entitled to use CE mark and the manufacturer can therefore sell the product in any European country.

GCF (Global Certification Forum) is industry collaboration between network operators and terminal manufacturers. It is a voluntary global certification scheme with the purpose of ensuring terminal equipment compliancy to applicable standards and interoperability between 2G (GSM900 and GSM1800) and 3G (FDD1, FDDVI and FDDVIII) devices and networks.

PTCRB (Personal Communication System Type Certification Review Board) is the American certification scheme covering GSM710, GSM850, GSM1900 and 3G (FDDII, FDDIV and FDDV). It is a network operator run certification scheme with members in North and South America. PTCRB approval is voluntary but in practice a requirement for terminals that are to be used in areas served by the PTCRB operators.

In addition there are two forums spanning all the certification forums:

- ODM (Original Design Manufacturer)
  Certification scheme to certify products done by ODM
- Type label forum
  The forum holds the ownership of the labeling process of Nokia mobile terminals and accessories in terms of regulatory requirements within the Certifications organization.

The Competence Forums assure that the competence of their members is on right level by requiring their attendance to trainings and workshops a well as getting into information loops of other groups and external parties. They also do the actual submissions and declarations on their own certification areas and ensure their quality and consistency. Competence Forums act as the single point of contact towards relevant

external authorities and by that way make those interfaces clear. (Competence Forum framework 2007)

4.4 Certification Workflow

4.4.1 Overall workflow

The Product Certification workflow is sketched as a whole in appendix 2 from Radio Access point of view. In the picture the parts within the scope of this study are outlined in red and the parts having some effect to the process outlined in red dash line. Note, that at this point the Radio Spectrum (RS) test flow, the other part of certification workflow, is cropped from the scope of this study. Radio Spectrum includes Over The Air (OTA), Electromagnetic Compatibility (EMC), and Specific Absorption Rate (SAR) testing areas whereas Radio Access (RA) testing includes Chipset Solutions (CS), Wireless Modem (WM), Security, Location and Smartcards (SLS) and Application Enabler (AE) testing areas. These different areas are established based on their technological nature of testing. CS entity includes tests from the Radio Frequency (RF) test specifications, WM includes Protocol and Radio Resource test specifications and SLS positioning and Subscriber Identity Module (SIM) test specifications. AE testing has its own test process and is therefore not included in the scope of this study. The figures presented in this chapter are intentionally taken straight from the process documentation of different stakeholders even when they are created based on different aspects of the whole certification process and have not harmonized form. The stakeholders in the Radio Access Certification Workflow are:

- Product Programs
- Certification Testing Board
- Certification Management
- Radio Access Test Laboratories.

In early phase of Product Creation a draft Certification Plan is created based on e.g. the features of the product, its launch target, planned customers and regions it is going to be sold in. All these variables dictate the whole plan and therefore the document is carefully checked by Certification Management organization in the Plan Review & Approval phase (see Figure 5).

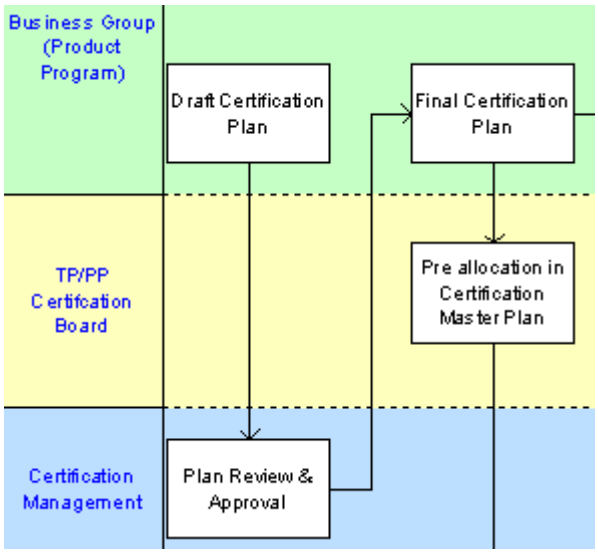

Figure 5 Certification planning (adapted from RA Certification workflow)

After the Certification Management has approved the plan the Product Program makes the Final version of the RA Certification Plan and pre allocation is done to RA Certification Testing Master Plan. The RA Certification Testing Master Plan is owned and updated by Certification Testing Board. In this phase the testing slots for the products are reserved from the testing laboratories schedule. The Master Plan contains information about the planned certification test rounds of products approaching their initial certification. It also includes the relations within product families where one product acts as the family lead. Within a family the copy products can use specifically defined test results from the lead product based on their similar software or hardware modules. Certification Testing Board is responsible for defining the certification families and planning the optimal test slots for every product considering also the Product Programs' demand dates, product priorities and certification requirements. The planning accuracy depends on the precision of the information given by the Product Programs. Especially the information about the maintenance releases (products update software or hardware because of e.g. known bug corrections) should arrive early enough to enable flexible resource allocation and planning also for these much shorter test rounds. This Excel-format plan is updated on a daily basis and available for all relevant personnel in Product Programs and Certification organization.

When these preliminary issues have been addressed the Product Program starts to create documentation describing the exact characteristics of the products, their features, SW- and HW modules, copy-lead relations etc. in copy-lead, baseline and difference documents according to the Certification Testing Board's instructions and document templates (see Figure 6). Baseline document describes the first SW or HW setup of a product and difference document differences between two SW or HW versions. The templates along with detailed instructions are located in Certification's web pages under

title “Info for Product Programs”. The required information and templates are dependent on nature of the certification of the product i.e. whether the product is a lead or not (copy product). Apart from Certification Testing Board a few members of Backend team (shown in the process level in Figure 8) will also attend to the difference document reviews in order to assure the document formalities and clarity from the certificate reporting point of view. The backend team is responsible for making sure the certification requirements are met and its personnel writes the test reports stating the product’s conformity with the requirements what comes to the RA part of certifications. When a product is applying for initial certification (not SW/HW/certification update) and is the lead for its family, the difference document path in the process is not required and next phase is the handling the test samples (Complete Sample Request) described in the next chapter. Products go over many changes during their life cycle even after sales start due to error and bug corrections made in their software and hardware. This activity is called certification maintenance. The effects of the corrections need to be carefully studied and, if required, some of the certification tests rerun in order to make sure that the functionality and performance remains on the required level. These test case reruns are caused by the SW/HW updates mentioned earlier. Every time when the hardware of the software is updated or corrected a particular document called HW/SW document is created in order to analyze and estimate the retesting need what comes to the certification tests. This activity is described in more detail in chapter 4.5.3.

Besides the maintenance activity the customer of the product or the product program may require that the initial certification version the product is certified against, is to be updated. The certification standards are living documents being under constant development due to newly developed features and functionalities having their own tests. The new versions of the standards are therefore released in a predefined interval, e.g. four times a year, a few of the latest versions being valid at the same time. The latest certification version having the recent requirements implemented is therefore more demanding to be met. Thus, certification update means testing the product against the latest certification standard version i.e. testing the differential test cases between the certification version the product is certified against and the latest, official version.

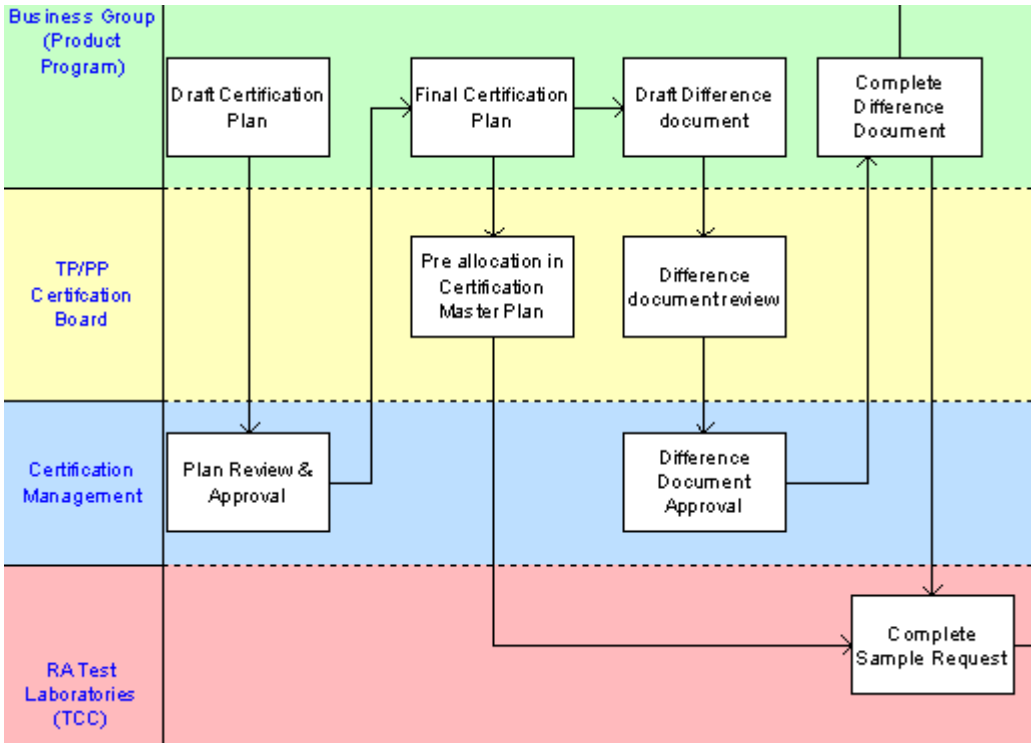

Figure 6 Creating the documentation (adapted from RA Certification workflow)

4.4.2 Work Request (WR)

An application called CertTool is used to store and manage all the information required in Certification Plan. The application provides basic functionalities for product, feature and requirement management. It helps in improving the visibility of Certification status and workflow to product programs. CertTool is a platform built on commercial eMatrix PDM platform and it is a centralized, global tool with global processes supporting Certification planning. CertTool makes the product and certification data available for all users throughout the company and therefore eliminates redundant data. The data is maintained in CertTool by a person from Certification Management, Product Certification Manager (PCM), appointed for every product and he or she prints out a Work Request from the tool. This request is sent to Certification Testing Board in excel-format and it holds all the product specific information required to start the RA testing activities.

After the possibly needed difference document (applicable for copy products) is ready and approved the labs require the product samples (products for testing) to be prepared according to their requirements located in the RA testing intranet pages. The instructions are listed in a Proto Handling process for RA laboratories which is not in the scope of this study. The Product Program starts preparing the samples accordingly

and sends them to laboratories. In parallel to these sample activities the previously mentioned Work Request (WR) is generated from CertTool and sent to Certification Testing Board via email for Final Allocation in Certification Master Plan (see Figure 7). At that point some fine tunings to the schedule are done if required and the exact test time reservations frozen.

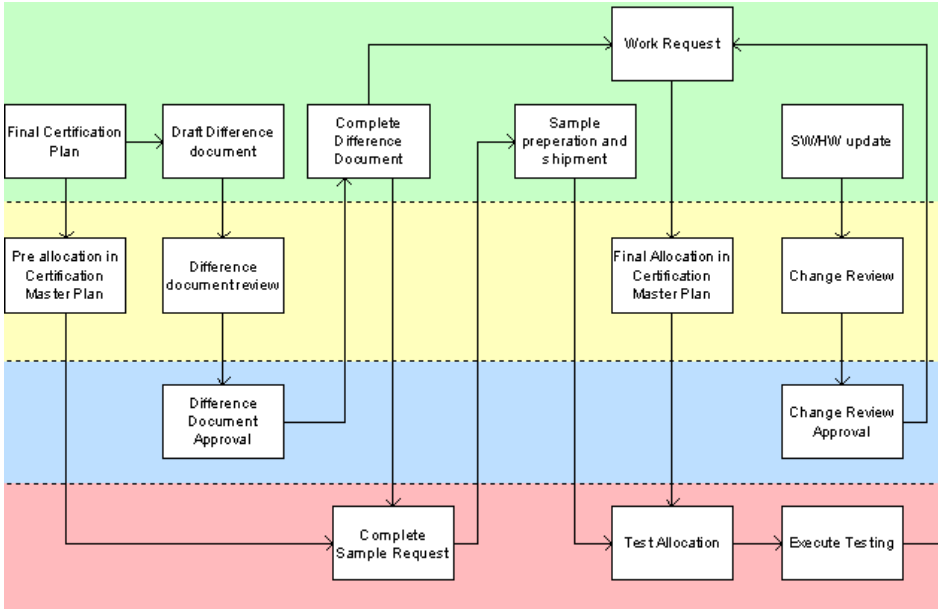

Figure 7 Requests and allocation (adapted from RA Certification workflow)

Document pre checks are done in the next phase and this activity follows the RA Certification Check Process described in Appendix 1. This phase includes a so called sanity check or maturity check in which, based on the documentation given, the product readiness for testing is evaluated. After the Certification Testing Board approves that all the required documentation is in place and sufficient, and the schedule for the testing is feasible and plausible, the Back End team receives the WR. If, on the other hand, Certification Testing Board discovers insufficiencies in the documentation, the needed corrections are required from Product Program via PCM before continuing the Certification Check process (see Figure 8). At this point it should be noted though that according to discussions with the people involved previously in this WR checking activity, this phase does not exist anymore due to Certification Testing Board's limited time. This part is corrected in the Revised Certification Process Flow in the appendix 5.

4.4.3 Test Request (TR) and Split

After receiving the WR, Back End team can continue the process by creating a Test Request (TR) based on the information provided in WR (see Figure 8. The TR is

created in a commercial data base called Testing, Organization and Management Database (TOM®) operating in the company server. The TOM-tool is accessible with Internet browsers. In this tool, described in more detail in 4.5.1, the WR is converted to actual Test Cases. For example R&TTE certification entails a bunch of Test Cases all checking the functionality of a specific feature, function or performance described in test specification. TOM-tool lists all the required test cases based on the selected certification version e.g. R&TTE v2.2.1. From raw list of test cases the Not Applicable (N/A) TCs are removed using Product Certification Information Statement (PCertIS), which is a document provided by the Product Program among other documentation to Product Certification Testing Board. Basically this PCertIS includes complete set of the TCs in all related test specifications and defines if they are applicable or not for the product in question. If some features are not supported by certain product, they are marked as N/A in the PCertIS. Every product has their own PCertIS regardless if it is a lead product or not. The PCertIS creation follows the PCertIS process which is not in the scope of this study.

Marking the N/A TCs is done automatically in TOM-tool by uploading the PCertIS to the correct TR in TOM which puts considerable pressure on the accuracy of the information given in PCertIS. Once the test list creation in TOM is complete the list is converted to excel-format and split to testing entities using excel macro tool called Split tool. After this the TOM-tool is used for result storage and certificate writing tool at the later phases of the certification work flow. Split tool includes all the tests within relevant test specifications divided into different testing entities. The entities are, as being previously stated CS, WM, and SLS testing areas, responsible of maintaining the testing capability (test systems, test cases and testing competence) and running the actual tests belonging to their testing area. They are “laboratories within laboratories” meaning that the physical testing facilities may have test equipment and personnel from more than one entity. The entity-based test lists divided by the Splitter tool are stored in TCC server in the product folder at issue but also sent via email links to laboratory allocation personnel and Certification Testing Board for a short Allocation check. At this point Certification Testing Board checks the contents of the entities related to testing and copy-lead relation, and optimizes the testing effort related to the above. Furthermore the Certification Testing Board grants the final test time slots for the Product Programs.

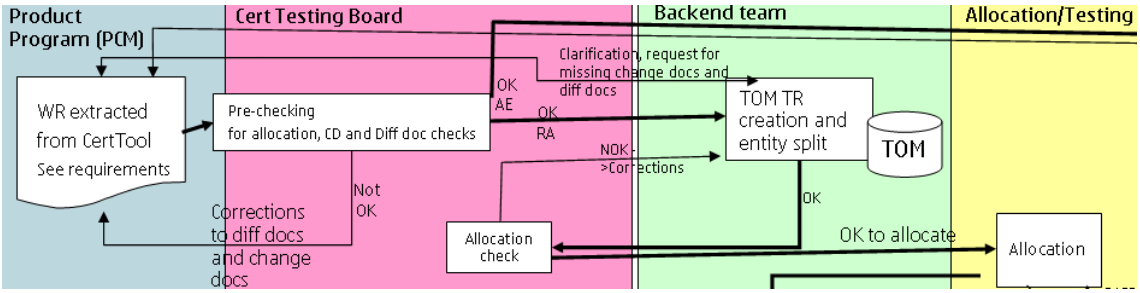

Figure 8 Checks, TOM TR creation and splits (adapted from RA Certification check process)

4.4.4 WR Reception

The split TC sets, PCertIS and the WR are sent to every involved entity Allocation responsible in the labs via email links. The requirements of the information concerning emails, their links and entity allocation responsible persons are described in more detail in internal process description: TCC Nokia RA Laboratory Process (2007) in TCC server. Allocation person checks the WR and split TCs according to a checklist and routes them back to Certification Testing Board for further information if it has not been sufficient or some information must be challenged (see Figure 9) from the RA Laboratory Process picture). The picture shows that the WR is coming from Certification Testing Board when it in fact is coming from Back End team but that is to show the process responsibility-wise i.e. Certification Testing Board has checked the request validity in Allocation check phase described in the previous chapter and shown in Figure 8.

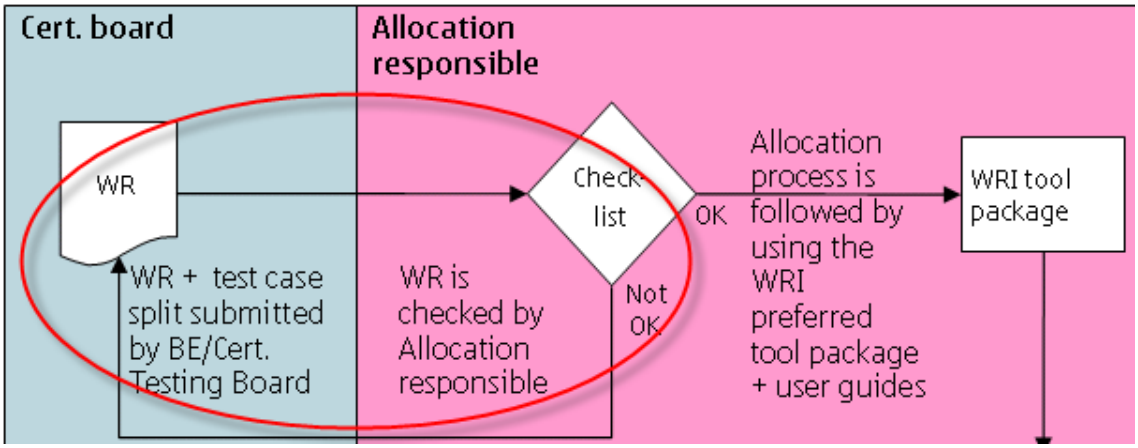

Figure 9 WR check and allocation from laboratory point of view (adapted from RA Laboratory process)

4.4.5 WR Allocation

If everything is in order with the provided documentation, schedules, copy-lead relations and demand dates, the tests are allocated to the different test platforms, i.e. to actual and physical test systems, in which the tests are actually run. The allocation is done with Preferred Platform -tool in Work Request Inventory (WRI) tool package, using excel-interface operated queries from MySQL-database. The overall structure of the rather complicated and self developed WRI-tool package and its features can be seen in chapter 4.5.2. The final output is a sheaf of sheets, one for every entity (see Figure 10) and further, one for every test system resourced for the running of the TCs (named as Work Order in Figure 11). The test system –specific test lists are stored in System Testing Inventory and can be viewed and updated via Operator Sheets designated for every test system.

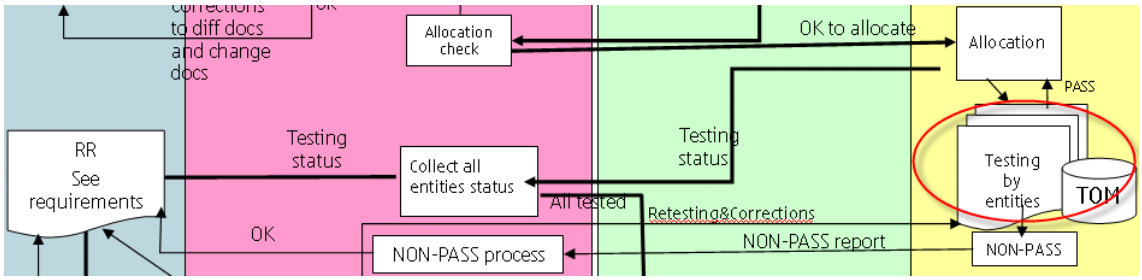

Figure 10 Test Case Allocation, Testing and Status (adapted from RA Certification check process)

After the WR allocation has been executed, a reply mail with headline ‘Allocation’ to the original work request and split from Back End is sent out containing the summary of the amount and split of the testing and links to the WRI Test Case Sheets. The mail is also sent to the Operators, running the test cases, as well as to Test System Managers, responsible of maintaining the test systems, in order to indicate them that a new WR has been added to WRI.

At this point there might come up some test cases which cannot be executed in-house because of validation factors or capability shortages. These tests should then be subcontracted but this process is not within the scope of this study.

4.4.6 WR Execution and status reporting

After receiving the allocation mail from allocation person the operators use the html link provided in the Allocation email in order to access to the test cases allocated to

their platforms. WRI-Tool Package's interface called Operator Sheet –tool gives the operators a full view of what has been booked to their system by querying the information from the MySQL-database. At this point the Test System Manager does the final check on the WO assigned to his/her system (see If there are some changes to be made to the requested list of tests, he/she informs the Allocation Responsible immediately and enters comments and reasoning behind the changes to WO in Operator Sheet. System Manager also informs Back End and requests changes to TOM Test Request accordingly.

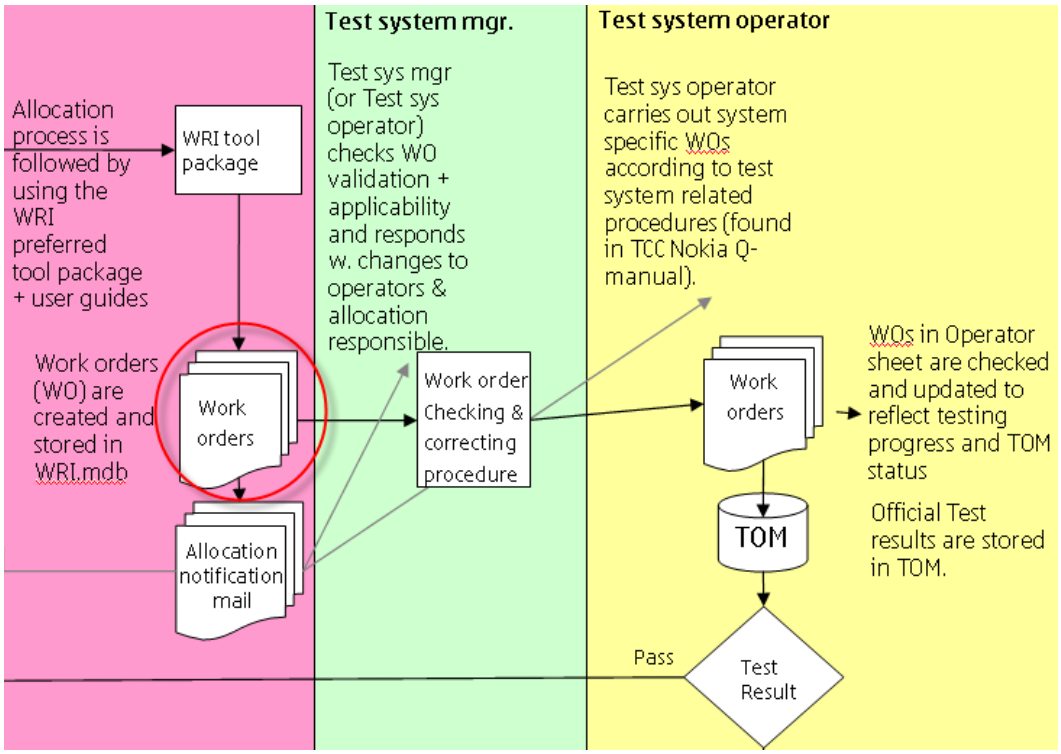

Figure 11 Test execution (adopted from TCC laboratory process)

In every test platform WO the TOM request number is marked indicating the location in TOM where the results are to be uploaded. As the testing goes along the testing personnel uploads the results to TOM but also marks the TCs based on the verdicts given by the test platforms to the Operator Sheet. By this way the laboratories can monitor the progress of the testing, platform by platform from the System Testing Inventory interface.

If the testing goes without problems and the TCs are passing, the allocation personnel can wait until the platforms have run their tests. As soon as the tests are completed the Operators upload and assess the results to TOM and mark them as 'Done' in the Operator Sheet. Not before these procedures have been done the Allocation Responsible is notified by email. When the Entity test system specific WR testing has been completed the Allocation Responsible verifies the status and informs

Certification Testing Board about it via email. If on the other hand there are problems getting some of the tests to pass, the testing personnel create a NON-PASS report after analyzing what was the root cause of the problems. The status reporting process is shown Figure 12. The NON-PASS analysis has its own sub process which is described in chapter 4.5.4.

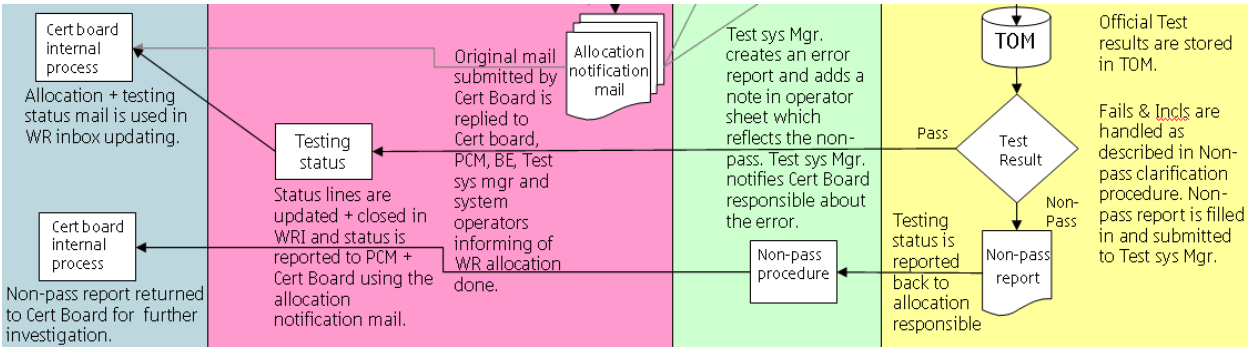

Figure 12 Status reporting and NON-PASS process (adapted from RA Laboratory process)

4.4.7 Report Request (RR) and Test Report Writing

After all the test cases have been performed, NON-PASS-cases analyzed and results stored in TOM, the Certification Testing Board notifies the Product Program about it via PCM. The PCM creates a Report Request (RR) document which includes all the information required to write the test report. The PCM sends the RR to Back End Team for Certification Check. Certification Check encompasses verification that all the tests have been run and the results are stored in TOM, the documentation is available and it is approved and fulfils the certification requirements. Information about the requirements of the RR is described in Certification intranet pages under the link: Info for Product Programs.

Report Requests are sent to Back End team's email distribution list and by that way delivered for further processing. Back End team has an excel-based Report Request Inventory (RRI) where it keeps a record of all the reports and assigns them among its personnel in bi-weekly meetings. When a report has been assigned to a report writer the status field on the RR for it is changed from 'Open' to 'Allocated'. As soon as the report writer has finished the previous reports he/she starts preparing the report assigned to him/her and changes the status of the request to 'Ongoing'. By changing the Status field of the requests the PCMs can monitor their requests progress through RRI link in Certification Testing –web page. The sheet behind the link is updated once a day. In the

RRI sheet there is listed the important information regarding the nature of the report e.g. technology (2G/3G), certification applied and its version etc. as well as a link to the original RR. All this information is taken from the provided RR (see Figure 13).

Type	NickName	Report Writer	RR	Des	Issue					Tech.				RR in date	Start date	Check OK	Status
					R&TTE	GCF	PTCRB	JRL	JBTL	2G	3G	OTA	AE				
			Week 3 (14.1)														
XX		NN	Link to RR	Init	9.0.2	3.26.0	3.13.0			X				4.12.2007	20.12.2007		Ongoing
YY		NN	Link to RR	Init	2.2.1	3.26.0	3.13.0				X			4.12.2007	20.12.2007		Ongoing
ZZ		NN	Link to RR	Init	9.0.2							X		4.12.2007			Allocated
AA		NN	Link to RR	Init									X	4.12.2007			Allocated
			Week 4 (21.1)														
BB		NN	Link to RR	Up	9.0.2	3.26.0				X				16.1.2008	17.1.2008	y	Ongoing
CC		NN	Link to RR	Up	9.0.2	3.26.0				X				16.1.2008			Allocated
DD			Link to RR	Init	9.0.2					X				17.1.2008			Open
EE			Link to RR	Init	2.2.1						X			17.1.2008			Open

Figure 13 A snapshot of the RRI

The actual test reports are done using the TOM-tool so the circle closes what comes to the TOM-tool's part in RA certification process. The TR created like described in chapter 4.4.3. is used because it includes already the right certification version the product is applying for as well as all the results from the testing. TOM-tool provides flexible possibilities to transfer results from one product to another (in case of copy-lead relation), combine requests and their test lists/results etc. tricks required to create reports according to certification requirements. The report consists of two parts, the test report part which includes the actual test list and the results, and the assessment part which assesses the conformity of the product according to the certification requirements. When the report reaches a point where all the information is there and it is verified to be correct the report is printed out to word document. Usually the sizes of the reports vary between 13 and well over hundred pages so the transfer may take a few minutes. After the word document is open the final fine tunings are done to it because some of the footer and assessment part texts are missing. When the word-format report is finalized it is converted further to pdf-format and electronically signed in order to protect its authenticity.

As soon as the report is ready and sent to PCM as well as uploaded to CTIA, if required, the report writer changes the status to 'Done'. All the different statuses are also indicated in different colors in RRI in order the give better visual touch of the overall reporting status in any given point of time. The certification process ends for a product with particular SW/HW combination when PCO (Product Certification Officer) accepts the report or the reports are accepted in PTCRB.

4.5 Key parts of the process

Some of the previously described, particular parts of the Certification Workflow process have the biggest potential of helping the process to improve and become smoother and more flexible. Nevertheless, the very same parts are also considered the sections with the biggest impact on the whole process and therefore they hold the largest risks of something going wrong. These parts are presented in this chapter in more detail.

4.5.1 TOM-tool

The commercially available and jointly with manufacturer further developed TOM-database acts as a vital part in the certification workflow. The users of the system consists of, as described previously, the members of the certification management, PCMs, certification testing board, back end team, and the laboratory testing and test system management personnel. Altogether over fifty people are using the database weekly, if not on a daily basis. All the users have their own user accounts in TOM with username, password and profile. On top of that, users are divided into different user groups having their particular access rights only to parts in TOM important to them. The user accounts are used not only for limiting the access inside TOM but also for log taking purposes. All the changes done in the database can be tracked down to the person who have done change and where.

The internet-based TOM-database is developed for the requirements of modern mobile communications technology and with a view to the special characteristics of the market. It has a modular structure including GSM, 3G and Application Enabler (AE) parts. The database enables automatic saving of all data on local servers, independently of location. The structure of TOM is described in Figure 14. TCC has its own TOM-database and TOM application servers which are updated and maintained remotely by Cetecom from Germany. The updates include error corrections, development updates according to requests and live-update operations maintaining and updating the correct categories of test cases and implementing the changes in certification standards.

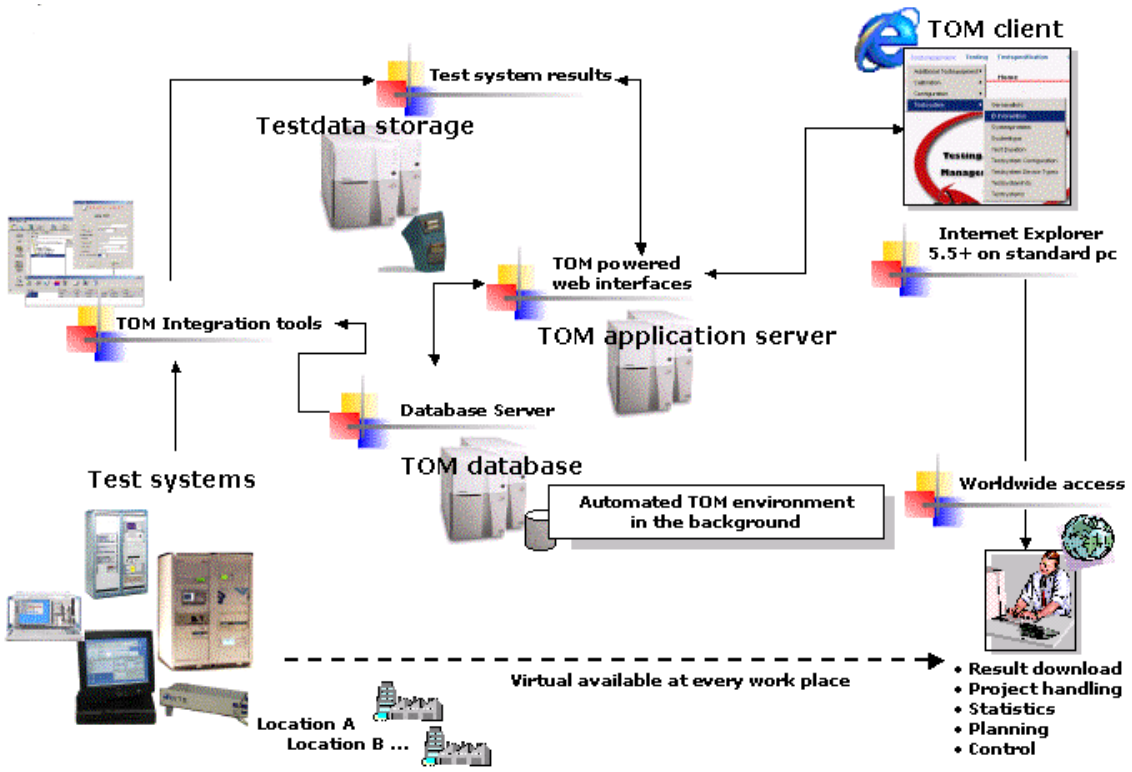

Figure 14 The structure of TOM-database

Back End-team is responsible of creating a TR in TOM-database using internet-based TOM client. The test lists are created to Application server based on the certification requirements of the applied versions. Once the WR is allocated using printouts of the application server and the testing proceeds, the operators of the test systems upload the TC results to TOM using Integration tools customized for interpreting the results of the specific test systems they are used for. The results are indexed in Testdata Storage linked to the right request in application server and the actual results are stored in TOM-database. The status of the WR can be checked by accessing the request by TOM client. TOM client is the interface for using TOM-database in every certification related activity, the report writing included. After the WR is completed the Back End team creates the test reports by using the TOM client which retrieves the data queried by the Application server from the TOM-database. All in all, TOM-database holds all the raw data and TOM client, TOM Integration tool and Application server are the means to manipulate and query the data in the way preferred.

At the time the decision to purchase the TOM-database from a German company, Cetecom, was done there were no truly competitive test management products available in the market. A few other softwares were evaluated but the decision to select in favor of TOM was rather easy. TOM has been in use for approx. five years now in TCC and the development of the database has been huge. Plenty of new and essential functionalities have been implemented but at the same time the organizations

dependence on the tool has increased greatly. The company behind the development of the TOM, is responsible for maintaining the database because of annual service contracts and on top of that the company makes changes and updates to the product according to certification organizations' requirements on a case by case basis. The changes requested to the database in use in TCC have caused the database being very different to other TOM-databases in other customers' use. No other TOM customer has as vast and challenging requirements of the product as TCC has which causes ever growing workload for Cetecom. This of course turns down to increases in the service pricing. The situation is challenging. The changes, corrections and development issues TCC requires develops the product further also in the eyes of other Cetecom's customers and therefore Cetecom has initiated a project to create new database from scratch taking into account the development ideas collected so far. The purpose of the new version is to use the latest database design tools in order to get better supporting structure for the product and its development. The manufacturer takes also into account the different requirements of the customers of the tool and designs the new version in to modular structure. These modules can be composed and customized easily to suit the different needs of the customers.

Implementing the functions of the WRI-tool package (described in chapter 4.5.2) is going to be one of the subjects to be studied further when developing the new TCC TOM version with Cetecom.

4.5.2 WRI-tool package

WRI-tool package, as presented previously, is used in RA laboratories for test allocation and scheduling, test case validation status updating, performance measurement and testing optimization as well as for reporting. The backbone of the system is the MySQL-database which has all the data required in the laboratory functions. On top of the database are the interfaces; Preferred platform, System testing inventory and Operator sheet (see Figure 15) used in running the operations on the MySQL-server.

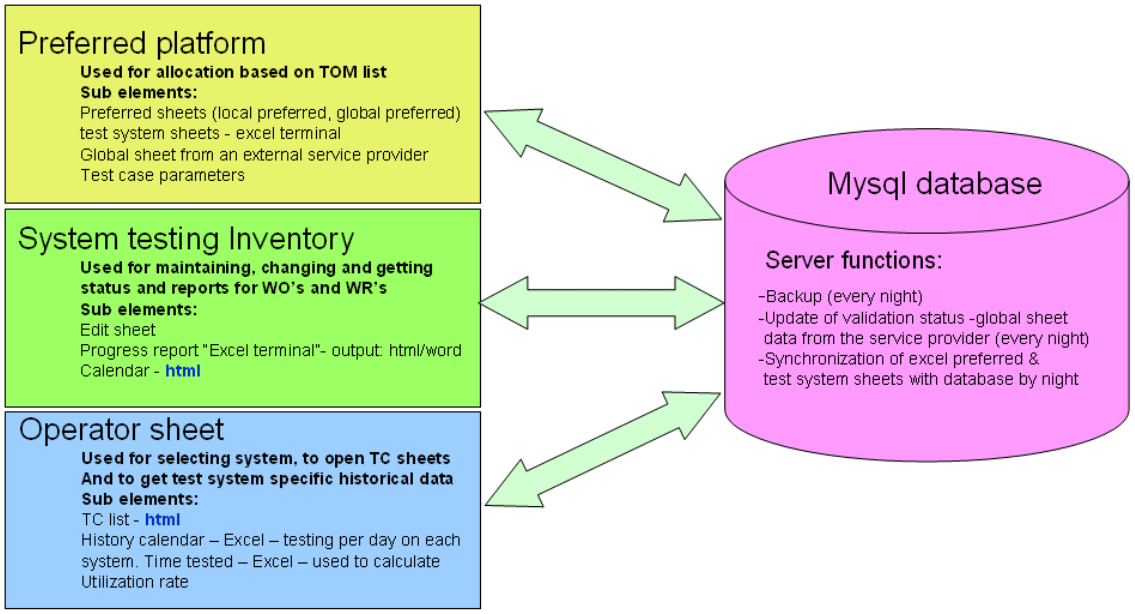

Figure 15 The overall structure of WRI-tool package

On the MySQL-server there are a number of automated updates running on a scheduled basis. During the update, occurring each night, the external service provider supplied data in Global Sheet as well as data on Preferred Sheets, Test System Sheets, TC Parameter Sheet and Automation Status Sheet (shown in Figure 16) are transferred to MySQL-database. On top of that, the MySQL-database is backed-up automatically once a night. The interfaces used to operate the MySQL-database are shortly described next:

Preferred Platform Sheet –tool imports the data in WR and TC split files, which are sent by the Back End team member, and processes them in order to have the allocation done. After the full test list is ready the WO file is exported to MySQL-database.

System Testing Inventory is used for maintaining, changing and getting status and reports from WOs and WRs using sub elements such as Edit -sheet, Insert -sheet, Progress Report, Calendar and Holidays. Basically, the System Testing Inventory is a tool to show the wanted data in the MySQL-database in informative form. Edit sheet contains all relevant information and link to every WO. Insert Sheet is used for making WOs without TOM TC list or for some other special reasons not described here. Progress Report creates a summary of the WOs in Edit Sheet. The summary is used in reporting to the Product Programs and certification management about the progress of the testing. Calendar creates a calendar view of the systems in selected entity and shows both historical and expected load. It also shows illustrated if a WO is late or is expected to be late. With Holiday sheet it is possible to see and edit the holidays of the laboratory personnel and use that information to estimate future capacities.

With the **Operator Sheet** the test systems specific TC sheets can be opened and get historical data of the systems and WOs. It includes sheets showing graphically information such as the load of the systems for each day and the systems' utilization rates and. The Operator Sheet is also used by the test system operators and system managers to update the testing status for every WO and mark the test result verdicts (PASS or FAIL / INCONCLUSIVE).

The Figure 16 below shows the connections between the Preferred platform and the different sheets used for managing the WRs in RA laboratories. The work request (printed out from the CertTool) and TC Split files (done by Back End people with Splitter –tool) are imported to Preferred Platform Sheet which in turn uses the data as input from different sheets shown below the Preferred Platform Sheet box.

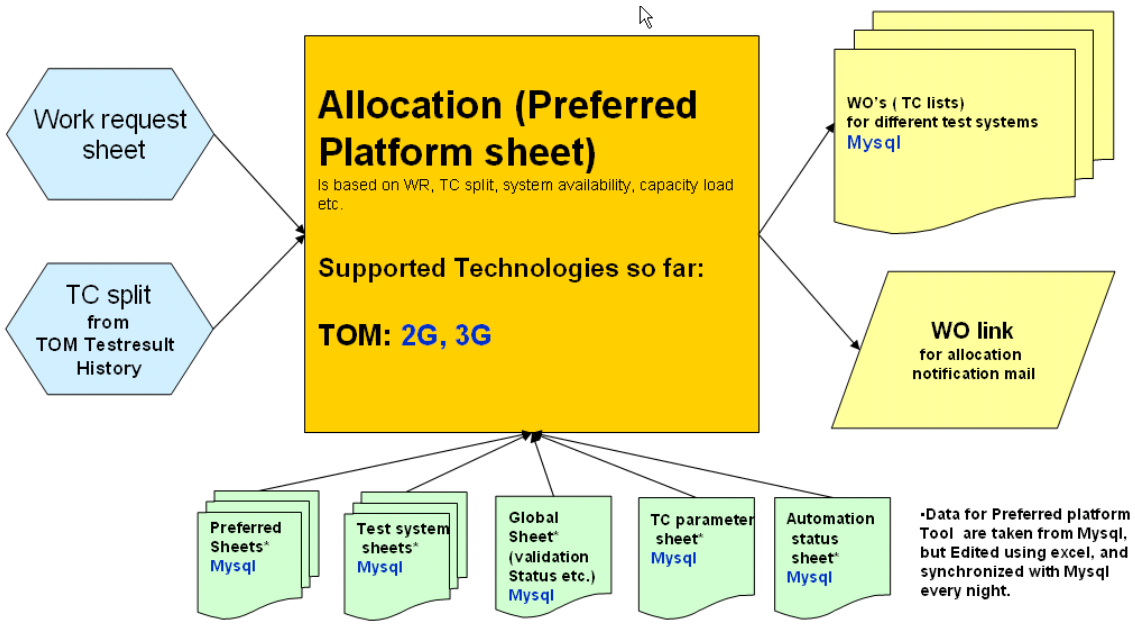

Figure 16 Preferred Platform

As an output from the Preferred Platform Sheet there are the WOs and html-links to the WOs stored in MySQL-database. The whole squad of sheets and tools are created in-house because proper and reliable tools where not available when the need to have them arise approx. 5 years ago. The WRI-tool package is triumph of resourcefulness in the certification organization but its development rests only on a few members of the organization. This can easily be seen as point of high risk in the certification process if e.g. one or two of these individuals left the company. Further research of the current supply of the tools and systems available for managing testing process is firmly advised.

4.5.3 Handling the change documentation

As mentioned earlier in this chapter a product specific change document is required every time the SW or HW is updated or corrected in order to clarify whether or not the corrections cause retesting of some of the certification tests. This document includes a summary of all the different modules and their versions changed in SW/HW and it also includes a conclusion table listing all the affected tests. The affected tests are tests, which are required to be retested because of the changes made. The change documents are used in the BE team in TOM test request creation phase and the tests are there selected manually to the TOM test lists. This phase when done manually is error prone even when conclusion table has standard form of listing the affected test cases. For this risky part of the process a small but demanding project of automating the TOM test list creation from change documents was started as a part of this research. The project team was established and the requirement analysis started but the actual specification phase was not initiated before this written part of the research was prepared. Therefore, the suggestion of going ahead with the change document automation is recommended because of the undisputable benefits it will offer.

4.5.4 NON-PASS Process

When during testing there are some problems encountered (shown in Figure 12) i.e. some tests are not passing the set requirements, the test operator who originally detected the NON-PASS verdict starts a process of NON-PASS clarification process. A NON-PASS verdict is other than PASS verdict. All the test systems have primitive built-in test case analysis function which checks whether the measured values are within the set limits and from that basis the systems give a PASS, FAIL or INCONCLUSIVE verdict for every test case. PASS verdict of course means that the requirements set for the test are met and FAIL means they are not. INCONCLUSIVE verdict means that the test did not finish as specified and that the actual measured values are not available. Both FAIL and INCONCLUSIVE verdicts require actions from the test operator to check what caused these verdicts. These actions initiate the NON-PASS clarification process described next.

The purpose of the NON-PASS clarification process is to give a guideline for how to:

- Make sure that the information about the new NON-PASSes are distributed further from TCC as quickly and reliably as possible to the relevant R&D communities
- Eliminate other than product caused NON-PASSes from further actions

- Ensure fast and managed loop for debugging, fixes, fix verifications and re-testing in certification
- Minimize the amount of people involved in the process
- Inform the product programs from the true fails without delays
- Comprise an overview of all certification FAILS / NON-PASSES for products using Field Test Reports

At the same time as allocation is done after WR creation and split, a Field Test Report is created to error database located in company server by allocation responsible. This report includes a frame for creating error reports described later in this chapter. The NON-PASS clarification process (see Figure 17) starts when a NON-PASS is detected during Certification testing. The test operator notifies the test system manager about the NON-PASS as soon as possible in order for him / her to fill out an error template or certification non-pass report. In these documents that are available in the intranet, the analysis what has caused the NON-PASS is conducted. At this point the test system originated problems causing the NON-PASSes are eliminated. If the NON-PASS is not caused by a test system error, the process continues by marking the test case as INCONCLUSIVE in the test request in TOM-database. Otherwise the process is stopped and test system support contacted. After marking the test case as INC in TOM the error report is created to error database by test system manager according strict rules given in a Non-PASS clarification in Radio Access Certification –document. The same document specifies the contact persons within every testing entity that should be included in the information distribution. These contact persons act as contact points regarding these issues from TCC to R&D. They also check the errors incase of known test specification or platform problems or just double check the TCC's analysis. The main contribution the contact persons give to the process consists of finding the right persons to look for solutions to problems behind the NON-PASSes and give the responsibility to them, inform product programs the details of the errors and monitor the progress of finding solutions to the problems in error database. The contact person-led process then divides to three paths depending on conclusion of the found error.

A-path includes errors which are not real NON-PASSes. Their verdict in TOM remains as INC, the PCM and TCC are informed and further studies with test system vendors are started.

B-path holds errors that are known beforehand. Contact person checks up if there is a fix already available or the schedule of the fix. PCM and TCC are informed and the verdict is changed to FAIL in TOM.

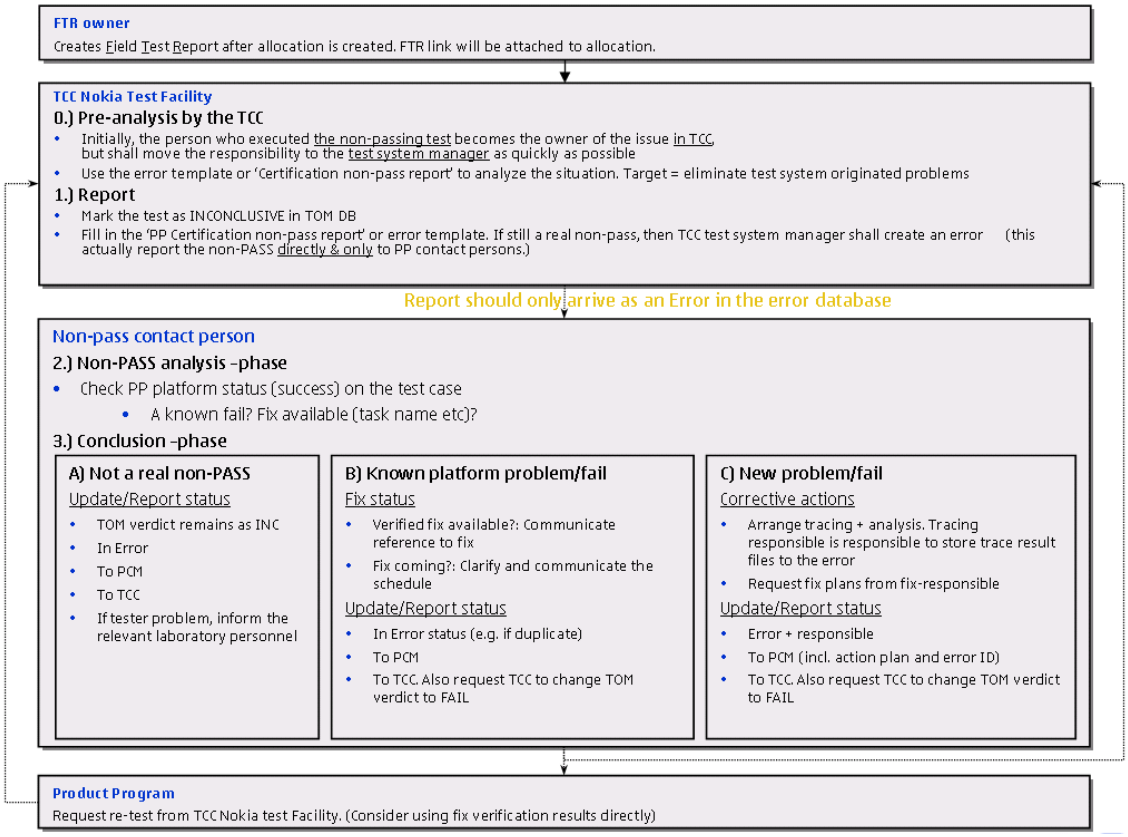

Figure 17 NON-PASS clarification process (Certification Testing web page 2007)

C-path includes errors that are new and not spotted before. Contact person arranges tracing (taking log of the all communication between the test system and the product) and persons to analyze the traces as well as request fix plans from the responsible people. The error database is updated accordingly, the PCM informed about the error status and created error ID and verdict changed to FAIL in TOM.

After this analysis is concluded, the FAILs are requested to be run again but only after there is a fix available, not before. There should be evidence about the fix before allocating the re-runs. After all the NON-PASSes are analyzed and solved the Field Test Report can be closed in the error database.

5 IMPRESSIONS ABOUT THE CERTIFICATION PROCESS

5.1 Interviews

In this chapter the different views and conceptions about the RA certification process are collected and contemplated. The material is gathered from the theme interviews conducted with the employees of the case organization. Specialists interviewed were selected from different parts and stakeholder parties of the process in order to cover the whole process within the scope of this research. The material collected to form the certification process scheme and act as a basis for the interviews was composed from extensive case organization's documentation examination and analysis. The document analysis was complemented with the findings of participatory observation done by the researcher during several years of working in the organization. As a result of the document analysis and participatory observations a picture of the RA certification process flow was created (shown in the appendix 4). This overall process scheme was used in the discussions gone through during the interviews in order to harmonize the interviewees' conceptions of the process parts and their relations as well as to align the interviewees' angles of views.

The theme questions gone through during the interviews are presented in the question template shown in the appendix 5. The questions were grouped into two parts. The first part was to find out the interviewees' conceptions and opinions about the operation of the current certification process whereas the other part was to collect development ideas. Altogether, ten people were interviewed. Three persons working both as a test system manager and as an operator gave their views from the laboratory point of view. Furthermore, two persons responsible for the allocations shared their experiences about the operation of the process and its challenges from their lab threshold perspective. The back end team's opinions and experiences as well as development ideas were gathered from three persons during the interviews and they were seasoned by the researcher's own input. The researcher was careful of not to interfere the research. One of the interviewees from the back end worked also in certification testing board and gave important information about the issues handled and the challenges faced in the board. Maybe in the best position regarding the certification process were the two interviewees having no operative role in the certification process. They worked for laboratory management. Due to the fact they had no active roles in the process, they were able to give input from the highest perspective of all the interviewees. They had the least amount of fixed impressions about the process and could speculate about things more freely without the boundaries of traditional process

habits. Because the researcher who conducted the interviews was a colleague with all the interviewees the researcher paid a lot of attention not to influence on the answers or the conceptions of the interviewees and to enable open, honest and fruitful discussion.

5.2 Process experiences and feelings

5.2.1 Overall feelings

All the interviewed people shared the same view of having a true process organization in place in TCC product certification although all the process material and information feeds were not standardized in a way common to the basic process industries such as paper or energy industries. Albeit the testing part of the process is handled in rather standardized units, test cases, in the laboratories, the process control and management parts cannot be harmonized in such a way. The characteristics and features as well as the copy-lead relations of the products are defined in rather extensive collection of documents making the parts of the process where the documentation is handled very challenging. The documentation is required in order prove the quality and in-depth scope of the certification function to the external parties such as different authorities, operators and accreditation bodies. Therefore the vast document handling process cannot be bypassed or done only by automated, machine-readable means.

Several interviewees said that the process works well if there are no exceptions or revelations in the process flow.

> *"It (the process) works rather well. Only the sudden changes e.g. in schedule which are not planned or foreseen early enough mixes up the palette rather easily. But if things are done according to the process, the system works well." (Interviewee 4)*

People interviewed shared the view of having a fluent and operational certification process which has developed and improved a lot during years. As a summary, all the people interviewed working in the roles of test system operator, test system manager or allocation responsible, i.e. work had straight relations to the laboratory activities, had better impressions about the process operation than the interviewed, working in other parts of the process, had. This supports the view of having more standardized and process-like activities and feeds in the laboratory part of the process. Nevertheless, all the interviewees had needs to improve some parts of the process important in their role in the organization as can be seen from the statement of the interviewee 3:

> *"A lot has been improved during the years but still there is a lot to do. I do not think the development ever stops but we are constantly going to the right direction." (Interviewee 3)*

Interviewee 9 presented the same idea by stating:

> *"Overall, process works really well, actually, but there are some fine-tunings required in some parts of process though." (Interviewee 9)*

5.2.2 Process parts that the users are satisfied with

According to the results gathered from the interviews there were a few parts in the process which the personnel was satisfied with. Maybe the biggest improvement during the last year has been the gate keeping role of Certification Testing Board. The Board has made it possible for other, succeeding parts of the process to do their job without interference from e.g. customers and focus on their core competences. The laboratory can focus on the testing and test management and Back End on the report writing and certification checks while the prioritization and schedules of the test requests are handled by the Certification Testing Board. Also the interviewees brought up in many discussions that the responsibilities and tasks within the process are clear. As interviewee 9 and 10 put it:

> *"The process works nicely like a conveyor belt and the boundaries of the different process phases are well defined and the roles are clear. It may, in turn, make some of the tasks a bit dull sometimes." (Interviewee 9)*

> *"I think the lab personnel is satisfied with the fine-tuned process and the standardized routines they conduct. It makes the job easier and more efficient than it has been before, although some people would like to have more variety in their tasks. We have tried to arrange some job rotation activities already. (Interviewee 10)*

The same impression of well defined process roles can be received from a statement of a member of the Back End team:

> *"The co-operation works well between the lab and the BE team. It is mostly because of the fact that these parts of the process are under our own control and we can internally agree about the process with the labs." (Interviewee 1)*

In addition, the tools used in the certification process are experienced as fast developing parts of the process which have a big, favorable impact on the overall functioning of the process and meaningfulness of the separate tasks.

5.2.3 Process weaknesses and bottle necks

Although the process was experienced as working well the people interviewed had many issues which they feel are weaknesses or bottle-necks in the process. One of the biggest problems and bottle-necks identified were the delays experienced in Back End test list creation and test splits as well as in the allocation. After discussing about the issue a bit more it was noticed that these problems are because of two main reasons:

1) The Certification Testing Master Plan is not fully synchronized with the actual status in the labs and product documentation. When a new and urgent test request is asked to be scheduled from the Certification Testing Board by a product program, the Board members check the status of the testing load from the Master Plan. If there is testing time available according to the Plan they promise that the testing can be done and they contact the lab. The working load maybe different in the labs due to some delays with the previous requests and the testing of the new request cannot be started as planned.
2) If there is time in lab schedule to run the request, the lab starts to wait for the TOM test list creation and split, done by BE and they feel that this phase acts as a bottle-neck. Usually in these situations BE is waiting for the documentation (change doc / PCertIS) for the request from the product program and cannot do anything before it is provided. Sometimes there are many other requests waiting for TOM test list creation and split and therefore also the short requests have to wait for their turn.

The remedies for these issues according to the interviewees would be to harmonize the Master Plan with the actual status in the labs and add in the process a prerequisite of having all the documents provided to the BE when these short notice request are made. Also it was hoped that the customers i.e. product programs would get holistic training from the certification organization in order to avoid misunderstandings and have the proper document feeds from them.

The persons interviewed working in the laboratory mentioned that there are some problems experienced constantly with the product samples. They can be equipped with wrong accessories, have no RF-cables or simply the amount of the samples is insufficient. One interviewee stated:

> *“The samples may be received two days late, have the wrong dummy batteries and cables and, on top of that, when there was supposed to arrive four samples, only one sample arrived!” (Interviewee 9)*

Suggestion was made to update the proto handling process to, first of all, be clearer in its content and to avoid misunderstandings but also to distribute the information about where it is stored so that everybody can find it.

Regarding the tools used in different parts of the process, several interviewees brought up the problems with them. A member from BE team said:

> *"TOM-database hick-ups i.e. the tool is down occasionally make our job impossible during those times. Also regarding TOM, its development is never ending task because for every fixed problem there arises one more to fix. These errors do not actually boost our job either. We are really TOM-tool dependent." (Interviewee 3)*

Also many interviewees said that there are too many tools in use and with no connections between each other which makes it very challenging to have them updated all the time. If e.g. the test categories are not updated the testing is done wrongly and these instances are not detected until the phase of certification check and report writing. One interviewee brought up the fact that Certification Testing Board has much to do in the process. He continued by stating that:

> *"Board is actually overbooked with work so that it cannot do its job properly. This can be seen from time to time in urgent test request when some issues defined as their responsibility are overlooked. If e.g. PCertIS is not updated or difference doc missing, the process cannot flow as it is supposed to." (Interviewee 3)*

One big problem the BE members have struggled with is the document quality they receive from the customers. Although there is very comprehensive packet of document guidelines in the certification intranet pages, the message in it does not transfer to knowledge in the PCMs side. This is because the rules behind the certification process are really complex and hard to present in short but covering form. The BE members admit that although the documentation is in place the context maybe hard to understand. In addition to clarifying the documentation appearance and readability the BE members suggested special trainings for the customers as can be noted from e.g. interviewee's 2 statement:

> *"It would be really helpful to be able to show to the customers how the different tasks are done in BE and by that way bring light to the requirements behind the documentation. If our customers do not know where we need the information they are not paying enough attention on those issues." (Interviewee 2)*

5.2.4 Support of the IS- tools and process measurement

During the interviews it became evident that the certification tasks, regardless of the task or process phase examined, are done with the help of different tools, databases and excel macros. In fact, there are not many phases in the process which are not done by

means of using tools. Based on the information gathered from the interviews the personnel is rather satisfied with the help gained from the usage of different tools. Many of them compared the current situation with the status which existed approximately five years ago when nearly all the tasks within the certification process, apart from the actual testing, were done manually with plain excel sheets and supported with paper and pencil. Nevertheless, the interviewees were also concerned about the tools turning against each other. Several interviewees actually said that there are too many tools created for various purposes and they have no connections or interfaces between them. At this point it should be noted that all the different excel sheets storing various kinds of data are also named as tools in the organization researched although some of them are not making any operations or manipulating the data in any way. The lack of tool integration and missing interfaces between the tools cause plenty of redundant data input making these parts of the process error prone. As interviewee 4 put it:

> *"There are many excel sheets in use and their amount is constantly increasing. Seems that the solution for every problem is creating a new excel sheet. This makes our job all the time more and more complicated." (Interviewee 4)*

The WRI-tool package and especially the Preferred Platform part in it includes several different sheets e.g. Preferred Sheet and Test system Sheet (see Figure 16) which are manually maintained by the laboratory personnel. These tools include sheets like test case validity status and test case package status i.e. information about where the packages have been installed. A few of the interviewees working in the labs stated that these tools should be updated automatically from the existing databases:

> *"All the different excels, which need constant updating, consume the effective working time. And, on the other hand, if the tools are not up-to-date, they will not work as they are supposed to. They should be somehow updated automatically." (Interviewee 6)*

Some of the excel sheets mentioned by the interviewee 6 above are created to record different events in the process and used for process measurement. It has become a tradition in TCC to measure different things in the process with these manually filled-in sheets. The process measurement should happen without extra form filling by analyzing the process check points and their data and without bothering the process workers with extra work. The interviewee 2 stated:

> *"We are currently creating all sorts of reports manually. We should think about what kind of reports we want out of the tools and use those as requirements when creating them. Our process is rather complicated but very close to production control so those systems should be benchmarked when creating and developing our tools." (Interviewee 2)*

People interviewed were mostly satisfied with the measurement practices and thought they measured the right things. As the certification organization is a service organization within Nokia, it was considered only natural to measure testing times and the fulfillment of the set demand dates. The utilization rates of different testers in the labs were monitored via the data stored in WRI-tool package and especially the laboratory management thought that it is a good measuring instrument to have. The laboratory personnel considered it as good thing to have some room for planning how the different and simultaneous test requests should be run the most efficient way and not have strict efficiency measurement instruments in place for those. Otherwise the measurement practices might take this flexibility away. The allocation personnel had a slightly different view of the process measurement practices and stated that there are plenty of tasks in the process for them to do which are not measured at all, even if they should. One example of these situations was mentioned as being the outsourcing of some of the testing in case of test laboratory overload or missing test coverage. If some parts of testing needs to be outsourced, the allocation personnel is required to fill in several different sheets in order to record all the details of these instances. According to the allocation personnel inputting and maintaining the data takes time and should therefore be measured.

An interviewee working in the laboratory had an opinion about measuring the NON-PASS (more details in chapter 4.5.4) analysis instances:

> *"Measuring and analyzing the NON-PASS instances may give further information about the process and what have caused these problems." (Interviewee 10)*

As these NON-PASS situations are interfering the certification process of the products involved, it would be beneficial to analyze the root causes of them in order to be able to eliminate some of the systematic problems in the future. If e.g. some test keeps failing and its cause is every time test method related, the testing procedures should be updated and the analysis would give impetus for that.

Some of the back end measurement instruments required manual collection of data and it was noted during the interviewees that the data should be collected and modified automatically. Measuring the report writing times was considered as a controversial measuring instrument since the quality of the reports can not be jeopardized at any time. It was also pointed out during the interviews that all the reports are different and require various degree of work so it makes no sense to measure such non-standardized bits of the process. Furthermore, the type of work, that the back team members do, is very specialized and therefore big parts of the working time is used for answering to clients questions and clarifying the certification requirements. This part of their work is done in meetings, teleconferences and via instant messages or emails which cannot be measured by any means.

The most important tools in use in the organization according to the interviewees are the TOM-database and WRI-tool package. The importance of these tools can be noticed e.g. from the following statements:

> *"TOM is the most critical tool for us!" (Interviewee 1)*

> *"TOM-tool is the vital part in our work even with its deficiencies." (Interviewee 3)*

> *"WRI is the tool which we currently rely on. If that tool is down we may be able cope but it will be a struggle and cause big delays." (Interviewee 8)*

Although the personnel of BE team use the TOM-tool and the laboratory personnel use mostly the WRI-tool package, they all share the view of TOM-tool being the most critical tool within the certification process. All the other tools and sheets can be replaced by some other means but TOM is the one which halts the whole certification process if it crashes or is unavailable. Even the WRI-tool package can be bypassed by using manual test list creation and TOM-tool functionalities. One interviewee was worried about the tool dependency of the certification process and speculated the following:

> *"If TOM or WRI crashes we can not operate with the excel sheets we used five years ago. In other words we do not have any back-up systems to replace TOM and WRI in these situations. Besides, we do not have any disaster recovery plans existing at the moment!" (Interviewee 8)*

People working in the test request allocation and testing were happy with the functions and operations provided by the TOM-database but the BE team members had a slightly different view. BE team members brought up several problematic features of TOM-database which need to be solved in order to better support the process and increase the efficiency. This demonstrates the difference of TOM use between BE team and the other parts of the process. BE team uses TOM in rather wide-ranging way because they are not only filling in the test request data, but also transferring results across requests, adding documents and creating the test reports. BE team members were the heavy users of TOM in the organization researched whereas laboratory and allocation personnel use the TOM-database only as a test result storage, WRI-tool package being their primary tool.

The development of the tools is not done in a centralized way and all the tools are developed by different stakeholders. A few interviewees from the laboratory side brought up that they need to update the same data about the progress of the testing to two separate tools, TOM and WRI. As interviewee 6 presented it:

> *"The result status assessment has to be done twice. First we update the WRI-tool and then the TOM-tool. It has been many times in my mind if those activities can somehow be integrated together and maybe expand the scope of TOM-tool to cover also WRI status parts." (Interviewee 6)*

Some of the people interviewed had an opinion of TOM-database dictating the process in some parts. It was noted that it is the tool which forces some of the tasks and procedures to remain the same and not allowing them to develop the way they otherwise would. An example of these views is the statement of the Interviewee 1:

> *"TOM actually dictates our process development." (Interviewee 1)*

TOM-database development in TCC is organized in a group of three people gathering data from the users about error correction needs and development requests. This group of TOM administrators in TCC acts as an interface towards Cetecom by controlling and prioritizing the change requests before communicating them to the TOM specialists in Cetecom. Generally, the TOM development goes ahead well and error corrections are done fast but due to the middlemen, the urgent error corrections or database crashes are not sometimes done rapidly enough. TOM development happens in phases which can be called as patches. In a patch, several error corrections and development item are bundled and they are installed to the system in predefined interval. The problem with the patching approach is that sometimes the old settings and parameters in different parts of the tool get compromised or changed when a new patch is installed and this shows up as malfunctions in the tool. As one of the interviewed person said:

> *"The trust in TOM-tool is a bit wobbling currently because of the patching of its errors and some major structural challenges Cetecom is facing." (Interviewee 1)*

The WRI-tool package development is done in-house by two persons. The advantage of the in-house developed tool is the perfect fit it offers to the organization as can be noted from the statement of the interviewee 8:

> *"Good part of the WRI is that it really is tailor made for our purposes. And can also be developed according the organization's requirements." (Interviewee 8)*

The package has gone through a long development path from the times the necessity of the tool was realized. The organization noticed that the old way of handling the test management using excel sheet was no longer adequate and the construction of WRI began from that impetus. The modular structure of the WRI is presented in the chapter 4.5.2. The different parts were constructed as the requirements increased and the overall architecture is not therefore by any means optimal. The same persons that started building up the tool were still in charge of its further development according to the interviewees. Furthermore, the person who has made the code of the WRI was working

only one day a week and the other person was responsible of collecting feedback from the users and planning the development. The WRI development clearly preoccupied people as can be noticed from the statements of some of the interviewees:

> *"WRI development is not done in controllable way. The version control is not sufficient" (Interviewee 10)*

> *"WRI-tool development is not clear but bugs get corrected rather fast." (Interviewee 5)*

All the interviewees saw the WRI-tool package as a source of high risk for the operation of the laboratory and the whole certification but those issues are presented in more detail in chapter 5.3.4

According to most of the interviewees TOM-database and WRI-tool package were somewhat overlapping in their functions but there still was a clear splitting between the tasks done with the help of TOM and WRI. Some people interviewed considered it as a good thing to have separate systems in use for laboratory activities on the other side and test requests and report writing on the other. They justified this by stating that if the other system is down, the other can be used for a short period of time in the mean while. Another reasoning they gave was because of lack of trust towards the possibility that all the functionalities of the two systems would be possible to be integrated in one system in a way that would satisfy all users. Even so, there were a few interviewees who mentioned that it would be a lot more beneficial to have only one information system in place for these activities not only because it would make the process more integrated and standardized but also because it would enable better and in-depth development possibilities of the tool. Having only one system the risks would also be simpler to control and the justification and allocation of the development investments would be easier.

5.2.5 Knowledge of the overall process and personal contribution in it

All the interviewees knew how they contribute to the overall certification process and what their responsibilities were. It was noted though that the knowledge of the other parts of the process, than where the interviewees were working for, diminished when going towards the laboratory along the process from the certification testing board. This was because the laboratory acted as a true process organization handling the constant stream of particles, test cases, regardless of their source or purpose. It was the responsibility of the previous parts of the process i.e. certification testing board, back end and allocation, to transform the requests to test cases. As stated by one of the interviewees:

> *"The back end is a sort of refinery in the process. The Board manages the overall plans and in back end these plans starts to become concrete and executable. BE outputs are executable plans and executable test cases. The rest of the process is the execution part." (Interviewee 8)*

The co-operation between BE and allocation personnel received recognition as can be noted from a comment of one of the interviewees:

> *"The role of the BE and tasks they are responsible of are clear to me because we are in close collaboration with them. If there are some unclear issues with the WRs we can always ask from BE. And we actually ask, almost daily." (Interviewee 4)*

Majority of the interviewees stated that the visibility to the PP / PCM organization, i.e. customer part of the process, is somewhat blurry. The people working for the rest of the process did not know well enough what was happening in the customer side and what were the reasons for some urgent product updates or test requests. As stated by the interviewee 4:

> *"It would be helpful to get reasoning behind the e.g. urgent requests. Also feedback about where the efforts have lead would be nice to receive from PP." (Interviewee 4)*

Although the process organization works the best when the roles and tasks are well defined and divided between people and the workflow is standardized, understanding the big picture helps in motivating people. Well standardized tasks are dull for the process workers in the long run. As the interviewee 10 stated, the overall understanding of the process would motivate people and help in setting their efforts to the big picture:

> *"More visibility to the big picture would be motivating for the people to have. The connection of their work to the real world (product market targets etc.) would concretize their efforts better." (Interviewee 10)*

5.2.6 Trust in the previous parts of the process

The basic idea of the process work, when presented in phases of the process, is to be able to continue from where the previous phase has finished. This means continuous chain of consecutive work phases in order to produce the final product, which in this case is the certification of a product. In order to be able to truly continue from where the previous process phase has finished, the inputs need to be trusted. There are many checks done in the different parts of the process as can be seen in the process flow illustrations in appendices 4 and 5. There should be some check points in the process in order to monitor the quality of the process. Interviewee 8 stated:

> *"I think it is good to have control points in the process. If those would not be required we would be talking about ideal world. Control points are about assuring the quality in our organization and therefore, as such, justified. The purpose of the checks is not to question the work of previous parts but only to make sure the data needed for the next phase is there and it is correct." (Interviewee 8)*

Generally can be stated that the people interviewed shared the opinion of having plenty of checks across the process but most of them are required. To the role of BE belongs checks when receiving the WRs from customers and making the test lists and splits but also when creating the final test reports. One of the interviewees stated:

> *"Back end is the check office in the process!" (Interviewee 3)*

The laboratory personnel did not think that the checks interfere the flow of the process and one of the interviewees said:

> *"We have to trust the inputs we receive. Otherwise it would make no sense. Sometimes some small clarifications and checks are required in case of missing info or other problems." (Interviewee 4)*

Checking the content of the input received seemed to be only natural for the people in the organization researched. People did not think that resources are wasted in any part of the organization for these checks but some clarifications and more precise guidelines especially for the customer side would help in the quality issues of the inputs received.

5.3 Process development and risk management

5.3.1 Development ideas

In the second part of the theme interviews the people were asked to share their views about what would help in the problems they described in the first part of the interviews. Usually, it is easy to criticize the operation and pinpoint the problematic areas in the operation but it is completely different thing to come up with ideas about what the better solutions would be and especially when taking into account the whole organization. The process scheme presented in the appendix 4 was used for to show the relations of different parts of the process and the workflow to the interviewees. With the help of the process scheme the people were able to see the effects their development ideas would cause in the operation of the whole process and maybe realize better the reasoning behind the current practices.

Most of the interviewees had not thought about their development ideas in the light of the other parts of the process and what would their consequences be. For the reason-consequence understanding difficulties the overall comprehension and knowledge about the process helped and the persons possessing that had already thought about the development points in the process. Some of the interviewees were apparently surprised at the possibility to state their development ideas. Example of this is the reaction of the interviewee 6:

> *"What I would change…ahh yes…so, ee… good question…" (Interviewee 6)*

5.3.2 Process development

The most popular development item presented during the interviews was about the need to improve the communication and information flow between different parties in the process. Nevertheless, special methods on how to improve the communication were not presented. Especially the information received from product programs required improvement according to most of the interviewees. Also the communication and information flows between different internal TCC parts of the process like laboratory, back end and certification testing board required improvements in the eyes of the interviewed people. One interviewee had an idea of establishing a forum:

> *"Information flow and information sharing between labs and backend can be made better by establishing a forum for lab managers and backend." (Interviewee 1)*

There were also concerns about the segregation of work roles in the process which would cause more ignorance towards the big picture of the process among personnel. People would not anymore know what the other people are doing in the process. One interviewee suggested that more meetings, trainings and happenings should be arranged across the organization in order to share the experiences and different ways of thinking between the entities in the certification.

Many of the interviewees also brought up the problem of having insufficient visibility to the coming requests in the near future. According to the opinions gathered during the interviews, the remedy would be to create a better way to schedule the future capacity than what the Master Plan offers. One solution offered was to connect the company's product roadmap information systems directly to the tools in use in certification area. By that way the changes in the market entry plans and roadmaps would show up also in the certification plans.

One big concern among the interviewed people was about the change documentation reviews. People do not completely rely on the profoundness of the change reviews and

are afraid that some required re-testings are overlooked. The interviewed people suggested a solution to have more resources available for change document reviews in the certification testing board but the extra resources would be hard justify to the management when the problems with current reviews have not yet concretized.

5.3.3 Development of the tools

All the interviewees were reluctant to have additional, new tools in certification process. Several new functionalities, people would like to have, were brought up during the discussions but according to the interviewees, they should be implemented in the tools in use already. They stated there already are too many tools in use in the organization as can be noted from the quotes:

> *"The less tools the better. No new tools if they are not replacing some of the old ones." (Interviewee 1)*

> *"There really are enough tools in use today already!" (Interviewee 4)*

> *"No additional tools are required." (Interviewee 9)*

The majority of the interviewees stated that the WRI-tool package and TOM-database should at least have better links between each other in order to avoid redundant data input and simplify the process.

> *"TOM-tool and WRI should be interconnected in a way that the redundant tasks are removed and the data is input only once." (Interviewee 9)*

A few of them even suggested integrating the tools into one, single database.

> *"Tools should be centralized into one single tool." (Interviewee 6)*

> *"It would be challenging task (combining the functionalities of WRI and TOM) but taking into account the gains it may offer, it is an effort worthwhile to consider." (Interviewee 8)*

The views whether to integrate the functions of WRI to TOM-database or vice versa varied between the interviewees but about the necessity of having the tools integrated, the people were unanimous.

As already presented in chapter 5.2.4 the people interviewed were not completely satisfied with the support received from the organizations developing TOM-database and WRI-tool package. As Cetecom was in charge of the TOM-database development the interviewees hoped better and more binding contract between TCC and Cetecom both in maintenance and database development parts:

> *"TOM-tool would require more strict support agreements in order for us to receivee better support from Cetecom. More assertive attitude is needed!" (Interviewee 4)*

Also according to interviewee 1, the use of middlemen between Cetecom and the users of TOM is not the best way to steer the development:

> *"There needs to be a straight link from backend to Cetecom order to speed up the updates and avoid misunderstandings in development and error correction initiatives." (Interviewee 1)*

What comes to the WRI development, the interviewees would like to have better visibility to the tool and its development management. Also the information about the changes made between the versions should be better distributed across the organization.

According to one statement there would be no need to split the testing into three entities (SLS, WM, CS) any longer if the tools are updated accordingly. If the allocation would be done in one single function, it would save time and resources as well as provide better overall, product specific visibility to the testing. The interviewees especially from back end saw the new plan of automating the TOM test list creation from change docs very useful and promising. They all were eager to have it in use because of the undisputable benefits the new function would offer.

5.3.4 Risks identified in the process

Most of the risks the interviewees experienced in the process were related to the operation and availability of the tools in use in different parts RA of certification. Especially the WRI-tool package and TOM-database included severe risks according to the interviewees but a few persons brought up other issues too:

> *"TOM-tool holds the biggest risks from the backend point of view and from lab point of view the biggest concern must be the WRI. Problems in the operation of these tools would jeopardize the whole process. On the other hand, the hiccups in the document review process would slow the process as well." (Interviewee 1)*

In fact, several interviewees were also worried about the reliability of the change documentation reviews and considered those as possible sources of risks:

> *"The documents (difference docs, change docs) are a risk in my opinion. Maybe something is tested gratuitously but sometimes some testing may not be done because of insufficient documentation." (Interviewee 9)*

> *"Change documentation review hiccups may cause big problems so they too need to be considered as risky." (Interviewee 1)*

”In my opinion, the change document reviews are a big risk as well.” (Interviewee 6)

“The operation of the documentation reviews is not clear to me and how the reviews are handled and, in turn, how reliable that part of the process actually is.” (Interviewee 5)

Undoubtedly, the biggest risk in the process was found in the TOM-tool because of the critical role of it in the certification process. According to some interviewees TOM-tool functionalities are hard to replace by any means in the organization:

“There are no possibilities to have a work around for it (TOM-database) at the moment.” (Interviewee 3)

Besides having high levels of risks and vast consequences of them in the operation of TOM, the organization’s dependency of the database concerned many interviewees too. They stated that the whole product certification of Nokia would be jeopardized in case of problems e.g. in Cetecom’s profitability.

“We would be in big trouble if Cetecom goes bankrupt. We would be completely paralyzed and something needs to be done to that.” (Interviewee 5)

All interviewees recognized also the risks related to the WRI-tool package but considered them as having smaller effect on the process than the TOM-database has:

“TOM-tool is much more critical tool than WRI but both of them interferes the operations a lot incase of them being down.” (Interviewee 4)

They also placed the risks of the WRI to the laboratory and testing part of the process:

“Although the laboratory risks are well under control what comes to the backup test systems and deputy arrangements, the WRI dependency is a risk!” (Interviewee 5)

All the interviewees considered the risk of not being able to run the tests as being very minimal even during test system break downs. They assumed that the testing is backed up with many test systems in case of instrument failures and malfunctions. Also the test operators’ and test system managers’ deputy arrangements in case of absences were noted as being under control.

The documentation used in the different parts of the process, besides the change documents, was found as including risks. There are plenty of document templates that need to be filled out by the product programs or PCMs as can be noticed from the process description in chapter 4 but the quality and reliability of the information they include was detected as being questionable. Documents like Work Requests and Report

Requests include product specific information which are critical for certification activities and are therefore required to be filled in carefully. In many instances during the interviews it was noted that the information in the documents were not correct. The errors were not noticed before the latter phases of process which made the corrections more difficult to do. In some cases it was clear that the documents were not filled in by using the recent templates stored in the intranet pages but by editing some old documents done for other products. If people edit old documents that have information in every field, it is only natural for them to skip some of those fields and not to check the validity of the data. This tendency needs to be stopped according to some of the interviewees.

5.3.5 Ideas for alleviating the risks

As mentioned in the previous chapter, the two biggest tool related risks the interviewees detected and described were the risks involved in WRI-tool package and TOM-database. The main problem noted with the WRI-tool package concerned the fact that it was developed and maintained by only two persons in the organization leaving other people unaware of all these things. Also the development of the tool was not transparent to the people interviewed. Most of the ideas presented during interviews about how to control the WRI-tool package risks were about widening the development team and distributing the knowledge of it across the organization. To the problem of having only one person capable of making any changes to the WRI-tool the interviewees stated the following:

> *"At minimum, the development and thorough knowledge of the WRI should be in the hands two persons. Already this would alleviate the risk really much." (Interviewee 8)*

> *The development and coding skills of the WRI should be transferred to people working for Nokia and spread around. Now it is under one single person. There is no proper documentation available about the WRI so something needs to be done!" (Interviewee 4)*

The statement of the interviewee 4 also reveals the need to create the documentation of the WRI-tool package. The missing WRI documentation worried many people in the organization and the necessity to create it was brought up during several interviews.

For the risks associated with TOM-database one interviewee saw the infrastructure and maintenance issues as one good target of improvement:

> *"In TOM there are too many parties involved (Microsoft, server support, Cetecom etc.). The whole TOM maintenance should be concentrated to a*

single party. This would make things not only easier but also faster. The support would be easier to arrange. "(Interviewee 8)

Other views regarding the operation of TOM-database were:

"TOM-database and servers are backed-up once a day so current data and versions of the tools should be in safe." (Interviewee 2)

"Some progress has been achieved with TOM already but it is not enough… There are no options for TOM, no possibility to switch to any other tool easily… Those are features, which I see including big risks. It would take at least 6 months to start using another tool." (Interviewee 1)

To the dependency problem of TOM-tool some of the interviewees suggested the following:

"No active analysis is ongoing or has been done about what kind of tools there are in the market for TCC in the future." (Interviewee 8)

"The analysis of what kind of other solutions there are available in the market which can replace TOM should be started immediately." (Interviewee 2)

A couple of interviewees stated that plans about how to guarantee the process flow even when TOM or WRI are down should be created. The plans would include creation of backup tools and guidelines of how to use them in case of problems with the usually used tools.

"TOM emergency plan should be created." (Interviewee 5)

"When problems occur (both with TOM and WRI) there should be plans ready about what to do. Thinking about these issues it will also concretize the problems and their depth in those problematic instances." (Interviewee 8)

"The criticality of the certification function is not clear enough for the company management. This can be seen if you look at the information system investments done for this activity." (Interviewee 2)

For the document quality problem the interviewees suggested some method of forcing the product programs and PCMs to fill in the empty templates. One possible solution would be that the templates are located in certification intranet page and they are sent from there automatically to the right people. A script would check that all the

fields in the documents are filled in and that the data is sufficient before sending them further.

5.4 Fundamental process development requirements

For the last few, open questions about the whole certification process and its organization and development the interviewees did not have much to offer. This may be due to the lack of visibility of the big picture or just because people are busy with their own tasks in the process. Nevertheless, some interviewees had a few ideas about how to better organize the process or some parts in it. According to one interviewee the customer handling and taking care of product families need improvements. There should be a party in the process which is responsible for streamlining and optimizing those issues. Another interviewee saw the certification process ownership as a problematic area:

> *"There is no owner for the whole certification process. Only the parts of it are taken care of by different stakeholders." (Interviewee 1)*

The lack of ownership of the whole process produces many problems not only in developing and fine-tuning the activities but also when searching for management involvement, investments and sponsorship to the process development.

Interviewee 1 continued the subject:

> *"The parts under our own control can be altered quickly but e.g. documentation and WR-issues cannot be corrected fast because they are not completely under our control but under customers' control. 9 months ago the change doc templates change was started but not until a few weeks ago they were implemented. Parts crossing the customer interface are stiffer. The reasons for that are the old organization habits and historical ways of doing things." (Interviewee 1)*

This comment too reflects the problem of having no single owner for the whole process. When some development issue crosses sub-processes' borders the change turns down to politics and struggle over power. That is not the best way to change things and a lot of time is wasted. Interviewee 8 touched the theme by stating:

> *"We need more dynamic organizational structure and processes in order to better meet the ever changing and more demanding needs of the business. We need to be able to change parts of processes on the fly." (Interviewee 8)*

5.5 Summary

Based on the information gathered from the interviews the personnel of the case organization is rather satisfied with the way the process has been developing but they are expecting the development to continue also in the future. Many problematic parts of the process were brought up and some interviewees have already had thought of corrective methods to make the process better. The process was considered as operating well and the roles of the different process parties were defined sufficiently but the problem expressed during many interviews was that usually the process is not fully followed in real life. The frequently happening exceptions interfere the process flow and cause gnashing of teeth among the process workers. These exceptions are of course not purposeful and should therefore be eliminated. The people interviewed shared the view of having more process like operation in the laboratory testing part of the RA certification. This was because the stream of operations is standardized as test cases which can be executed process wise. The other parts of the certification process such as the certification testing board, BE and allocation, have no standardized item flow and cannot not be fully considered as process organization parts.

The role of the certification testing board was considered as one of the most critical parts for the operation of the whole process. The board has the overall responsibility of the certification schedules, prioritization and some of the most important product documents but the interviewees were worried about the resources there were available in the board. The interviewees brought up instances when the board did not have the time to do their job properly which caused delays in the process. Other problems notified about the process were the missing synchronization between product roadmaps and the certification master plan, incomplete documentation from the customers' side, tool and information system related problems and insufficient process measurement practices. The TOM-database was considered as hindering the process development because of its design which naturally should not be the case. The personnel of the RA certification process knew well their role and responsibilities in the process but they were eager to know more about the big picture i.e. the market and customer based issues behind the certification requests and updates. The people would consider the knowledge about the requirements of the markets as motivating their job. Otherwise the urgent requests are only tasks among plenty of others and the results of their efforts are not visible.

For the process development issues the interviewees had rather concrete input to give. The communication both internally in RA certification and externally to product programs were considered as having problems and it was suggested during the interviews to establish a forum for BE and laboratory management to discuss in set interval about the operative issues regarding the ongoing test requests Also more

meetings and happenings between different entities would help in sharing information and knowledge about best practices across the organization. For the too short visibility towards the future requests a suggestion to introduce straight linkage between product roadmap systems and certification master plan was expressed. A clear message to have more resources in the certification testing board was conveyed in many interviews especially to cover the missing power of reviewing the change documentation. For the questions regarding changes in the information systems in use all the interviewees were reluctant to have more tools. They felt that there are in fact too many tools in use and incorporation of the functions to a fewer tools would be needed. The biggest project would be to integrate the functionalities of the TOM-database and WRI-tool package into a one single tool. Faster development regarding the tools can be achieved by developing an interface between TOM and WRI in order to avoid redundant data input and information mismatch. Also the already started activity of automating the test list creation to TOM-database from change documentation received support.

The biggest risks in the RA certification process came from TOM and WRI. The interviewees saw the development and maintenance of both of the tools as insufficient. According to the interviewees the knowledge about the WRI-tool and its development activities should be spread around in the organization. These can be achieved by enlarging the development team and creating full documentation about the tool. TOM development was seen as being in good level but the support received from Cetecom frustrated some of the interviewees. More binding contract with shorter response times from Cetecom in case of problems was suggested but also the need to have one service provider responsible of the tool was demanded. At the time of the interviews the responsibility of the operation of TOM database was actually divided between server hardware provider, server software provider, server maintenance and backup provider and Cetecom. Furthermore, for the full dependence of the TOM-database many interviewees demanded that a market analysis about other possible solutions and products there are at the market should be started as soon as possible.

In order to alleviate the affects of the risks associated with the tools an emergency plan should be created and possible workarounds to replace the paralyzed parts should be prepared. Most of all, the management of the business group should be made aware of the criticality of the certification function for the whole company and through that way have a single owner for the whole certification process. By having one sponsor who understands the requirements of the certification function, the parts that require development can be prioritized and proper resources allocated accordingly.

6 RESULTS AND ANALYSIS OF THE RESEARCH

6.1 Results of the research and conclusions

The results of the research are presented in a form of answers to the questions set in the beginning of the research.

1. What kind of process there is in place at the moment regarding Nokia Product Certification in Radio Access area and what are its weaknesses and bottle necks?

The Radio Access product certification process flow, created as one of the results of this research, is described with the parts belonging to the scope of it in appendix 4 and the full process description in chapter 4. The kind of holistic scheme of the different stakeholders and functions in the process did not exist before this research. Therefore the process flow scheme and description provided a new, integrated and upper level angle for the managers developing the different parts of the process. The weaknesses and bottlenecks of the process gathered by means of interviewing the different process workers stem from many different sources. Most of the important and sometimes critical bottlenecks relate to the tools in use in the organization. The hiccups and operational failures of the TOM-database and WRI-tool package boosted with the organization's dependency on those tools can be seen as very challenging problem. Also the development of those tools is not done and controlled in best possible and professional way. WRI is maintained by a part-time, external resource and its documentation is insufficient. TOM-database is bought from an external service provider but the relationship with the company seems to be problematic. Both of the tools were originally developed or procured as essential investments which still can be seen in the process. Furthermore, there seems to be too many different tools in use in the process which are interfering the control and development of the certification. There also are plenty of redundant data input throughout the process due to the unconnected tools which are measuring the performance of the different parts of the process.

One big theme which is not in the right level in the process is the communication between different parties involved. Most of the communication is engaged through documents and tools but there has not been paid enough attention to the quality of those instruments. The documentation is hard to read and understand, the process descriptions and guidelines are unclear and the customer requirements are sometimes ambiguous.

Occasionally there are delays experienced in the process and those are occurring mostly because of unsynchronized test planning between Certification Testing Board and laboratories or because the documentation from the customer is delayed. By the

documentation at this point is meant the PCertIS, change documents, difference documents or work requests. Because most of these problems relate to the information system problems, it seems that the business unit management does not realize the importance of the certification function to the success of the whole company. This can be seen from the investments done and sponsorship given to the organization what comes to information systems development projects in certification area.

2. How can the process be developed in order to better meet both the current and the future ever growing demands what comes to Product Certification activities in Radio Access Testing area?

As can be seen from the list of identified bottlenecks and problems in certification process, there are a plenty of things to do in order to alleviate the situation. The process corner stone, communication, requires fast improvements both in the areas of TCC internal communication and in the communication crossing customer interface. More focus should be concentrated on the documentation made available for the customers in the intranet pages. The information and guidelines should be very clear and readable even though their content is heavy. Also workshops and trainings of the certification requirements for customers should be considered as methods of improving the communication between TCC and product programs. For the TCC internal communication improvement and better certification process knowledge, technology area forums, trainings and happenings around changing themes are recommended. People working for certification process should be aware of how things are done in other parts of the process even if their daily routines do not cross.

The roles of the different stakeholders in the certification process are very well defined but because of the Certification Testing Board's central role they require more resources. The situation is rather critical at this point and some of the tasks assigned to the board are not properly done because of overloaded responsibilities. Especially in the quality of very critical change documentation and PCertIS reviews cannot be trusted according to the process personnel interviewed. Far too wide field of responsibilities of the Certification Testing Board causes that some of the tasks can sometimes be overlooked. The problem is that without being able to pinpoint the problems or errors done because of the overload, it will be difficult to justify the need for extra resources. Suggestion for this is the establishment of a temporary task force to check the quality of the change documentation. Based on the experiences collected by the task force, the further actions can be considered.

Visibility towards the future product certification issues and changing schedules is a challenge for the TCC organization. It seems that the accuracy and modifiability of the Master Plan is not sufficient to meet the ever demanding business requirements. The solution recommended to cover these issues is connecting the existing product roadmap databases to the certification scheduling. It might not be an easy task to do but as the

gains are significant, it is a project worthwhile to consider. The revised process scheme describing the suggested changes and improvements to certification process can be seen in the appendix 5. In the revised process scheme the product roadmap systems are directly connected to the combined product certification plan and certification pre-allocation. Also many previously marked as separate process phases are combined or removed because of simplification and optimization reasons and because of having only one integrated database enabling the elimination of some of the checks. One of the most important process changes regarding certification checks and report writing is the connection of the NON-PASS process to the rest of the process. If there are fails which need corrections, the details of them are fed to the SW or HW change documentation phase and in any case the status is updated to the Integrated certification database.

Maybe the biggest issue behind the certification process, and behind all the problems it includes, is the lack of process ownership. The certification process has many stakeholders but the responsibilities of the maintenance and development of the process are divided. Because the whole process is not actually owned by anybody the possibilities to have it running smooth as a whole are limited. Every party and stakeholder can fine-tune their part of the process but the returns will only be local and limited. It is therefore extremely recommended to sell the whole certification ownership idea to the management of the business group or to the management of the whole company. Before the certification process has a single owner, all the stakeholders are named and process boarders are set, there cannot be any other, more radical process development endeavors started than the process fine-tuning and incremental improvements presented in the process theory chapter. When these process corner stones are in place the process reengineering activities can be initiated according to e.g. the phase model introduced in chapter 2.4 by Valiris and Glykas. The development of the certification process measurement could be started with work-flow based monitoring or self-assessment techniques presented in chapter 2.3 because they seem to be best-suiting for the case organization and support well the existing ISO9000 quality system in place.

Other process development issues relate more or less to information systems and tools in use in RA certification testing and are therefore described in detail after the next research question.

3. What can be done to the information systems in use in Radio Access certification to enable them to better support the process and its development and how to harness the IS suppliers in this?

As mentioned earlier, most of the process tasks are done using different tools and excel macros in the RA certification process and the IS therefore plays a crucial role also in the process development. The amount of different tools is breathtaking when considering the functions they are responsible of, thus the amount of tools should be

reduced. The gamut of the tools elevate the risk levels of the process not only because their occasional unavailability but also because of their dispersity which inhibits their centralized maintenance.

The most important tools for the operation of the process are TOM-database and WRI-tool package. The support and development arrangements of these tools do not correspond to their necessity and dependency and urgent actions to correct the status are required. Both of the tools were developed or selected because of process necessities and without fast actions, the functioning of the process can be jeopardized. First of all, the knowledge of the functioning and development of the WRI-tool package should be shared to at least two additional persons working for Nokia in certification organization. Also the user guides, design schemas and other documentation about the tool should be created. These changes alone would alleviate the risks associated with the WRI-tool package substantially. What comes to the TOM-database the support and development agreement with Cetecom should be renewed to include shorter response times and quicker error corrections even with the expense of costs. The contract should better reflect the importance of the tool to the whole certification function. These changes suggested to be done to WRI and TOM can be considered as being only incremental improvements and the major objective for reengineering should be set for integrating the functionalities of both of the tools into one database. The combined system covering all the functionalities of the current WRI-tool package and TOM-database is presented in the revised process scheme in the appendix 5 by the name of Integrated certification database. The process functions the new database is planned to include are marked in blue. The sample processes and the actual running of the certification test cases are not within the database functions. The integration endeavor would require careful planning and it is suggested to approach Cetecom with this project. They have proven record of being able to implement features to TOM according to TCC organization’s requests and they have knowledge about the special environment of certification.

The previously recommended step to integrate the two important tools would naturally raise the risk level and dependency of the single tool. If the database would then be down it would halt the whole process but then the risks could be located into a single source. One risks source with critical severity level is easier to take into account and control than the current dispersed sources of risks with high severity levels. Having said that, it would not be wise in the long run to put all the eggs into the same basket and therefore a market analysis about what other products there are available for the purpose of certification should be initiated. The characteristics and phases of the information system procurement process can be found in chapter 3. As stated previously, the selection of the TOM-database and development of the WRI-tool package were done under pressure and as necessities at the time but this only proves the

importance of planning the information system acquirement carefully. Lessons are to be learned from the mistakes done but the eyes should be focused towards the future.

The certification process development should be started with finding a process owner and then analyzing the current state and problems. Then the targets and desired state of how the process would look like and operate should be straightened out. The development endeavor of the certification process would be quite demanding but the quick hits like the test list creation automation from change docs and database aided document feeds would encourage the project people along the way to finish the important undertaking. The process will be never ready so the incremental improvement state of the process remains as long as the organization exists and people are willing to stay connected…

6.2 Result Analysis

This research is based on a review of theoretical material about Information System purchasing and about processes, their use and development. The empirical part of the research constitutes of extensive document analysis and interviews among the process workers of the case organization. The purpose of the research was to sketch the RA product certification process in place at the time the research was conducted and refine it to operate smoother by interviewing the people working in different parts of the process and find out their views about how the process is working. The theoretical material was used in forming the development ideas in different parts of the process. As a result from the research a refined process flow chart was created and suggestions about how to handle and develop the information systems in use in the process were stated.

Especially in qualitative research the evaluation of the research is often a question of its trustworthiness. The trustworthiness of the qualitative research is contemplated by the reader on the grounds if she or he can agree with the issues stated. When evaluating the qualitative research the starting point is to accept the objectivity of the researcher and thereby analyze the trustworthiness of the whole research process. (Eskola & Suoranta 2005, 210)

Research quality is often measured by the terms reliability and validity. Reliability means according to Hirsjärvi et al. (2005, 216) the repeatability of the research results and is therefore the ability to produce non-random results. Basically, the reliability is that two separate researchers can end up with similar results and conclusions. The reliability of this research can be evaluated by analyzing the results of the theme interviews. As can be seen from the results they are somewhat uniform although the

process view points of the interviewees varied. There naturally are some differences in the opinions of the interviewees but that only reflects the diversity of the roles in the process. Because the results of the interviews are presented authentically it is unlikely to end up in different conclusions. Furthermore, the detailed process description made as a result of extensive process document analysis followed by process reviews with the process workers during the interviews should convince the reader about the reliability of the research.

According to Hirsjärvi et al. (2005, 216) the validity of the research means the ability of the research method or instrument to measure what they were supposed to measure. Validity can be considered as a measure of suitability of the chosen scientific research method to the practical research problem. Eskola and Suoranta (2005, 212) go further and divide the validity into inner and outer validity. By inner validity it is referred to the harmony of the theoretical and conceptual definitions of the research. This measures in practice the mastery and understanding of the researcher in the field of study. Outer validity means that the interpretations and conclusions correlate with the material. The validity evaluation of this research includes the evaluation of suitability of the chosen research method, case study. Also the data collection methods, document analysis, interview and participatory observation are evaluated. Because of the research commission the case study method was natural choice. By using the method triangulation the validity of the research was made better. The first part of the method triangulation, document analysis, provided the fundamental base for the case organization's certification process and the other data collection methods continued from there. The interviews provided essential information about how the process actually worked in the eyes of the stakeholders and process workers. The most problematic parts and phases of the process appeared in most of the interviews and the interview material reached the point of saturation. The same happened with the process development ideas and concepts. The third data collection method used in the research, participatory observation done during the last five years of researcher working for the organization, was used to complete the overall process description and it acted in big role when conducting the interviews and steering the discussions. The researcher paid attention to not influencing on the views of the interviewees with his own conceptions and concentrated on providing confidential, relaxed and open ambience for the interviews. Furthermore, the interviewees were colleagues with the interviewer which eliminated the social thresholds of being careful about what to say to an unfamiliar researcher.

6.3 Further researches

This research was started with the aim of outlining the current RA certification process and finding ideas and solutions to make the process better and smoother. During the research some ideas for further process modeling and development were realized. When analyzing the process and the actions in the different phases of the process it was noticed that a great deal of knowledge the process workers have is so called tacit or silent knowledge which is not written in any process descriptions. Therefore, it is suggested to continue the process development by making a study about how to store, share and distribute the tacit knowledge resources the organization has. Also a review of the knowledge management theories and how to make use of those in the organization is advised to be conducted. Approaches and methodologies such as Knowledge Requirements Analysis (KRA), Knowledge Engineering method (CommonKADS) and process modeling method (EDPDT) can be considered as starting points. In the later phases of process development endeavors a review of scientific literature about change management would also be advised to be conducted before implementing the changes. Organization without prejudices or resistance towards the new does not exist and the case organization is not an exception. There is plenty of valuable information for the organization’s management about how to handle the personnel’s resistance towards the new practices and processes which usually occur during the implementation of the new process.

7 SUMMARY

Organizations and companies organized in process-centered way are not uncommon among functional or product-oriented organizations. Today's demanding, global market place requires that the companies are flexible and capable of adapting according to the dynamic business environments. The process perspective offers a view for the organizations to analyze their operations and connect the tasks and activities with the organization. The research was done in order to examine the existing process in place in the case organization operating in the global markets of mobile device manufacturing, expose the problematic parts and suggest process improvement ideas to the management of the organization. There are numerous ways how to divide the processes based on their characteristics and several different types are introduced in this research. The process perspective includes also some problematic areas and those issues are also presented. Furthermore, a review of some of the process measurements practices is also included and the best suiting methods for the case organization were detected as being Workflow-based monitoring on the other hand and Self-assessments on the other. Out of the different process development and improvement initiatives the incremental improvement and quick hits were considered as best suiting for the current status of the case organization. At the moment when there are no single process owner and sponsor in the certification process, the more fundamental process development initiatives such as reengineering and redesign are not considered as providing the best results. This does not naturally mean that the case organization should not strive for the comprehensive process reengineering but it should be started after the process owner matter is settled.

It became clear during the research that the process of the case organization relies heavily on information systems but its resources to develop the existing systems, not to mention developing new ones, are very limited. Therefore, information about how to procure information systems from system vendors or develop them in co-operation is presented. Also a guideline package about how to run the IS procurement projects and how to select the software vendor is provided.

The empirical chapters of the study provide the commissioner of the research a holistic process scheme containing the case organizations certification activities and a written process description to act as a firm basis for developing the process according to the suggested development recommendations.

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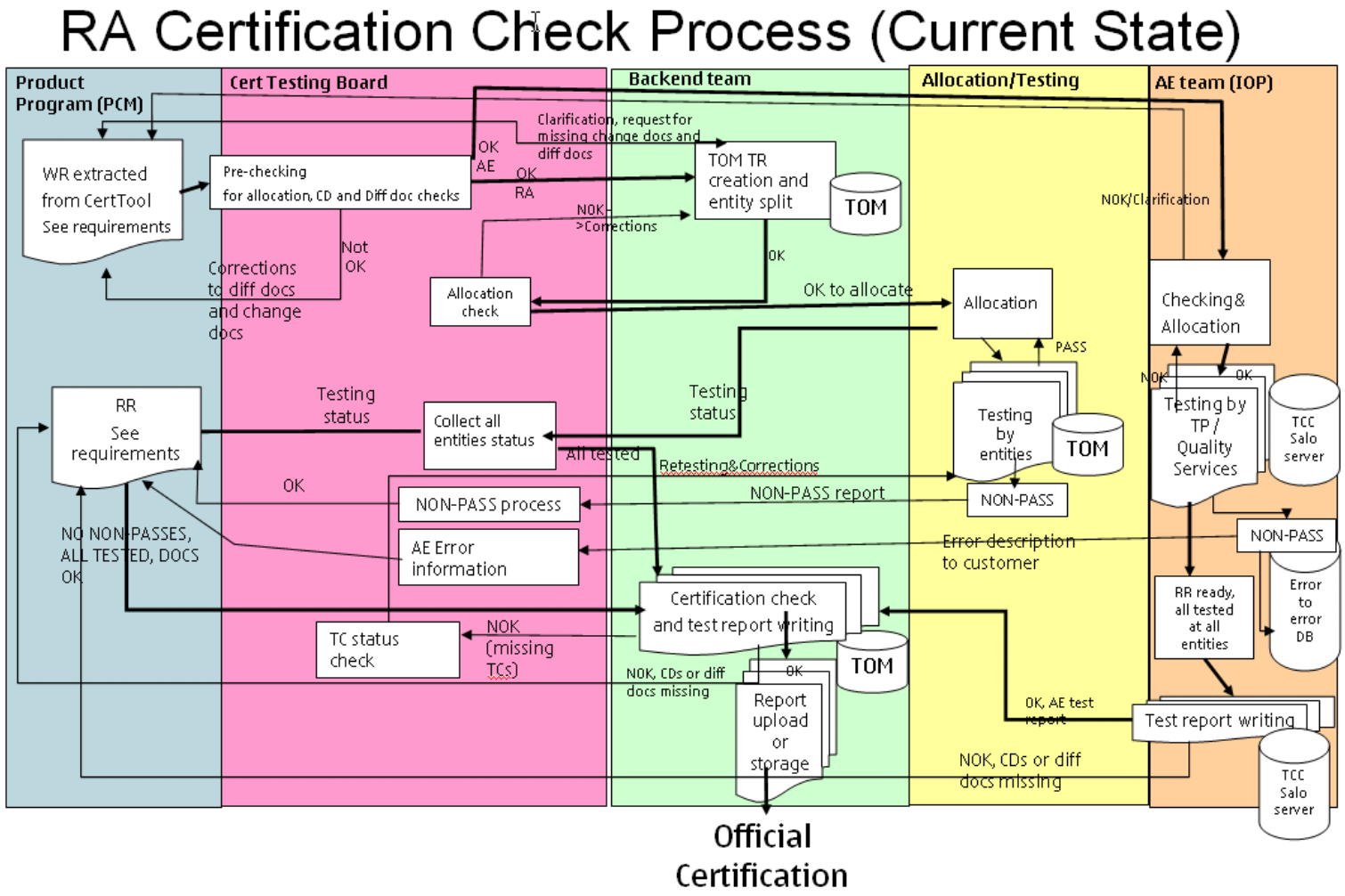
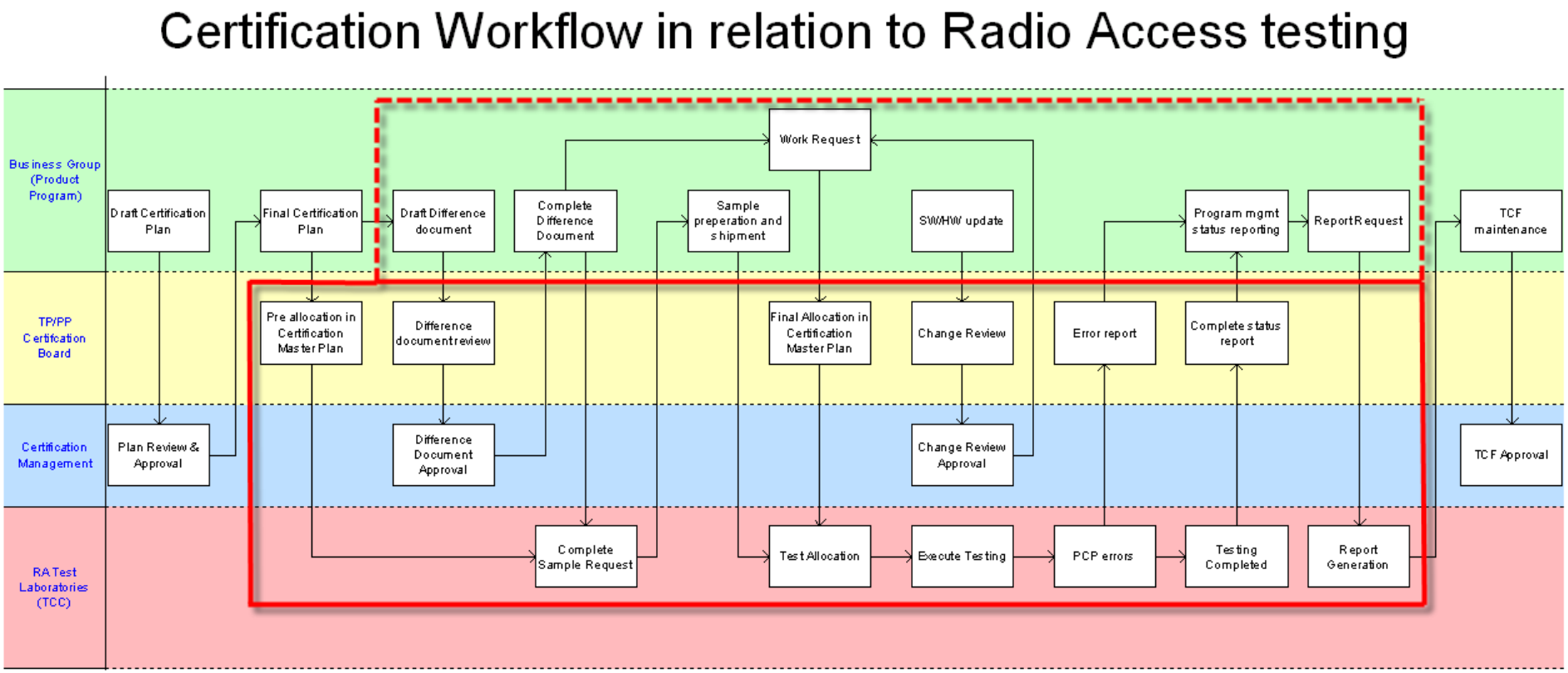
APPENDICES

Appendix 1 Radio Access Certification Check Process (Starting point)



(Back End website, 2008)

Appendix 2 Certification workflow (Radio Access)

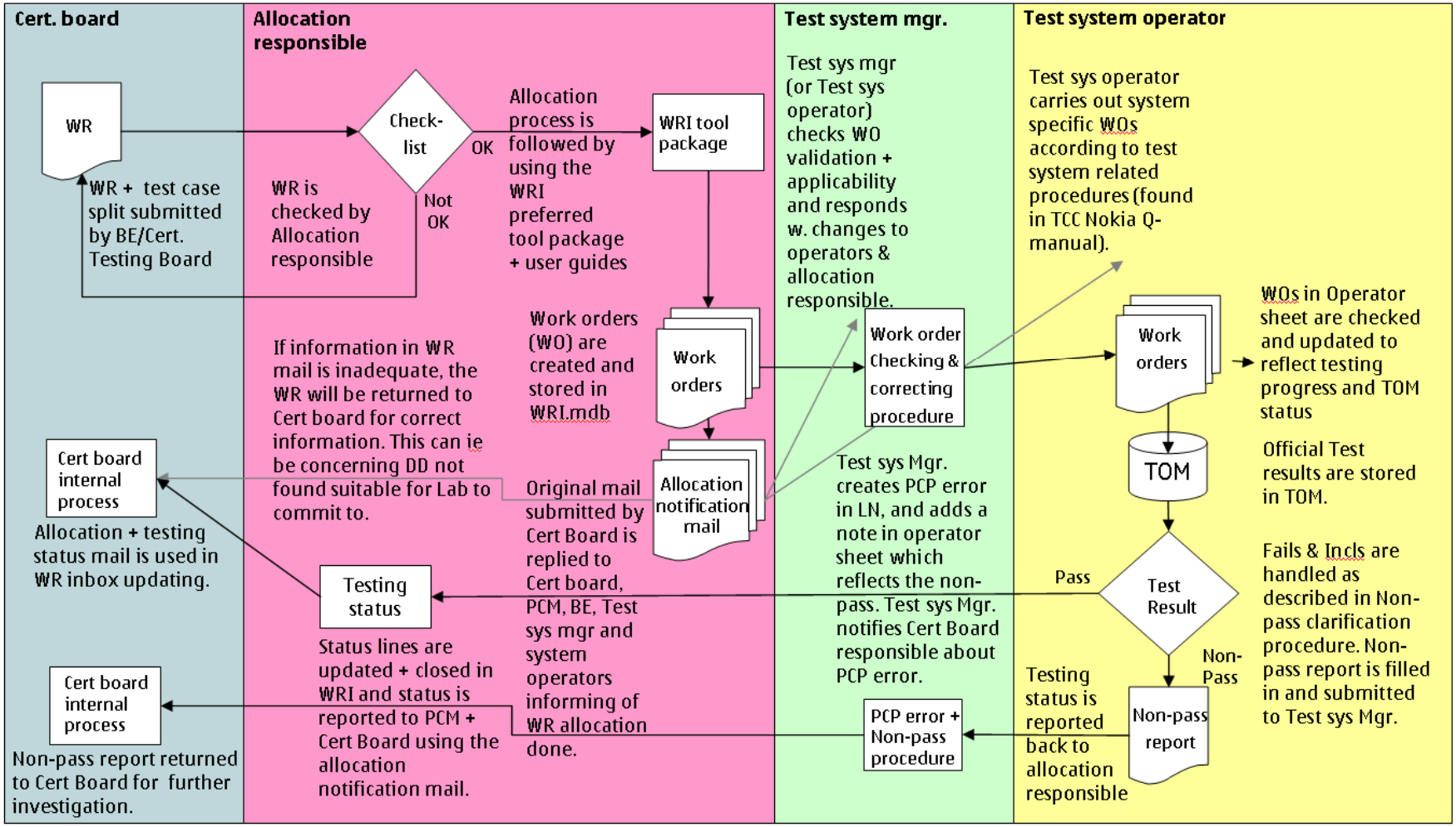


This is trying to illustrate the activities from Certification Plan generation to Product Approval.

(Product Certification Website 2007)

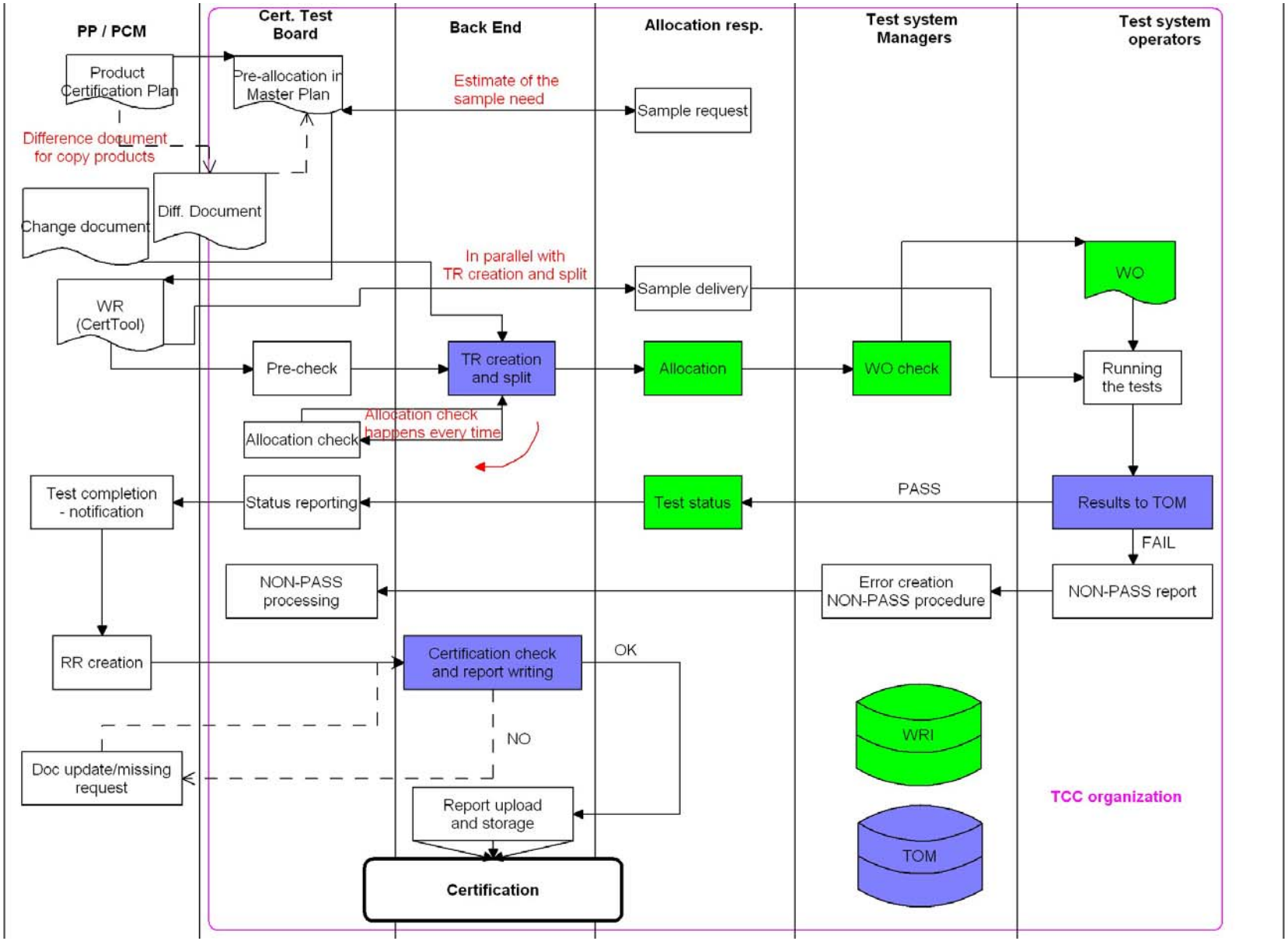
Appendix 3 Laboratory Process

TCC Nokia RA Laboratory process picture

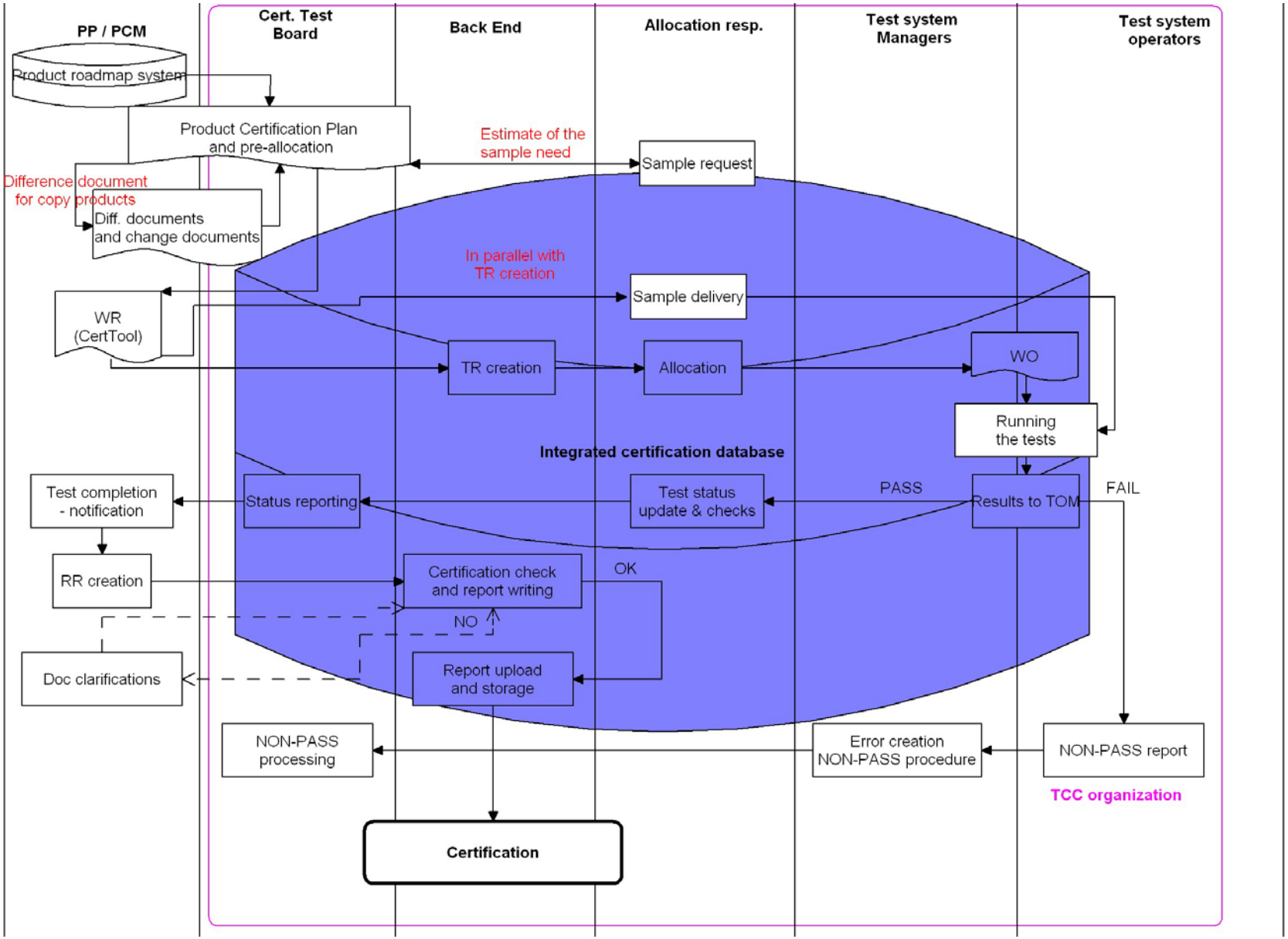


(TCC Nokia RA Laboratory process, 2007)

Appendix 4. Certification Process Flow



Appendix 5 Revised Certification Process Flow



Appendix 6 Interview template

This theme interview is conducted for Master's Thesis in Information Systems Science at Turku School of Economics and Business Administration. The interview aims for getting different views about the problems faced in different parts of the Radio Access certification process and how they could be improved. The purpose of the study is to recognize the weaknesses and bottlenecks of the process and think about how these problems can be solved. The Certification Process chart (Appendix 4) is shown to the interviewee to act as a basis for the interview.

Date:
Interviewer: Jukka Björn

Interviewee
Name:
Organization and the role in it:

Certification process experiences and feelings

1. Does the Certification Process chart reflect the actual process from your part?

2. How do you feel the certification process from your part is functioning?

3. What are the parts and issues in the process that you are satisfied with?

4. What are the bottlenecks and weaknesses of the process that are obstructing you from doing your job more efficiently?

5. Are the tools you are using supporting your job well?

6. Do you know your role in the whole process and how you can contribute in it?

7. How are your actions measured in contributing the process?

8. Is the input you get from the previous parts of the process reliable?

Certification process development ideas

9. What would you change in the process which you think would help in the problems you are facing?

10. What kind of input would you like to receive from the previous parts of the process in order to be able to do your job better?

11. What kind of tools (what they would do) would help you in your job?

12. Which parts of the process in your opinion holds the biggest risks of something going wrong?

13. If the risk you described in the previous question realizes how the process can cope with it?

14. What should be done to minimize the risks from realizing?

15. What would you do and where to get the RA certification process better and more fluent?

16. Any other issues you would like to bring up here?