SOFTWARE PROCESS IMPROVEMENT

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ABSTRACT

SOFTWARE PROCESS IMPROVEMENT

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In this thesis the software development process and in particular, the requirements management processes in a major software development company have been investigated. The current problems related to requirements quality and process performances have been identified. Process improvement measures have been proposed based on the suggestions found in the relevant literature. The current process and the improved version have been compared with respect to the process evaluation metrics proposed particularly for software process improvement.

Keywords: Software Process Improvement, Requirements Management

ÖZ

YAZILIM SÜREÇ İYİLEŞTİRME

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Bu çalışmada, büyük bir yazılım geliştirme şirketindeki, yazılım geliştirme işleyişi ve özellikle gereksinim yönetim işleyişi incelenmiştir. Gereksinim nitelikleri ve süreç performanslar ile ilgili mevcut problemler belirlenmiş, yapılan araştırmalar sonucunda literatürde belirtilmiş olan süreç iyileştirme metotları önerilmiştir. Mevcut süreç ve önerilen süreç, özellikle bu amaç için önerilen şüreç değerlendirme metriklerine göre karşılaştırılmıştır.

Anahtar Kelimeler : Yazılım Süreç İyileştirme, Gereksinim Yönetimi

To My Family

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LIST OF ABBREVATIONS

CCB	Change Control Board
CMMI	Capability Maturity Model Integration
CMT	Change Management Tool
COTS	Commercial off-the-Shelf
CSC	Computer Software Component
CSCI	Computer Software Configuration Item
CX	Company X
CY	Company Y
PMG	Program Management Group
RCD	Requirements Change Document
RCT	Revision Control Tool
RMT	Requirements Management Tool
RS	Requirement Specification
SCCB	Software Change Control Board
SCR	Software Change Request
SPI	Software Process Improvement
SRS	Software Requirement Specification
WRMT	Web access Requirements Management Tool

CHAPTER 1

INTRODUCTION

Software plays an important role in our daily life, and its importance is continually increasing each day. It is used in the products we use in our daily lives, such as mobile phones and vehicles; and performs vital functions in various fields, such as enabling airplanes to fly, and factories to operate. With the increasing number and size of the companies developing and maintaining software, market requirements have been tightened; and a need to produce software more and more rapidly has emerged, which may lead to quality problems. Software process improvement has become one of the main aims of companies, because of the fact that quality of the product is closely related to the quality of the process that produces it. In order to get better products, companies need to improve their software development processes. Thus companies have started to plan, set up budget and staff to review and improve their software development processes.

Werth gives the following description for software process: "Software process is defined as a set of activities that begin with the identification of a need and concludes with the retirement of a product that satisfies the need; or more completely, as a set of activities, methods, practices, and transformations that people use to develop and maintain software and its associated products (e.g., project plans, design documents, code, test cases, user manuals)"[16]. There are many ways in the literature to improve software processes. In the scope of this thesis, the static process evaluation methodology proposed by Güceğlioğlu [26] is used to evaluate the suggested improvements.

The purpose of this study will be to identify problems in requirement change management activities in a global software development practice that takes place in a major software development company and to propose improvements with utilization of different software requirements management tools to overcome these problems. The static process evaluation methodology proposed by Güceğlioğlu is used to measure process quality of the current activities and the proposed activities. While defining and modeling these processes, the system engineering management plan and related documents are reviewed and interviews with members of the development team are made.

Chapter 2 provides, in the present day, information about the current approaches to software process improvement, requirements management, requirements traceability, tool support to requirements management activities and distributed software development.

Chapter 3 presents the model and measurement of current process used in Company X for requirement change process using modeling and process quality measurement methodology proposed by Güceğlioğlu

Chapter 4 presents the model of the proposed requirement change process, which is prepared in accordance with the inputs from different members of the project team. The chapter also contains measurement of the proposed process model according to methodology proposed by Güceğlioğlu

Chapter 5 compares the current process with the proposed process using the measurement results in Chapter 3 and Chapter 4 and a conclusion of the study is given.

CHAPTER 2

LITERATURE REVIEW

2.1 Software Process Improvement

Software Process Improvement (SPI) is defined as follows by Seija: “The purpose of improvement is often to enhance software development in order to raise the quality of software. On the other hand the goal may be to shorten the delivery cycle, to lower the costs and thus improve profitability, or to strengthen the market position. There may also be a need to prove the maturity of development, which many require changes in software development processes” [17].

Various researchers designed different models and methodologies for SPI. Capability Maturity Model Integration [20], Software Process Improvement Capability Determination [21], and similar SPI models focus on improving software quality by trying to reduce differences between the process and a standard one. Goal/Question/Metric [22], Experience Factory [23], Quality Improvement Paradigm [24], and similar SPI methodologies focus on improving software quality by measuring various metrics obtained by analyzing the current process and then proposing improvement suggestions to improve those metrics. This could be narrowed down to 4 simple steps as follows;

1. Observe existing solutions,
2. Propose better solution,
3. Build or develop,
4. Measure and analyze.

2.2 Requirements Management

With the increasing complexity and size of today's software projects, requirements management plays a crucial role in software development. The definition of requirements management is given as the science and art of gathering and managing user, business, technical, and functional requirements within a product development project [1]. Opposite to the common belief, requirements management activities are not finished after the generation of requirement specification document, actually requirements management activities are present in all of the activities of a software project development.

In investigation phase, requirements are gathered from the customer, developer, and financial people, via surveys, literature research and individual meetings with experts of the field. After gathering initial requirements, meetings are held with representatives from each side. In meetings, requirements are re-investigated and cots and priorities are assigned to the requirements. Afterwards, requirements are organized and a requirement specification document is generated. In design and development phase, requirements managers ensure that requirements are successfully mapped to software elements, and developed project remains in the scope of the requirement specification. Meanwhile, test procedures are generated by a team separate from the development team. The duty of the requirements managers is to ensure that test procedures are successfully generated and indeed successfully test the subject requirements. In the test and verification phase, the main responsibility of the requirements manager is to make sure that requirements are successfully implemented and verified. In case of failures, requirement managers have to inform the developers about the defects found in the software.

Also during all these activities, there is the fact that some requirements may change due to various reasons like change request by customers, advancements in the field of development, changes took place in the business interests. Moreover in some projects customers do not know the requirements fully in the initial phases of the project and requirements are developed throughout a considerable portion of the project. Requirement managers have to reflect those changes to the each

development artifact. In other words, testers have to re-investigate the test procedures, developers have to re-design the systems, and managers have to re-investigate the schedule and cost. All of these activities require great amount of effort and they are nearly impossible to be fulfilled without a good requirements management practice.

While generally being underestimated, requirements management is the most crucial activity in today's most software projects. It plays an important role in producing quality software and meeting the estimated cost and schedule of the project. Importance of the requirements management has only been understood in the last decade, and a generally accepted methodology does not exist yet. Main problems in the field of requirements management occur in the requirement generation process and the requirement traceability problems.

2.3 Requirements Traceability

Requirements traceability is an important aspect of requirements management. It is well documented that most of the errors in software development occur in the requirements. Requirement traceability helps to find those errors early and help to fix those errors and affected artifacts with minimal effort. With the complexity of software systems and the interdependencies of requirements, requirement traceability models and tools become very critical for improving software fault detection and the overall software quality [3].

Requirements Traceability is defined as the ability to describe and follow the life of a requirement, in both forwards and backwards direction In other words from its origins through its development and specification to its subsequent deployment and use, and through all periods of on-going refinement and iteration in any of these phases. Furthermore it is divided into two sections named as Pre-Requirement Specification (RS) traceability and Post-RS traceability. Pre-RS traceability is concerned with those aspects of a requirement's life prior to its inclusion in the RS, (requirement production). Post-RS traceability is concerned with those aspects of a requirement's life that result from its inclusion in the RS (requirement deployment).

Researchers conclude that most of the current problems occurring in the requirement traceability are due to poor Pre-RS traceability [2].

Pre-RS traceability is the trace of the facts that make up a specification; those facts include meetings held with customers, developers, producers, experts in the field, surveys done, studied documents, standards, etc. These traces are required in the project because in several cases it is necessary to understand the rationales behind the specification. Furthermore, in various cases it is necessary to reconsider the requirement itself: for that purpose, it is obligatory to know the previous decisions taken to produce such a specification [2]. In most projects, such information is neither stored, nor traced in any manner. There are generally a number of key people, i.e. there is a person who attends all meetings and knows the decisions behind the specifications. If such a person exists, a common question arises: "Why are the rationales not documented?" The answer is often the need of pre-RS traceability is not recognized, and resources allocated to Pre-RS traceability are way less then the required amount, and also in some projects Pre-RS traceability is not practical because of the customer oriented problems. [2]

Post-RS traceability is a bit more advanced than Pre-RS. At worst traceability matrices are utilized in most of the today's software development projects. The two biggest problems in the post-RS traceability are to keep those traceability links up-to date in today's increasing software size, and to reduce the effort required to update the necessary artifacts of the software project when a change occurs in the requirement specification. An event based traceability model is suggested by Cleland-Huang, *et. al.*[4]. In this model, requirements and other software artifacts that may induce changes are considered to be publishers while artifacts dependent on such changes are considered to be the subscribers. A change in the requirements will cause events to be published to an event server, which in turns will send out notifications to all dependent subscribers. At this point, the developers, who are responsible for the effected artifacts, can make necessary changes. Also information retrieval methods are suggested for automatic generation of the traceability links between the different artifacts of the software development. In this approach it is assumed that developers use similar words in the documents to be related.

2.4 Tool Support

While requirements management is for the great benefit of the project, it will require great amount of effort. Often the cost spent in the management of traceability links and requirement generations in-signify the benefits of requirements management to the project [5]. Requirements management tools help to reduce this effort by various ways, such as but not limited to; relate many different documents; obtain a synoptic view of these document relations; retrieve information from within those documents; handle changes made across the documents; accommodate diverse document structuring requirements, generate automatic traceability links, etc. [6].

Information retrieval methods are suggested for generating automatic traceability links [7][8][9][10]. The aim is to decrease the effort required to keep all traceability links up-to date. However information retrieval methods do suffer for recall and precision problem [5]. If a query returns 70% of the critical links but fails to find the remaining 30%, then the query could be ineffective in supporting impact analysis, and a critical side effect of a proposed change could go unnoticed [7]. Trace retrieval strategies must favor recall over precision to counter this difficulty, where recall measures the number of correctly retrieved documents out of the entire set of correct documents, and precision measures the number of correctly retrieved documents out of the set of retrieved documents. Therefore in most of the information retrieval methods a final analyzer checks and removes the unnecessary traceability links. There are various suggestions to decrease the number of such links [5][11][12].

Finkelstein and Emmerich [6] have done a work about the future of the requirements management tools. They believe that in the short term future, requirements management tools will integrate best features of their competitors, to increase their share of the market. Moreover they state that being able to handle very large sets of documents is an issue, and even some well know products have failed to perform well under such conditions. While producers have to keep their tools flexible enough to integrate in the different defined process of large companies, there is also another share of the market, which consists of small companies that do not have a well

defined requirements management process. Therefore it is possible to produce tools with requirements management process “package”. Another concern in the short-term future is the integration with other tools, ability to support different document versions, ability to keep structure of the imported documents, ability to work with other software development tools such as IBM Rational Rose.

In mid-future, the main issue will be the distribution of the software development team. Most of the tools are logically centralized, as distribution becomes an important part of today’s business, these tools have to adapt themselves to distributed development environments. Integration of multimedia sources to the requirement is another feature that could be expected in the mid term future, with the decreasing cost of multimedia devices, requirements management tools should be capable of processing and integrating multimedia sources to their systems.

2.5 Distributed Software Development

Over the last decade, consistent with the globalization of the world, the global software development has become a popular practice in spite the risks and the complexity involved in it. According to Bulgurcu [13]; strong communication infrastructure, clear definitions of the roles and responsibilities, significance of teamwork, utilization of a comprehensive tool support, coordination of sequential and dependent activities, and parallel working play an important role in the success of global software development. Furthermore, she states that the tool used in global software development projects should be a comprehensive online system solution which is capable of adapting to the development processes and organizational infrastructures of collaborative organizations. It should mainly provide facilities to support communication, planning, decision making, storing and achieving, and coordinating activities between geographically speared collaborative parties.

According to a survey in nine global software development projects of Siemens Corporation [14] differences in project planning and tracking discipline cause substantial problems in global software development. While this is a problem in any setting, it seems much harder to solve with organizational and geographic

boundaries. On the other hand, the broadest problem seems to be the greatly reduced communication in multi-site projects as compared to single-site projects [15]. Subtle cultural differences in corporate, technical and national culture often complicate communication, and can lead to frustrations and misunderstandings. If requirements are not clearly conveyed, cultural differences may lead the different interpretations of requirements in different sites, and these interpretation differences may not be observed until integration. It is encouraged to the projects to try out tools that support asynchronous collaborations, such as wikis, discussion boards and synchronous collaboration tools like chat and instant messaging [14].

Bussman [25] further identified the challenges experienced in distributed requirements management activities in a globally distributed development environment. She mentions that even thought sites were using similar tools for managing requirements, there were still problems like; incompatible versions, differences in configuration management process, and differences in generated documents. In addition, she identifies the fact that the different companies have different requirements management practices, and it is quite impossible to modify them by without affecting other project of those companies. In her study, she proposed to manage requirement database at a single site and allow other companies remotely access this database.

2.6 Güçeğlioğlu's Static Process Evaluation Methodology

In this study static process evaluation methodology proposed by Güçeğlioğlu is used in both modeling and measurement of the current process and proposed improved processes. Güçeğlioğlu describes his method as follows;

"The structure of the model is based on the ISO/IEC 9126 Software Product Quality Model. The ISO/IEC 9126 describes a software products evaluation approach for developing or selecting high quality software products. The software product is evaluated for every relevant quality characteristics in the model by using validated and widely accepted metrics" [27].

Basically in his evaluation methodology he adapted ISO/IEC 9126 software quality metrics to the process concepts, because of the fact that there are close relationships between software product and software process. Users of his methodology are encouraged to modify metric defined by him, or even defined application specifies metrics. [27]

Güçeğlioğlu defined total of seventeen metrics for process evaluation, which are grouped in four categories; Maintainability, Reliability, Functionality, and Usability.

Maintainability category is composed of "Complexity" and "Coupling" metrics, both of which measures analyzability of the process. Complexity is the measurement of "number of decision points in process activities". Coupling is the measurement of "number of interactions with other processes". [27]

Reliability category is composed of "Failure Avoidance", "Restorability", and "Restoration Effectiveness" metrics, which measures the error recognition and restoration capability in case of failures of the process. Failure avoidance is the measurement of reviews, inspections, checkpoint or similar techniques in the process flow that are used to recognize mistakes. Restorability is the measurement of whether activities are recorded or not, it is assumed that restoration of activates can not be performed if it is not recorded. Restoration effectiveness is the measurement of effectiveness of restoration capability. [27]

Functionality category is composed of "Functional Adequacy", "Functional Completeness", "IT Usage", "IT Density", "Computational Accuracy", "Data Exchangeability", and "Access Audit ability" metrics. Functional adequacy and Completeness are the measurement of the differences between processes in regularity documents and processes in practice. IT usage is the measurement of usage of IT applications in the process, where as IT density is the measurement the usage of IT application in preparing, deleting, updating or searching reports forms and other similar documents. Computational accuracy is the measurement of accuracy requirements in the process. Data exchangeability is the measurement of how data which is received from the interacted process is used. [27]

Usability category is composed of “Functional Understandability”, “Existence in Documents”, “Input Validity Checking” , “Undo ability”, and “Attractive Interaction” metrics. Functional understandability is the measurement of the difficulties experienced by staff in comprehending activities. Attractive interaction is the measurement of difficulties of eases in preparation, deletion or updating forms, reports or similar other documents in the process. [27]

The main reason behind usage of static process evaluation methodology proposed by Güçeğlioğlu is that it enables users to evaluated proposed processes before applying them to real projects. Users will be able to measure process improvement in shorter time without affecting any project, which will allow users to re-evaluate proposed process and run improvement cycle defined in section 2.1.

CHAPTER 3

CURRENT PROCESSES IN COMPANY X AND COMPANY Y

In this chapter, current requirements change process used in the project is given using modeling and process quality measurement methodology proposed by Güçeğlioğlu. First a brief description of the project is given in section 3.1. Then static process definitions of the current requirements change process, modeling diagrams and measurement details of the processes are given in section 3.2. While modeling the requirement change process, various project documents including system engineering management plan, and software development plan are inspected and interviews with the development team are carried out. Section 3.3 lists the forms, documents, tools and applications used with process and finally section.

3.1 Project Information

The project that will be investigated in this study is a multination defense project developed for country *T* (Project *B*). The project contains both software and hardware development activities. The main supplier of the project is the company *Y* (CY). Company Y is an USA based major aerospace and Defense Corporation, which is among the top five defense contractors in the world wide. Found in early 19th century. It is producing wide range of products varying intelligence, surveillance, command and control, missile defense systems to satellites, with more than fifty thousand employers world-wide, CY is developing a similar project to another country (Project *A*), which is being developed along with Project *B*, contains core capabilities for most of the potential project; and is designed considering flexibly-configurable system. There are various suppliers for CY from different countries of world. Company *X* (CX), which is a supplier for CY from country *T*, is mainly involved in software development activities of the Project *B*.

Company X is found in late 19th century and is among top five Defense Corporation of country T with more than thousand employers. It is mainly producing software products ranging from Command and control, simulation and governmental systems with the quality certificates of CMM Level 3. CX's main responsibility is to modify Project *A* software to satisfy country *T* specific requirements, develop new components, modify or remove existing components, and to integrate and test modified, unmodified and new developed components. This also includes participating in identify subsystem and low-level requirements to satisfy country *T* requirements.

Project *B* and *A* is being developed using an incremental method, for the purpose of systematic development, integration and test of the software and the hardware while representing initial functionality. Functionalities to be implemented in each incremental cycle and a subsystem to implement that functionality are contained in a document, which is managed by the CX. It is possible to have functionalities which span multiple cycles and/or were implemented by multiple subsystems. If a function is implemented by multiple subsystems, each subsystem is required to provide interfaces for supporting integration and test of functionality implemented by other subsystems. For some functionality, the corresponding infrastructure is implemented in early cycles; the remainder of the functionality is completed on future cycles.

Because of those facts for functionalities which are implemented over multiple cycles and by more than one subsystem, it is required to have all subsystems to implement the functionality in the same cycle. If that is not possible for some subsystems, that subsystem is required to provide interfaces for supporting integration and test for functionalities implemented by other subsystems. For some functionality, the infrastructure is implemented in early cycles, and the remainder of the functionality is completed on the following cycles.

The project is divided into several Computer Software Configuration Items (CSCI), which are further divided in to distinct Computer Software Components (CSC). Some of the CSCs are developed by CY, some of the CSCs are reused from previous products, and other CSCs are developed by CX.

Requirements management functions include managing the system requirements database and establishing and maintaining traceability through the requirements to their implementation and verification allocations. CX has the primary responsibility for ensuring that the requirements database is correct and complete, which includes identifying and resolving or coordinating the resolution of missing and incorrect information. Requirements functional analysis include analyzing the system requirements to resolve conflicts, provide consistent interpretation, and complete and correct requirements allocations for their implementation and verification. For managing requirements Commercial off-the-Shelf (COTS) tool Telelogic DOORS database, hereafter referred as Requirements Management Tool (RMT), is used in the project. For managing other forms and documents, COTS product IBM Rational ClearCase, hereafter referred as Revision Control Tool (RCT), is used. Change request to software artifacts is submitted using COTS product IBM Rational ClearQuest, hereafter referred as Change Management Tool (CMT).

Following traceability matrices are managed,

- System/subsystem specification to Software Requirement Specification (SRS)
- SRS to system/subsystem specification
- Computer software component to SRS
- SRS to computer software component
- CSCI requirement to system/subsystem requirements
- System/subsystem requirement to CSCI requirement
- Verification test case to CSCI and if possible to system/subsystem requirement
- CSCI and if possible system/subsystem requirement to verification test case
- Software requirement specification to allocated Development Cycle
- System/subsystem specification to Human-Machine Interface Specification

3.2 Static Process' Definitions

In this section static process definitions of the current requirement change management process used in the Project are modeled and measured according to Güceğlioğlu's proposed modeling schema. First forms, documents, tools and applications used in the following process are explained in section 3.2.1. Then section 3.2.2 contains the activities performed by Company X starting from generating change request in Software Change Request (SCR) database to the time SCR is exported to Company Y. Section 3.2.3 contains the activities performed by engineers to generated Requirement Change Document (RCD). Section 3.2.4 contains the activities performed by Company X and Y after Company Y receives the RCD SCR. Section 3.2.5 contains the activities performed by Company X when they receive a new requirement database replica from Company Y.

3.2.1 Forms/Documents/Tools/Applications

3.2.1.1 SCR Submit Form

SCR Submit form is filled using CMT. This form is filled during the submission state of the SCR. This form includes following data items:

- Originator Name
- Originator Group
- Found In Cycle
- Problem Origin
- Problem Priority
- Problem Severity
- Cycle in which problem Found
- Submission Date
- SCR Unique Identification Number
- Problem Description
- Problem Title

3.2.1.2 SCR Analysis Form

SCR Analysis form is filled using CMT. This form is filled after a Lead Engineer or Software Change Control Board (SCCB) assigns an analyst to the SCR and changes the state of the SCR to "Analysis". Automatically generated e-mail is sent to assigned analyst. This form includes following data items:

- Technical Lead of the assigned analyst
- Analyst Name
- Analysis
- Cycle in which problem will be solved
- Change Authority
- List of Affected CSCI
- List of Affected CSC
- SCR Type
- Analysis Due Date
- Date Analysis Completed

3.2.1.3 SCR Verify Form

SCR Verify form is filled using CMT. This form is filled when the entire problem related with this SCR is assumed to be handled, or it is no longer practical to use this SCR to track problem, in which case another SCR is initiated to track the problem. In this state, software artifacts are inspected, analyzed or executed on desktop or lab environment to observe that problem statement in the submit section no longer exists. This form includes following data items.

- Verification Method Used
- Verification Comments
- Name of the Person that verified
- Time Spent for Incorporating this SCR
- Verification Date

3.2.1.4 SCR Close Form

SCR Close form is filled using CMT. This form is filled in the SCCB meetings for those SCRs which are decided to be closed by board. This form includes following data items.

- Closed By
- Closed By Date
- Date Closed

3.2.1.5 SCCB Meeting Form

SCCB Meeting form is kept in both paper based environment. It contains a list of changes performed on SCR in the SCCB Meeting. The list contains following data items.

- SCR Number
- Old State of the SCR
- New State of the SCR
- Notes about SCR.

SCCB Meeting form also includes a list of attendants.

3.2.1.6 Minutes of Meeting

Minutes of Meeting document is written in a Microsoft Word Template file, but also kept in paper based environment. This document is recorded for all of the meetings held. This form includes following data items.

- Subject of the Meeting
- Meeting Place
- Meeting Date and Time
- List of Attendants
- List of Discussed Issues
- List of Decisions
- List of Action Items Each action item includes following data:

- Action item no
- Action Item description
- Responsible Person
- Planned Due Date
- Realized Due Date (filled later)

3.2.1.7 Requirement Change Document

Requirement Change document is a Microsoft Excel Workbook file. This document is generated when a change of requirements is necessary. This document is divided in to two parts. First part contains the current values, and the second part contains the suggested changed value of following data items:

- Source of the Requirement
- Supplier of the Requirement
- Cycle allocation of the Requirement
- Paragraph Number of the Requirement
- Requirement Text
- Requirement Verification Method
- Allocated CSC
- Trace links to One Tier higher requirements
- Trace links to Human Machine Components

Also following data items are supplied for each requirement:

- Requirement Unique ID
- Change Rational
- Modification Kind

3.2.1.8 Question Database

Question database is a worksheet managed by CX. Engineers working at CX use question database to ask questions about the requirements, reused source code, system design and etc… The question database contains following data

- Question unique ID

- Originating person
- Question Text
- Question Submission Date
- Point of Contact at CY
- Answer Text
- Answer Submission Data
- Severity of the questions

3.2.2 Requirement Change Document Initiation

3.2.2.1 Process No

Process Number is 1.

3.2.2.2 Short Description

Subsystem Requirement Specification is a set of requirements, which are derived from system level requirements, defines the requirements to be fulfilled by subsystems. SRS Database is managed by using requirements management tool. Master copy of the SRS database is managed by CY and a replica of the database is present in the CX. This process defines the procedures followed by CX to request a set of changes in the SRS database.

For the purpose of changing requirements CX engineers prepare a RCD and submit it to software change request (SCR) database, which is tracked using configuration management tool. These SCRs are then exported to CY for analyze and implementation.

3.2.2.3 Activities

Activities employed in requirement change initiation process are given in the Table 3-1 and Figure 3-1. Measurement results of the process are given in Table 3-2, Table 3-3, Table 3-4, and Table 3-5.

Table 3-1 Activities involved in RCD initiation

No	Activity Name	Activity Definition	Staff	Forms/ Records Documents/ Archival Tools/ Applications/ Other Medias
1	Initiate Requirement Change Document SCR	An engineer initiates Software Change Request in the Company X SCR database. Automatically generated e-mails are sent to leaders of each group.	Software Engineer from Related CSC	CMT SCR Submit Form
2	Generate RCD Document	RCD Document is generated according to RCD document generation procedure. RCD document is stored in revision controlled common shared space, then an e-mail is sent to the Project Management Group (PMG) indicating that RCD document is finalized and ready to be reviewed	Software Engineer from Related CSC An Engineer from PMG	RCT RCD E-mail
3	Organize Peer-Review Meeting	Project management group labels the latest revision of the RCD document as "to be revived" using RCT, and organizes a "Peer Review Meeting" according to the size of the RCD to be review and sends out meeting requests, at least three groups with one of them being test group.	PMG	E-mail RCT
4	RCD Review	RCD is reviewed by groups; notes are taken and sent back to originating group before the Peer review meeting for the purpose of pre review before the meeting.	Several Engineers from different groups.	E-mail
5	RCD Peer Review Meeting	RCD is reviewed and discussed in the Peer review meeting. Required corrections/clarifications and modifications to be made to RCD document are recorded as "Action Items" in the "Minutes of meeting" document by an engineer in the PMG.	Several Engineers from different groups Software Engineer from Related CSC PMG	Minutes of meeting

Table 3-1 Activities involved in RCD initiation cont'd

No	Activity Name	Activity Definition	Staff	Forms/ Records Documents/ Archival Tools/ Applications/ Other Medias
6	Update RCD according to Review Results	Software Engineers from the RCD initiating group takes responsibility in performing required corrections/ clarifications and modifications. Afterwards corrected RCD document is attached to the SCR and analysis form of the SCR is filled. PMG is notified after performing all necessary changes. PMG investigates the corrected RCD to check if all of the "Action Items" are corrected, then RCD document is attached to SCR in the SCR database using RCT, PMG Engineer modifies the state of SCR to "SCCB", which means that this SCR will be discussed in Software Change Control Board meeting.	Software Engineer from Related CSC PMG	E-Mail SCR Analysis Form CMT
7	SCCB Meeting	In SCCB meeting if SCR is accepted, the state of the SCR is changed to "HOLD", which means that no modification can be performed on SCR, and "RCD" documents is forwarded to CY for review and implementation. Software Configuration Management (SCM) Group of CX forwards SCR information, including the problem description, analysis and attached documents to CY.	Software Change Control Board. SCM group.	SCCB Meeting Form, SCR SCCB Form SCR Export Package CMT
8	Update Local Requirement Database	Local Requirement database is updated by PMG after RCD SCR state is changed to HOLD. PMG send an e-mail to all groups when update of local database is completed. Local database is used as a baseline for development activities.	An Engineer from PMG	Requirement Database E-mail RMT

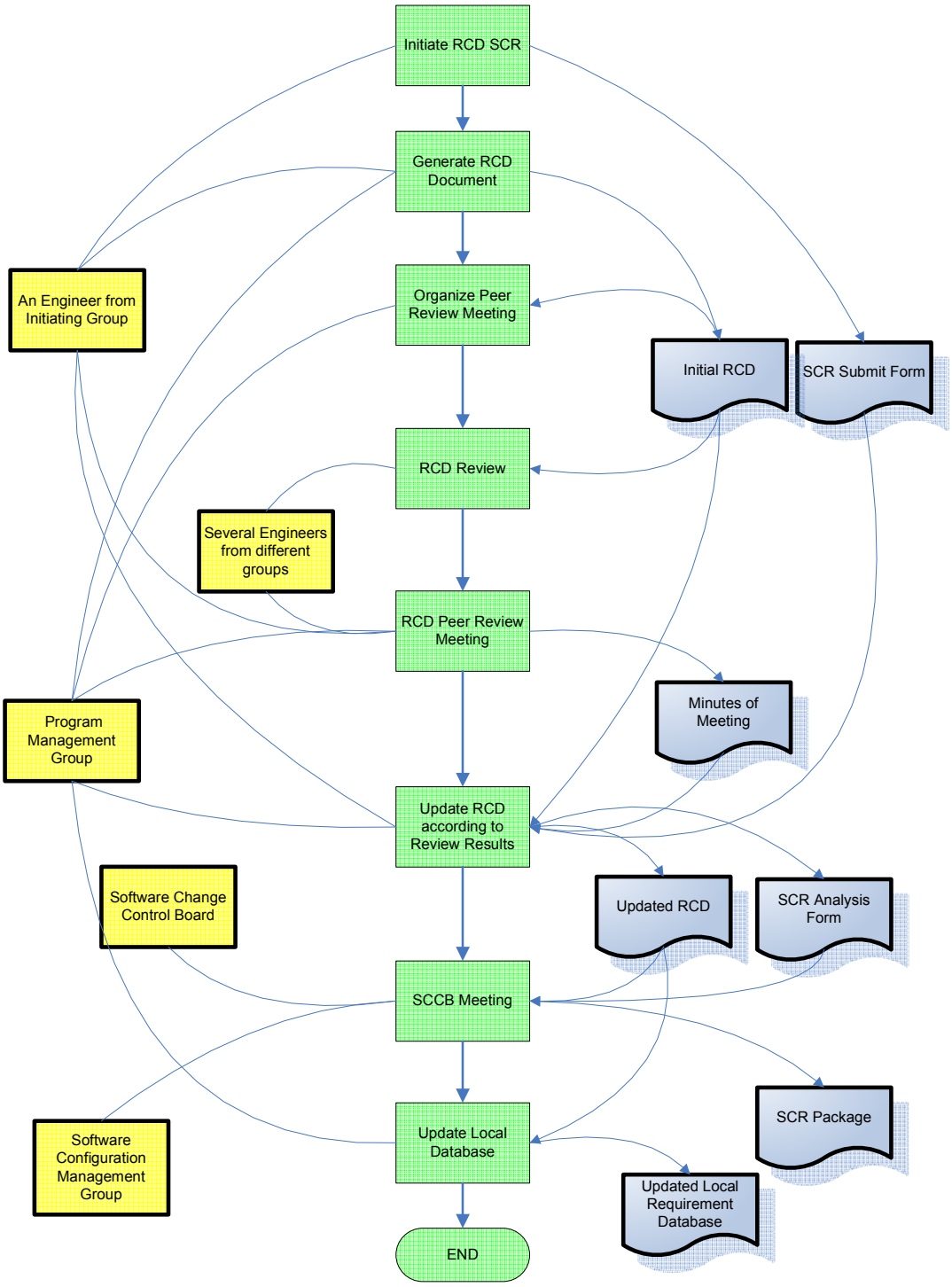

Figure 3-1 RCD initiation diagram

Table 3-2 Results of process RCD initiation for metrics 1-5

Activity Number	Complexity (1)	Coupling (2)	Failure Avoidance (3)	Restorability (4)	Restoration Effectiveness (5)
1	No decision	Interaction with SCR process	No review, inspection, checkpoint or similar techniques	Recorded in SCR database	Restoration from SCR database backup.
2	No decision	No interaction	No review, inspection, checkpoint or similar techniques	Recorded by revision control tool.	Restoration from revision backup.
3	Semi-structured decision for determining the time of "Peer Review" meeting.	No interaction	No review, inspection, checkpoint or similar techniques	Labels are recorded by revision control tool. E-mails are recorded by mail server.	Restoration from revision backup.
4	Unstructured decision for determining problems in RCD document.	No interaction	RCD Document is reviewed by each group.	Not recorded	No restoration.
5	Unstructured decision for determining problems in RCD document.	No interaction	RCD Document is reviewed in "Peer Review" meeting	Review results are recorded in minutes of meeting.	Restoration from soft copy stored in revision control tool.
6	Semi-structured decision for corrections/clarifications/ modifications.	Interaction with SCR process	An Engineer from PMG reviews the RCD for corrections.	Updated RCD is recorded by revision control tool.	Restoration from revision backup.
7	Semi-structured decision for accepting RCD SCR.	Interaction with SCR process	SCR forms are reviewed in SCCB meeting.	Recorded by SCR Management Tool	Restoration from SCR database backup.
8	No decision	Interaction with SCR process	No review, inspection, checkpoint or similar techniques	Recorded by Requirements management Tool	Restoration from Requirement Database backup.

Table 3-3 Results of process RCD initiation for metrics 6-10

Activity Number	Functional Adequacy (6)	Functional Completeness (7)	IT Usage (8)	IT Density (9)	Computational Accuracy (10)
1	Adequate	-	IT Usage in generating SCR, Sending e-mail to group leaders.	Software Change Request From is created in SCR Management Tool E-mails are sent to groups leaders using SMTP Server.	No specific accuracy requirement
2	Adequate	-	IT usage in Creating RCD document, sending RCD document for review	RCD document is created in MS Excel. RCD document is saved to revision controlled workspace	No specific accuracy requirement
3	Inadequate In some cases RCD document is just riverweed by test groups and originating groups without organizing a peer review meeting.	-	IT usage in preparation of "Peer Review" meeting	RCD document is labeled using RCT. Meeting requests are sent using MS Outlook.	No specific accuracy requirement
4	Inadequate In some cases RCD document is just riverweed by test groups and originating groups without organizing a peer review meeting.	-	IT usage in peer review	Review notes are created in MS Word. E-mail is used to send notes to originating group.	Accuracy requirement : RCD is reviewed by each group to check whether it is prepared according to general RCD guidelines.

Table 3-3 Results of process RCD initiation for metrics 6-10 cont'd

Activity Number	Functional Adequacy (6)	Functional Completeness (7)	IT Usage (8)	IT Density (9)	Computational Accuracy (10)
5	Inadequate In some cases RCD document is just riverweed by test groups and originating groups without organizing a peer review meeting.	-	No IT usage	No forms, documents, archival records or other similar documents that are prepared, updated, deleted or searched	No specific accuracy requirement
6	Adequate	-	IT usage in updating RCD document	RCD document is updated in MS Excel, Updated RCD document is attached to SCR using SCR Management Tool	No specific accuracy requirement.
7	Adequate	-	IT usage in reviewing SCR	SCR Management Tool is used while reviewing SCR.	No specific accuracy requirement
8	Adequate	-	IT usage in updating DOOR Database	Requirement Database is used to update and store updated set of requirements.	No specific accuracy requirement

Table 3-4 Results of process RCD initiation for metrics 11-15

Activity Number	Data Exchangeability (11)	Access Audit ability (12)	Functional Understandability (13)	Completeness of Documentation (14)	Input Validity Checking (15)
1	No data conversion	Audit able access to SCR database.	No difficulties or misunderstandings	Described	No input data.
2	Requirements are inserted in to MS excel with using conversion tool.	Audit able access to SCR database.	No difficulties or misunderstandings	Described	No input validity check is performed
3	No interaction	Audit able access to shared disk space Only PMG group can use “to be reviewed” label	No difficulties or misunderstandings	Described	No input validity check is performed
4	No interaction	No access	No difficulties or misunderstandings	Described	Input validity checking by reviewing the RCD document.
5	No interaction	Everyone can access the data, There is no edit.	No difficulties or misunderstandings	Not described	Input validity checking in review meeting
6	No data conversion	Audit able access to SCR database.	No difficulties or misunderstandings	Described	Input validity checking by PMG, PMG checks the list of corrections
7	No data conversion	Everyone can access the data, There is no edit.	No difficulties or misunderstandings	Described	Input validity checking by SCCB, checks the forms of SCR.
8	Change requests at Excel sheet are inserted in to Requirement database manually	Everyone can access the Requirement Database, Modify audit ability Only PMG can edit Requirement database	No difficulties or misunderstandings	Described	No input validity check is performed

Table 3-5 Results of process RCD initiation for metrics 16-17

Activity Number	Undo ability (16)	Attractive Interaction (17)
1	Created SCR could be canceled.	Attractive interaction in filling submit form of SCR.
2	Recorded, undo ability of RCD document.	Not attractive interaction while creating RCD because of various guidelines to follow.
3	Recorded, cancel ability of "Peer Review" meeting.	No interaction with forms, reports, archival records or similar other documents, only e-mail
4	Not recorded.	No interaction with forms, reports, archival records or similar other documents, only e-mail
5	Not recorded	Not attractive interaction while creating minutes of meeting.
6	Recorded, undo ability by using RCT.	Attractive interaction in filling analysis form of SCR.
7	Recorded, undo ability by cancel request at SCR telecoms, and undo ability by SCM Admin to change state of SCR back to analysis.	Not attractive interaction in preparing SCCB Meeting Form, SCCB form of SCR.
8	Recorded, undo ability by performing inverse of RCD changes.	Attractive interaction in updating Requirement Database

3.2.3 Requirement Change Document Generation

3.2.3.1 Process No

Process Number is 2.

3.2.3.2 Short Description

In the beginning of the project there was not a standard template for RCD, every group was writing RCD according to best format they feel suitable, in some cases even two RCD prepared by same group differ in the format. This situation often resulted in clarification request from CY, telephone conferences, e-mails etc… RCD document standardization is defined in an effort to reduce this clarification work.

3.2.3.3 Activities

Activities, which are employed RCD document generation, are given in Table 3-6 and Figure 3-2. Measurement results of the process are given in Table 3-7, Table 3-8, Table 3-9, and Table 3-10.

Table 3-6 Activities involved in RCD generation

No	Activity Name	Activity Definition	Staff	Forms/ Records Documents/ Archival Tools/ Applications/ Other Medias
1	Extract Requirements	Subsystem Requirement Specifications are extracted from the local requirement database, which is held at the Company X, to MS Excel Workbook.	Software Engineer from Related CSC	MS Excel Requirement DB RCD
2	Overstrike Modifications	In the current section of the document strikethrough text of attributes which will either be changed or be removed in the "Suggested Change" section.	Software Engineer from Related CSC	MS Excel RCD
3	Attribute Modification	In the "Suggested Change" section of the document bold text of attributes that will be modified.	Software Engineer from Related CSC	MS Excel RCD

Table 3-6 Activities involved in RCD generation cont'd

No	Activity Name	Activity Definition	Staff	Forms/ Records Documents/ Archival Tools/ Applications/ Other Medias
4	Link addition/ removal	In the "Suggested Change" section of the document links which are added will be labeled with the word "ADD" In the "Suggested Change" section of the document those links which are removed will be labeled with the word "DEL"	Software Engineer from Related CSC	MS Excel RCD
5	New Requirements	Each new requirement is given a temporary unique ID which composes of software Development Group, RCD SCR number and a document unique number.	Software Engineer from Related CSC	MS Excel RCD
6	Color Codes	Excel Rows that contain new requirements is colored blue. Excel Rows that contain modified requirement is colored in green. Excel Rows that contain deleted requirement is colored in red.	Software Engineer from Related CSC	MS Excel RCD
7	Change Rational	Fill the change rational column of the each modified requirement. Try to explain the reasons of the change clearly.	Software Engineer from Related CSC	MS Excel RCD
8	Remove unmodified requirements.	Requirements which are not modified are deleted from RCD document.	Software Engineer from Related CSC	MS Excel RCD
9	Fill "Mod Type" column	"Mod Type" Column of the RCD will be set to "Modified" for changed requirements, "New" for new requirements, "Deleted" for requirements that are removed, and "As Is" for headers which are included for reference. "As Is" should not be used for requirements.	Software Engineer from Related CSC	MS Excel RCD
10	RCD Review	Before releasing the document to other groups, RCD document is reviewed internally by other group member.	Software Engineers from Related CSC	MS Excel RCD

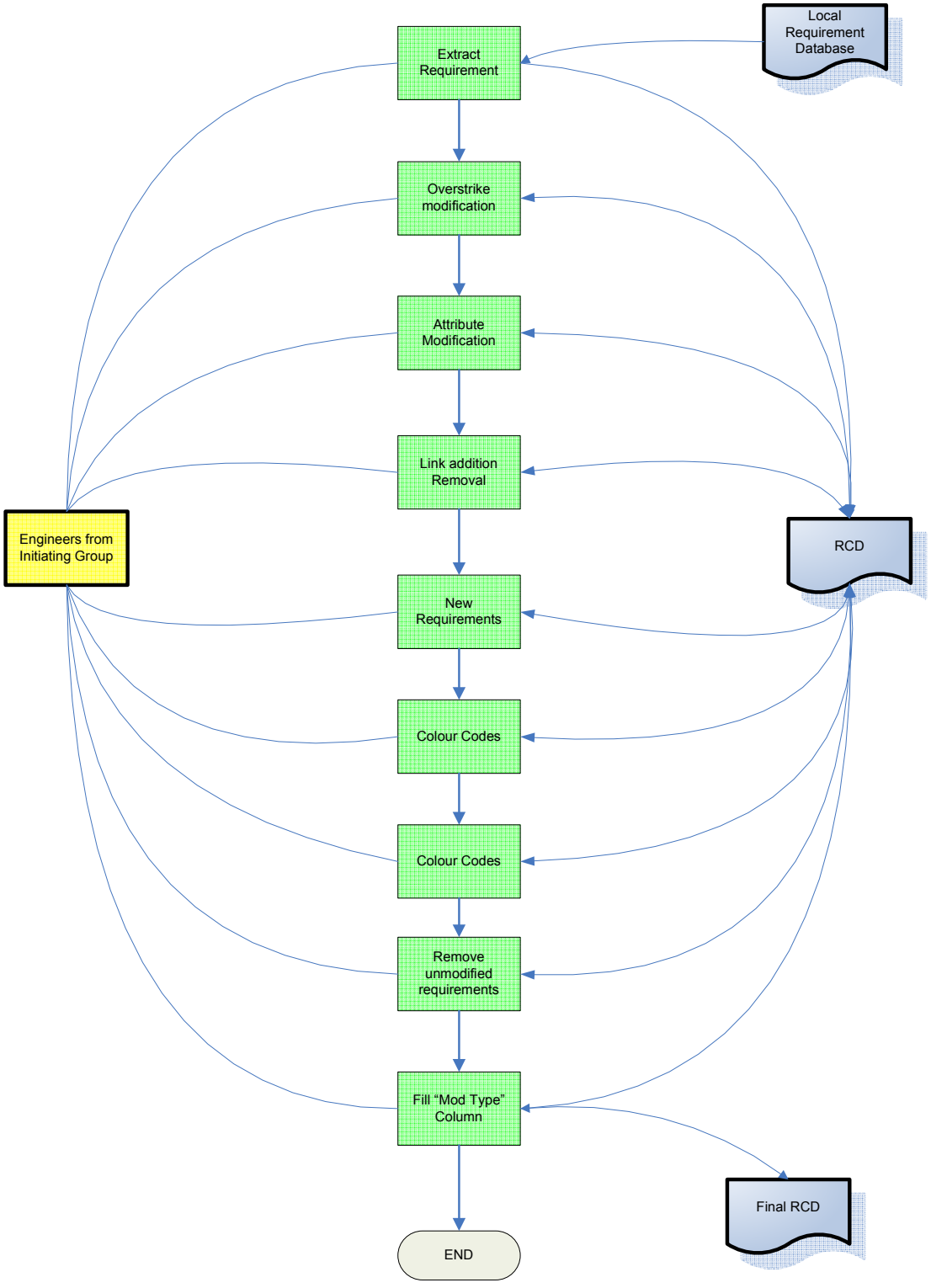

Figure 3-2 RCD generation diagram

Table 3-7 Results of process RCD generation for metrics 1-5

Activity Number	Complexity (1)	Coupling (2)	Failure Avoidance (3)	Restorability (4)	Restoration Effectiveness (5)
1	No decision	No interaction	No review, inspection, checkpoint or similar techniques	Recorded by revision control tool.	Restoration from revision backup.
2	No decision	No interaction	No review, inspection, checkpoint or similar techniques	Recorded by revision control tool.	Restoration from revision backup.
3	No decision	No interaction	No review, inspection, checkpoint or similar techniques	Recorded by revision control tool.	Restoration from revision backup.
4	No decision	No interaction	No review, inspection, checkpoint or similar techniques	Recorded by revision control tool.	Restoration from revision backup.
5	No decision	No interaction	No review, inspection, checkpoint or similar techniques	Recorded by revision control tool.	Restoration from revision backup.
6	No decision	No interaction	No review, inspection, checkpoint or similar techniques	Recorded by revision control tool.	Restoration from revision backup.
7	No decision	No interaction	No review, inspection, checkpoint or similar techniques	Recorded by revision control tool.	Restoration from revision backup.
8	No decision	No interaction	No review, inspection, checkpoint or similar techniques	Recorded by revision control tool.	Restoration from revision backup.
9	No decision	No interaction	No review, inspection, checkpoint or similar techniques	Recorded by revision control tool.	Restoration from revision backup.
10	No decision	No interaction	RCD Document is reviewed by other group members	Recorded by revision control tool.	Restoration from revision backup.

Table 3-8 Results of process RCD generation for metrics 6-10

Activity Number	Functional Adequacy (6)	Functional Completeness (7)	IT Usage (8)	IT Density (9)	Computational Accuracy (10)
1	Adequate	-	IT usage in extracting the requirements.	RCD Document is update using IT applications.	No specific accuracy requirement
2	Adequate	-	IT usage in preparing RCD	RCD Document is update using IT applications.	Accuracy requirement: Software Engineer should strikethrough necessary text attributes of requirements in RCD
3	Adequate	-	IT usage in preparing RCD	RCD Document is update using IT applications.	Accuracy requirement : Software engineer should bold the necessary text attributes of requirements in RCD
4	Adequate	-	IT usage in preparing RCD	RCD Document is update using IT applications.	Accuracy requirement: Software engineer should label requirement links.
5	Adequate	-	IT usage in preparing RCD	RCD Document is update using IT applications.	Accuracy requirement : Software engineer should give correct IDs to new requirements
6	Adequate	-	IT usage in preparing RCD	RCD Document is update using IT applications.	Accuracy requirement : Software engineer should color lines correctly
7	Adequate	-	IT usage in preparing RCD	RCD Document is update using IT applications.	Accuracy requirement: Software engineer should explain change rational clearly.

Table 3-8 Results of process RCD generation metrics for 6-10 cont'd

Activity Number	Functional Adequacy (6)	Functional Completeness (7)	IT Usage (8)	IT Density (9)	Computational Accuracy (10)
8	Adequate	-	IT usage in preparing RCD	RCD Document is update using IT applications.	Accuracy requirement: Software engineer should delete the unmodified lines from document.
9	Adequate	-	IT usage in preparing RCD.	RCD Document is update using IT applications.	Accuracy requirement: Software engineer should fill "Mod Type" column correctly.
10	Adequate	-	IT usage in review of the RCD	No forms, documents, archival records or other similar documents that are prepared, updated, deleted or searched	No specific accuracy requirement

Table 3-9 Results of process RCD generation for metrics 11-15

Activity Number	Data Exchangeability (11)	Access Audit ability (12)	Functional Understandability (13)	Completeness of Documentation (14)	Input Validity Checking (15)
1	No interaction	Non auditable read access. Auditable modify access.	No difficulties or misunderstandings	Described	No input validity check is performed
2	No interaction	Non auditable read access. Auditable modify access.	No difficulties or misunderstandings	Described	No input validity check is performed

Table 3-9 Results of process RCD generation metrics for 11-15 cont'd

Activity Number	Data Exchangeability (11)	Access Audit ability (12)	Functional Understandability (13)	Completeness of Documentation (14)	Input Validity Checking (15)
3	No interaction	Non auditable read access. Auditable modify access.	No difficulties or misunderstandings	Described	No input validity check is performed
4	No interaction	Non auditable read access. Auditable modify access.	No difficulties or misunderstandings	Described	No input validity check is performed
5	No interaction	Non auditable read access. Auditable modify access.	No difficulties or misunderstandings	Described	No input validity check is performed
6	No interaction	Non auditable read access. Auditable modify access.	No difficulties or misunderstandings	Described	No input validity check is performed
7	No interaction	Non auditable read access. Auditable modify access.	No difficulties or misunderstandings	Described	No input validity check is performed
8	No interaction	Non auditable read access. Auditable modify access.	No difficulties or misunderstandings	Described	No input validity check is performed
9	No interaction	Non auditable read access. Auditable modify access.	No difficulties or misunderstandings	Described	No input validity check is performed

Table 3-9 Results of process RCD generation metrics for 11-15 cont'd

Activity Number	Data Exchangeability (11)	Access Audit ability (12)	Functional Understandability (13)	Completeness of Documentation (14)	Input Validity Checking (15)
10	No interaction	Non auditable read access. Auditable modify access.	No difficulties or misunderstandings	Described	No input validity check is performed

Table 3-10 Results of process RCD generation for metrics 16-17

Activity Number	Undo ability (16)	Attractive Interaction (17)
1	Undo ability: Exported document could be discarded.	Attractive interaction while extracting requirements from database.
2	Undo ability: Texts which are strikethrough could be changed back to normal text.	Not attractive interaction while strikethrough requirement text attributes.
3	Undo ability: Texts which are bold could be changed back to normal text.	Not attractive interaction while changing text type to bold.
4	Undo ability: Word Labels could be removed.	Not attractive interaction while word labeling the links
5	Undo ability: New requirements and their unique IDs could be discarded	Not attractive interaction while creating temporary unique IDs
6	Undo ability: Color of lines could be changed.	Not attractive interaction while coloring the lines.
7	Undo ability: Change column could be modified.	Not attractive interaction while entering change rational.
8	No Undo ability: Requirements should be extracted from database, and manually inserted to necessary places.	Not attractive interaction while deleting the unmodified requirements.
9	Undo ability: Mod Type column of the document could be changed.	Not attractive interaction while filling the "Mod Type" column.
10	Review could be repeated.	Not attractive interaction while reviewing the RCD document.

3.2.4 Requirement Change Document Analysis and Update

3.2.4.1 Process No

Process Number is 3

3.2.4.2 Short Description

Company X is developing project for Company Y. Subsystem requirements of CX are derived from one tier higher level System requirements. CY main responsibility in the requirement change process is to check if requested modifications are in the scope of the project, make sure that all of the higher level requirements are successfully linked to at least one of the lower level requirements and indeed low level requirements satisfy the needs of high tier requirements, and requirements are correct, complete and clear. If analyzes result in change requests not meeting these conditions, CY engineers contact with RCD initiating group to resolve the problems.

3.2.4.3 Activities

Activities employed in RCD analysis and update by CY process is given in Table 3-11, Figure 3-3, Figure 3-4, and Figure 3-5. Measurement results of the process are given in Table 3-12, Table 3-13, Table 3-14, and Table 3-15.

Table 3-11 Activities involved in RCD analysis and update

No	Activity Name	Activity Definition	Staff	Forms/ Records Documents/ Archival Tools/ Applications/ Other Medias
1	Import Received Package	When SCR package is received by SCM group of CY, it is imported into the SCR Database. CMT automatically generates SCR in the CY held SCR Database.	CY SCM Group	CMT package Import Tool SCR Package Imported SCRs
2	SCCB Meeting	In the SCCB Board of CY; SCRs, which are in submit state, are assigned to related Engineers for coordination of analysis and implementation.	SCCB of CY.	CMT SCCB Meeting Form,

Table 3-11 Activities involved in RCD analysis and update cont'd

No	Activity Name	Activity Definition	Staff	Forms/ Records Documents/ Archival Tools/ Applications/ Other Medias
3	RCD Analysis by CY	Assigned engineer analyzes the requested changes, with the aid of other system engineers asserts if the requested changes are in the scope of the project, if requested changes are consistent with the overall system design, if the wording is suitable, and clear.	Software Engineer Assigned to SCR Analysis	MS Excel Requirement DB MS Word RCD
4	RCD Problem Coordination	If updates are necessary to RCD document an e-mail is sent to group leader of the CSC that opened the SCR indicating problems and possible solutions, if solutions could not be solved via e-mails, telephone conferences or meetings could be held to solve the issues.	Software Engineer Assigned to SCR Analysis Engineers from Originating CSC	Telephone E-Mail Requirement DB MS Excel
5	Updated RCD	After coordinating necessary changes, CY Engineer prepares updated form of the RCD. (RCD_updated). Document is peer-reviewed prior to sending CX.	Software Engineer Assigned to SCR Analysis System Engineers	MS Excel
6	Export to CX for Analysis.	RCD_updated is attached to the SCR, and the SCR is exported back to CX with the new attachment.	An Engineer from CY SCM Group	CMT package export Tool SCR Export Package E-Mail
7	Import Received Package	When SCR package is received by SCM group of CX, an engineer from the SCM group imports the package into the SCR database. Then the states of the updated RCD SCRs are changed to "Analysis", and an e-mail is sent to group leaders with a list of modified SCR numbers.	An Engineer from CX SCM Group	CMT package Import Tool E-Mail
8	Assign Analyst	Group leader assigns an engineer for the re-analysis of the RCD SCR.	Group Leader	
9	Identification of changes in the updated RCD document.	Assigned engineer compares the RCD document that is stored on the common shared space with the RCD document that is received from CY and highlights the updated portions of RCD document	Software Engineer Assigned to SCR Analysis	MS-Excel

Table 3-11 Activities involved in RCD analysis and update cont'd

No	Activity Name	Activity Definition	Staff	Forms/ Records Documents/ Archival Tools/ Applications/ Other Medias
10	Updated RCD Review	Engineers from different groups review the updated RCD document. If the updated RCD document is acceptable an e-mail is sent to CY Engineer indicating that CY may continue to update requirements using update form of the RCD document. If there are still some issues about RCD document, RCD document is updated (RCD_update2) After completion of the analysis, the engineer labels the latest revision of the RCD document as "CX_RCD_As_Updated" using RCT modifies the state of the RCD SCR to "SCCB".	Several Engineers from different groups. Software Engineer Assigned to SCR Analysis	E-mail Ms-Excel RCT CMT
11	SCCB Meeting	In the SCCB meeting SCR is discussed if SCR is accepted the state of the SCR is modified to "HOLD". If necessary SCM group of CX exports RCD_update2 document to CY	SCCB SCM group.	SCCB Meeting Form, CMT package export Tool SCR Export Package
12	Update Local Requirement Database	Local Requirement database is updated by PMG after RCD SCR state is changed to HOLD. PMG send an e-mail to all groups after completing update of local database. Local database is used as a baseline for development activities.	An Engineer from PMG	Requirement Database E-mail RMT
13	Generation of final form of RCD	After coordinating necessary changes, CY Engineer prepares final form of the RCD that is to be implemented (i.e. to be updated in the Requirement database) (RCD_to_be_implemented) Document is peer-reviewed prior to attacking SCR.	Software Engineer Assigned to SCR Analysis	MS Excel
14	Update RCD SCR	RCD_to_be_implemented is attached to the SCR, and the state of SCR is changed to "SCCB".	Software Engineer Assigned to SCR Analysis	CMT
15	SCCB Meeting	In the SCCB meeting if SCR is accepted, the state of the SCR is changed to "IMPLEMENT", which means that requested changes are to be incorporated to Requirement database. RCD_to_be_implemented is sent to CX for inspection.	SCCB of CY. SCM of CY	SCCB Meeting Form, CMT package export Tool SCR Export Package
16	Update Requirement database	System engineers responsible from managing requirement database updates database according to RCD_to_be_implemented.	System Engineer Group Managing Requirement database	Requirement DB RMT

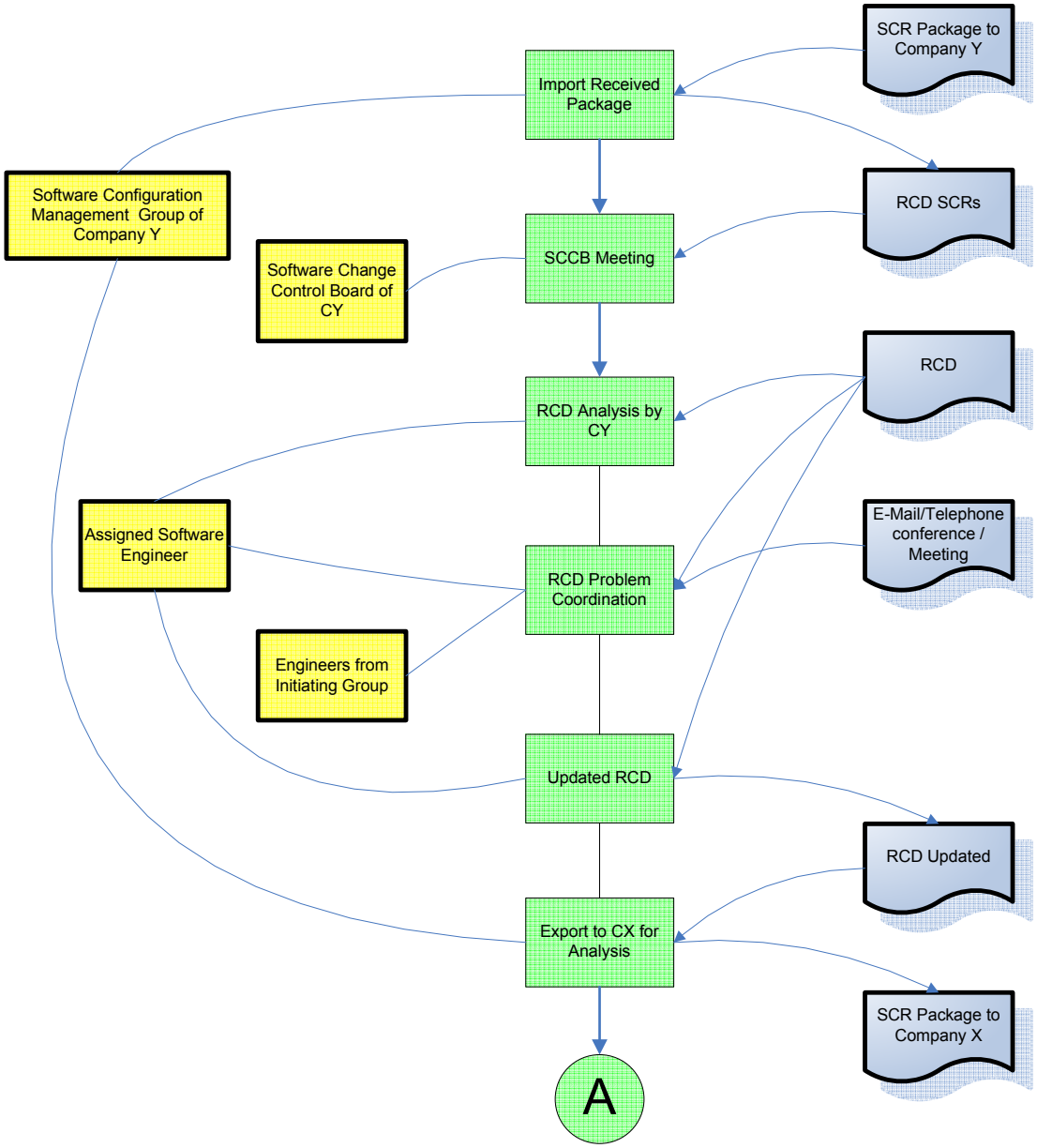

Figure 3-3 RCD analysis and update

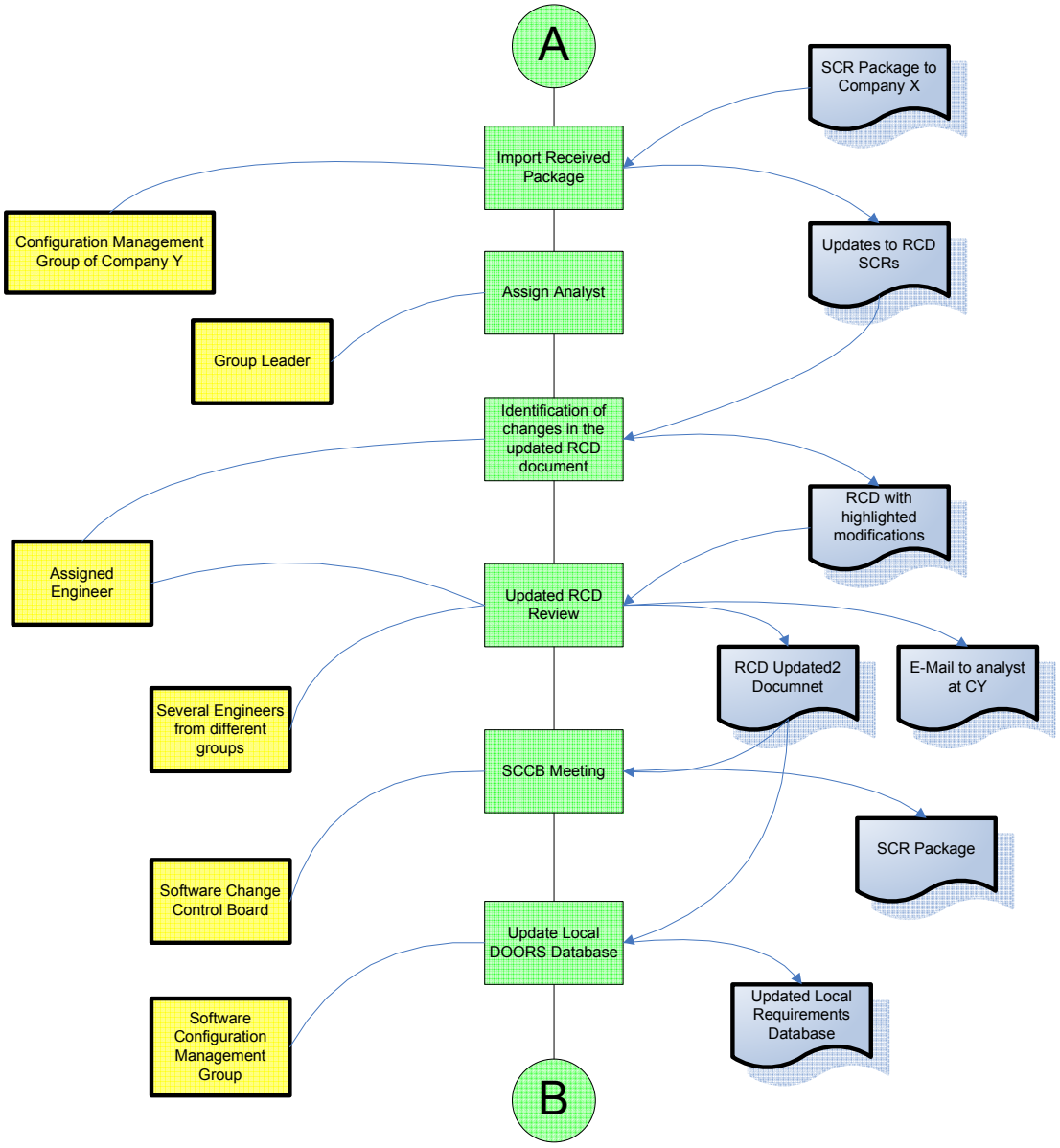

Figure 3-4 RCD analysis and update cont'd

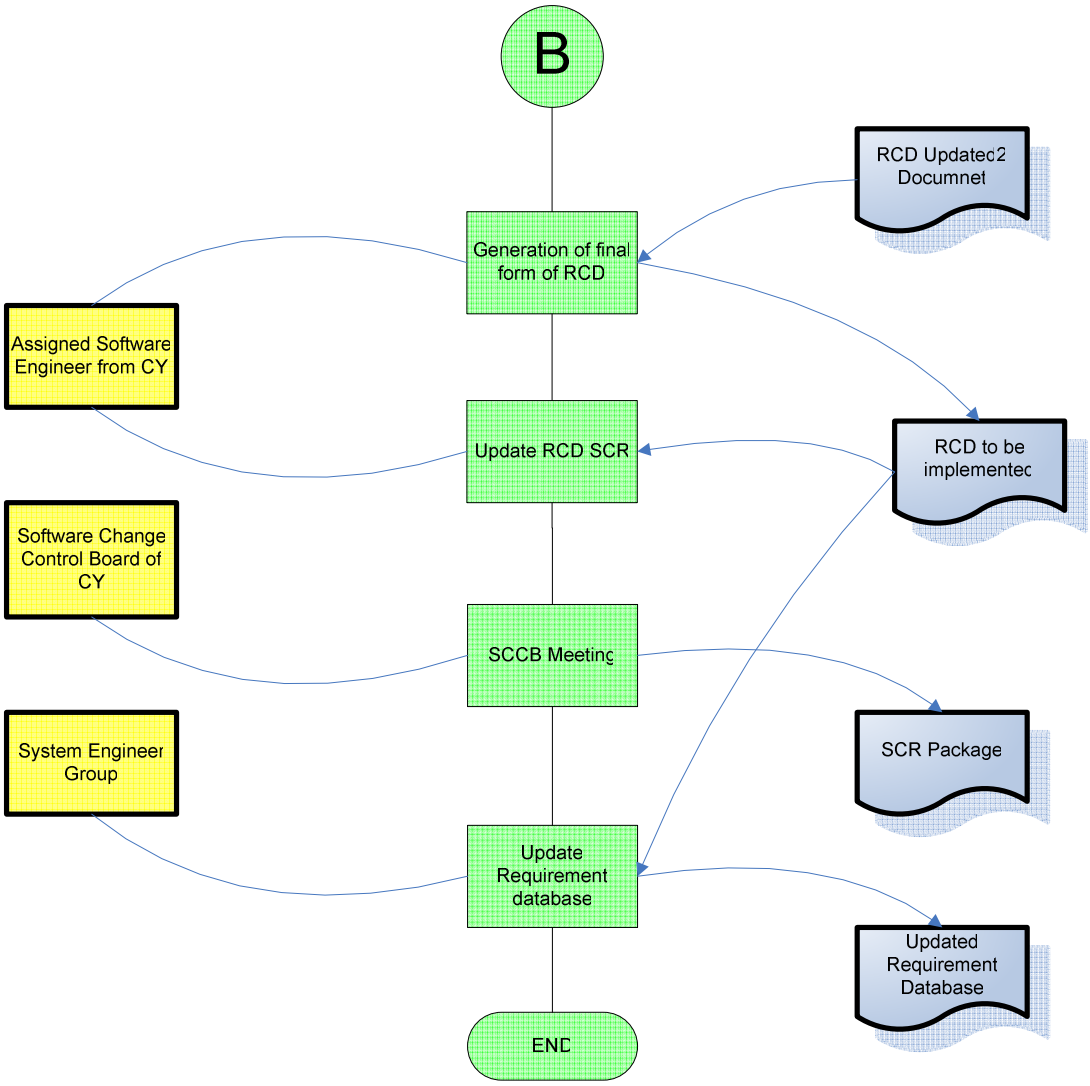

Figure 3-5 RCD analysis and update cont'd

Table 3-12 Results of process analyze and update for metrics 1-5

Activity Number	Complexity (1)	Coupling (2)	Failure Avoidance (3)	Restorability (4)	Restoration Effectiveness (5)
1	No decision	Interaction with SCR process	No review, inspection, checkpoint or similar techniques	Recorded by SCR Management Tool	Restoration from SCR database backup.
2	Semi-structured decision for assigning an Engineer for analysis.	Interaction with SCR process	SCRs are reviewed in SCCB Meeting.	Recorded by SCR Management Tool	Restoration from SCR database backup.
3	Unstructured decision for determining problems in the RCD like consistency, wording, clarity.	No interaction	No review, inspection, checkpoint or similar techniques	Recorded by revision control tool.	Restoration from revision backup.
4	Unstructured decision for coordinating problems in the RCD.	No intersection between processes but communication between two companies introduces coupling.	Reviews are performed on the suggested changes by both parties.	Recorded in minutes of meetings forms, e-mail servers etc.	Restoration from soft copy stored in revision control tool.
5	No decision	No interaction	Updated RCD document peer-reviewed.	Recorded by revision control tool. Review results are recorded in minutes of meeting form.	Restoration from revision backup.
6	No decision	Interaction with SCR process	SCR Database is check pointed regularly.	Recorded by SCR Management Tool	Restoration from SCR database backup.
7	No decision	Interaction with SCR process	SCR Database is check pointed regularly.	Recorded by SCR Management Tool	Restoration from SCR database backup.
8	Semi-structured decision for assigning an Engineer for analysis	No interaction	SCR Database is check pointed regularly.	Recorded by SCR Management Tool	Restoration from SCR database backup.

Table 3-12 Results of process analyze and update for metrics 1-5 cont'd

Activity Number	Complexity (1)	Coupling (2)	Failure Avoidance (3)	Restorability (4)	Restoration Effectiveness (5)
9	No decision	No interaction	No review, inspection, checkpoint or similar techniques	Not recorded	No restoration
10	Unstructured decision for determining if the updated RCD document is suitable.	No intersection between processes but communication between two companies introduces coupling.	Updated RCD document is reviewed by a group of engineers from different groups.	Recorded by SCR Management Tool	Restoration from SCR database backup.
11	Unstructured decision for accepting the SCR. Structured decision for changing the state of SCR. Structured decision for sending updated document.	Interaction with SCR process	SCR forms and attached documents are reviewed in SCCB meeting. SCH Database is check pointed regularly.	Recorded in SCCB meeting form.	Restoration from soft copy stored in revision control tool.
12	No decision	No interaction	Local Requirement database is check pointed regularly.	Recorded by Requirements management Tool	Restoration from Requirement Database backup.
13	Semi-structured decision to prepare final form of the RCD	No interaction	RCD to be implemented document is peer-reviewed.	Recorded by revision control tool.	Restoration from SCR database backup.
14	No decision	Interaction with SCR process	SCR Database is check pointed regularly.	Recorded by SCR Management Tool	Restoration from SCR database backup
15	Unstructured decision for accepting the SCR. Structured decision for changing the state of SCR.	Interaction with SCR process	SCR forms and attached documents are reviewed in SCCB meeting. SCH Database is check pointed regularly.	Recorded in SCCB meeting form.	Restoration from soft copy stored in revision control tool.

Table 3-12 Results of process analyze and update for metrics 1-5 cont'd

Activity Number	Complexity (1)	Coupling (2)	Failure Avoidance (3)	Restorability (4)	Restoration Effectiveness (5)
16	No decision	No interaction	Requirement database is check pointed regularly.	Recorded by Requirements management Tool	Restoration from Requirement Database backup.

Table 3-13 Results of process analyze and update for metrics 6-10

Activity Number	Functional Adequacy (6)	Functional Completeness (7)	IT Usage (8)	IT Density (9)	Computational Accuracy (10)
1	Adequate	-	ITtusage in importing received package	No forms, documents, archival records or other similar documents that are prepared, updated, deleted or searched	No specific accuracy requirement
2	Adequate	-	IT usage in SCCB meeting	SCCB meeting form is prepared using IT applications	Accuracy requirement: All SCRs should be assigned to an analyst.
3	Adequate	-	IT usage RCD analysis.	Several search activities are performed using IT applications, RCD document are updated using IT application.	Requested changes should be in the scope of the project. Requirement wording should be clear and suitable
4	Inadequate: In some cases RCD is changed without coordinating with CX		IT usage in RCD problem Coordination	Meetings and Teleconference minutes are generated and save using IT applications.	No specific accuracy requirement

Table 3-13 Results of process analyze and update for metrics 6-10 cont'd

Activity Number	Functional Adequacy (6)	Functional Completeness (7)	IT Usage (8)	IT Density (9)	Computational Accuracy (10)
5	Inadequate: In some cases RCD is changed without coordinating with CX	-	IT usage in RCD update	RCD document is update using IT application.	No specific accuracy requirement
6	Inadequate: In some cases RCD is changed without coordinating with CX	In some cases because of the coupling between requirement change and SCR process RCD_Updated.doc is sent via e-mail to speed up process.	IT usage in exporting update RCD document to CX	SCR analysis is updated using IT application.	No specific accuracy requirement
7	Inadequate: In some cases RCD is changed without coordinating with CX	In some cases because of the coupling between requirement change and SCR process RCD_Updated.doc is sent via e-mail to speed up process.	IT usage in importing and updating SCR database	No forms, documents, archival records or other similar documents that are prepared, updated, deleted or searched	No specific accuracy requirement
8	Inadequate: In some cases RCD is changed without coordinating with CX	-	No IT usage in assigning analyst	No forms, documents, archival records or other similar documents that are prepared, updated, deleted or searched	No specific accuracy requirement
9	Inadequate: In some cases RCD is changed without coordinating with CX	-	IT usage in identification of the changes in update_RCD document	Identification of changes in the RCD document are generated and saved using IT application.	Accuracy requirement: All of the updated to sent RCD should be highlighted.

Table 3-13 Results of process analyze and update for metrics 6-10 cont'd

Activity Number	Functional Adequacy (6)	Functional Completeness (7)	IT Usage (8)	IT Density (9)	Computational Accuracy (10)
10	Inadequate: In some cases RCD is changed without coordinating with CX	-	IT usage in update_RCD document review	RCD document is reviewed and updated using IT application	No specific accuracy requirement
11	Adequate	-	IT usage in SCCB meeting	No IT usage in preparing SCCB meeting form.	No specific accuracy requirement
12	Adequate	-	IT usage in updating local Requirement database	Requirement database is updated using IT application.	Accuracy requirement: Local requirement database should be updated according to RCD.
13	Inadequate: In some cases RCD is changed without coordinating with CX	-	IT usage in generating final form of RCD	Final form of RCD document to be prepared using IT application.	Accuracy requirement: changes should be reflected to the updated RCD document.
14	Adequate	-	IT usage in updating RCD SCR	SCR analysis form and attachment record is updated using IT application.	No specific accuracy requirement
15	Adequate	-	IT usage in SCCB meeting	No IT usage in SCCB meeting form.	No specific accuracy requirement
16	Adequate	-	IT usage updating requirement database	Requirement database is updated using IT application.	Accuracy requirement: requirement database should be updated according to to_be_implemented version of RCD.

Table 3-14 Results of process analyze and update for metrics 11-15

Activity Number	Data Exchangeability (11)	Access Audit ability (12)	Functional Understandability (13)	Completeness of Documentation (14)	Input Validity Checking (15)
1	Received SCR packet is imported to SCR DB using tool support.	Auditable access only SCM group can import received packages.	No difficulties or misunderstandings	Described	Automatic Input validity check performed by SCR management tool.
2	No data modification.	SCCB Meeting form is signed by attendants	No difficulties or misunderstandings	Described	No input validity check is performed
3	No intersection	In meetings and telecoms Minutes of meeting form is signed by attendants. E-mails are only accessible by people who received them.	There are difficulties in analyzing change requests.	Described	No input validity check is performed
4	No intersection	In meetings and telecoms Minutes of meeting form is signed by attendants. E-mails are only accessible by people who received them.	No difficulties or misunderstandings	Described	No input validity check is performed
5	No intersection	Non auditable read access. Auditable modify access.	No difficulties or misunderstandings	Described	No input validity check is performed
6	No data modification.	Auditable access only SCM group can export packages.	No difficulties or misunderstandings	Described	No input validity check is performed
7	Received SCR packet is imported to SCR DB using tool support.	Audit able access only SCM group can import received packages.	No difficulties or misunderstandings	Described	Automatic Input validity check performed by used tool.

Table 3-14 Results of process analyze and update for metrics 11-15 cont'd

Activity Number	Data Exchangeability (11)	Access Audit ability (12)	Functional Understandability (13)	Completeness of Documentation (14)	Input Validity Checking (15)
8	No intersection	Non auditable read access. Auditable modify access.	No difficulties or misunderstandings	Described	No input validity check is performed
9	No intersection	Non auditable read access. Auditable modify access.	There are difficulties in determining differences between RCD document sent to CY and RCD_updated document received especially if there are multiple RCD documents.	Not Described	No input validity check is performed
10	No intersection	In meetings and telecoms Minutes of meeting form is signed by attendants. E-mails are only accessible by people who received them.	No difficulties or misunderstandings	Described	No input validity check is performed
11	No data modification.	SCCB Meeting form is signed by attendants	No difficulties or misunderstandings	Described	No input validity check is performed
12	No intersection	Non auditable read access Modify auditability Only PMG can edit Requirement database	No difficulties or misunderstandings	Described	No input validity check is performed
13	No intersection	Non auditable read access. Auditable modify access.	No difficulties or misunderstandings	Described	No input validity check is performed

Table 3-14 Results of process analyze and update for metrics 11-15 cont'd

Activity Number	Data Exchangeability (11)	Access Audit ability (12)	Functional Understandability (13)	Completeness of Documentation (14)	Input Validity Checking (15)
14	No data modification.	Non auditable read access. Auditable modify access.	No difficulties or misunderstandings	Described	No input validity check is performed
15	No data modification.	SCCB Meeting form is signed by attendants	No difficulties or misunderstandings	Described	Input validity checking by SCCB, checks the forms of SCR.
16	Change requests at Excel sheet are inserted in to Requirement database manually	Non auditable read access Modify auditability Only PMG can edit Requirement database	No difficulties or misunderstandings	Described	No input validity check is performed

Table 3-15 Results of process analyze and update for metrics 16-17

Activity Number	Undo ability (16)	Attractive Interaction (17)
1	Undo ability, Imported SCRs could be canceled.	Attractive interaction during importing received package.
2	Undo ability, SCR could be assigned to another engineer.	Not attractive interaction during preparing SCCB Meeting form.
3	Not recorded	Not attractive interaction while analyzing RCD.
4	Not recorded	No interaction with forms, reports, archival records or similar other documents, only e-mail
5	Not recorded	Not attractive interaction while updating RCD.
6	No undo ability.	Attractive interaction during exporting SCRs.
7	Undo ability, Imported SCRs could be canceled.	Attractive interaction during importing received package.
8	Undo ability, SCR could be assigned to another engineer.	Attractive interaction while assigning an analyst.
9	Not recorded	Not attractive interaction while identifying updates in the RCD.

Table 3-15 Results of process analyze and update for metrics 16-17 cont'd

Activity Number	Undo ability (16)	Attractive Interaction (17)
10	Not recorded	Not attractive interaction while preparing minutes of meeting form.
11	No undo ability if SCR is exported, Undo ability, SCR state could be change again.	Not attractive interaction while preparing SCCB meeting form.
12	Undo ability, changes performed on requirement database could be reverted.	Attractive interaction while updating Local Requirement Database.
13	Not recorded	Not attractive interaction while generating final form of RCD.
14	No undo ability, when document is updated in the SCR database, old version is lost	Attractive interaction while updating RCD SCR.
15	No undo ability if SCR is exported, Undo ability, SCR state could be change again.	Not attractive interaction while preparing SCCB meeting form.
16	Undo ability, changes performed on requirement database could be reverted.	Attractive interaction while updating requirements database.

3.2.5 Receiving new Requirement Database

3.2.5.1 Process No

Process Number is 5

3.2.5.2 Short Description

The set of requirements that CX has to implement is changed by using RCD process, the master copy of the Requirement database is held at CY, master copy is not only updated by request from CX but also updated by CY and other subcontractors. In the intervals that is defined in the contract, the master copy of the Requirement database is sent to CY. New Requirement database is checked for correctness and RCD SCRs are inspected either they are incorporated or not.

3.2.5.3 Activities

Activities employed after receiving new requirement database are given in Table 3-16 and Figure 3-6. Measurement results of the process are given in Table 3-17, Table 3-18, Table 3-19, and Table 3-20

Table 3-16 Activities involved in receiving new requirement database

No	Activity Name	Activity Definition	Staff	Forms/ Records Documents/ Archival Tools/ Applications/ Other Medias
1	Import Requirement Database	System engineer responsible from managing requirement database imports the received package in to the requirement database, When import operation is completed an e-mail is sent to the lead engineer of the project.	System Engineer responsible from Requirement Database	Requirement DB E-mail RMT
2	Inform Group Leaders	Lead engineer sends an e-mail to the group leaders, informing them about the imported requirement database.	Lead Engineer	E-mail
3	Completeness Review	Group leaders perform an overall completeness review on the Requirement database to check if it is acceptable as a baseline.	Group Leaders	Requirement DB

Table 3-16 Activities involved in receiving new requirement database cont'd

No	Activity Name	Activity Definition	Staff	Forms/ Records Documents/ Archival Tools/ Applications/ Other Medias
4	Review Results Meeting	If group leaders find errors on the requirement database, lead engineer requests another database export from CY, indicating a list of errors found in the previous release.	Lead Engineer Group Leaders	Formal Letter
5	Assign Analyst	If the group leaders find requirement database acceptable as a baseline, they assign engineers to check whether if RCD SCR's are incorporated to the release or not.	Group Leaders	
6	Detailed Review	Engineers compare the requirement database with attachments of the RCD SCR, and generate a report indicating the number of changes incorporated, changes which are not incorporated, and changes which are incorporated with a modification without notification.	Software Engineer Assigned to Analysis	Requirement DB MS-Excel CMT
7	Verify incorporated RCD SCRs	The state of RCD SCRs which are fully implemented or implemented with modifications which are acceptable are changed to "Verify" state SCR verify form is filled.	Software Engineer Assigned to Analysis	CMT SCR Verify Form
8	Verify partially incorporated SCRs and open new SCRs	The states of RCD SCRs which are partially implemented are changed to "Verify" state and SCR verify form is filled. Another RCD is initiated for the changes which are not implemented.	Software Engineer Assigned to Analysis	CMT SCR Verify Form RCD Document
9	Close RCD SCRs	In the SCCB meeting if the other criteria for closing and SCR is met, the RCD SCR is closed, and the SCR close form is filled.	SCCB	SCR Close Form SCCB Meeting Form
10	Update Local Requirement Database	After closing SCRs, PMG group checks the SCR database for RCD SCR which are not closed and still in "HOLD" state. Those SCRs are inserted in to the locally held requirements database by PMG. PMG send an e-mail to all groups after completing update of local database	An Engineer from PMG	Requirement DB RMT CMT E-mail

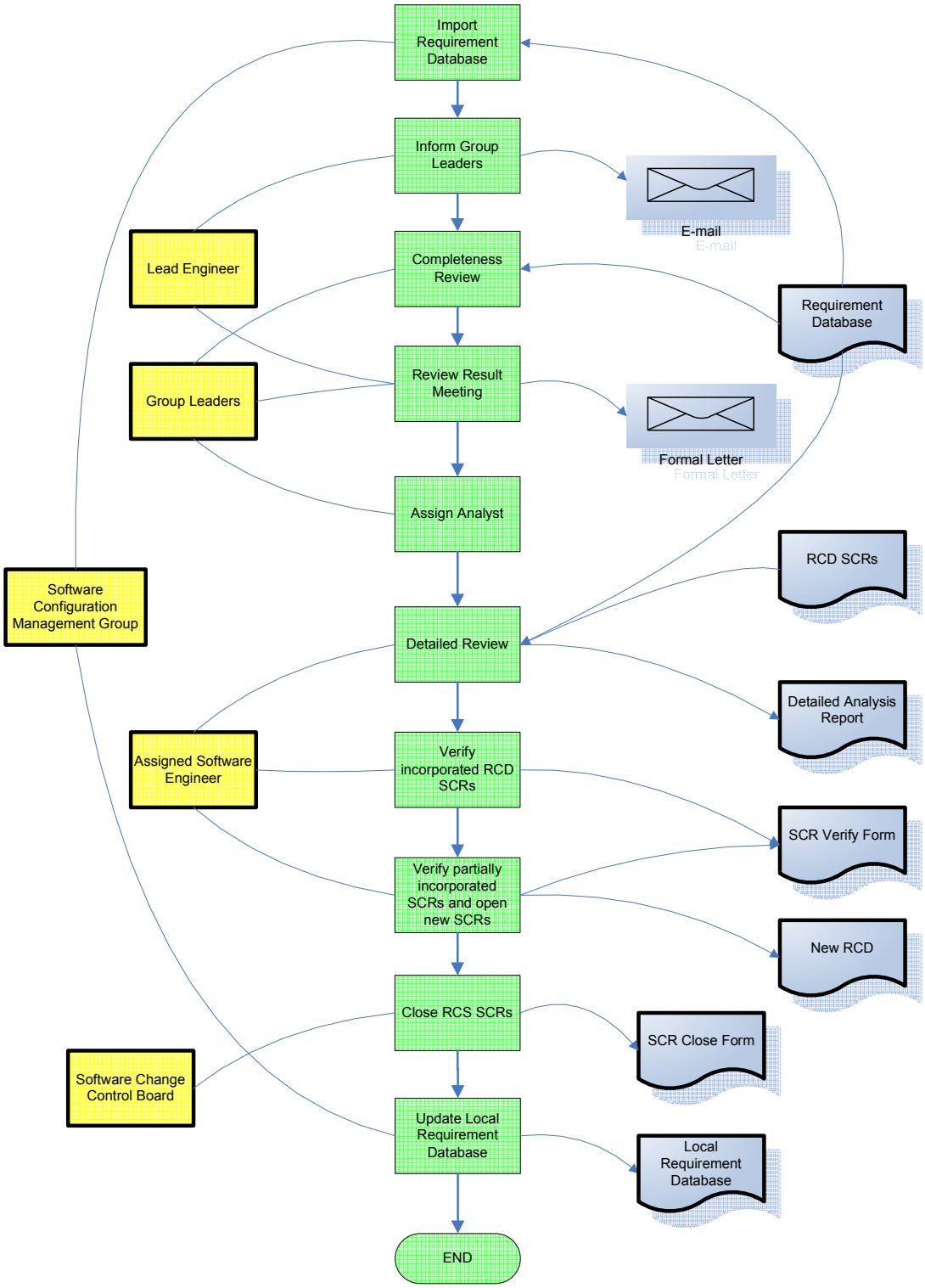

Figure 3-6 Receiving new requirement database

Table 3-17 Results of process receiving requirement DB for metrics 1-5

Activity Number	Complexity (1)	Coupling (2)	Failure Avoidance (3)	Restorability (4)	Restoration Effectiveness (5)
1	No decision	Interaction with SCR process	No review, inspection, checkpoint or similar techniques	Recorded by SCR Management Tool	Restoration from backup for SCR database.
2	No decision	No interaction	No review, inspection, checkpoint or similar techniques	Recorded by mail servers.	Restoration from backup of mail database
3	No decision	No interaction	Imported requirements database is reviewed by Group leaders.	Not recorded.	No restoration
4	Unstructured decision if requirements database is acceptable.	No interaction	No review, inspection, checkpoint or similar techniques	Recorded in the minutes of meeting.	Restoration from soft copy stored in revision control tool.
5	No decision	No interaction	No review, inspection, checkpoint or similar techniques	Not recorded	No restoration
6	No decision	No interaction	Assigned analyst reviews the requirement database	Not recorded	No restoration
7	Structured decision on verifying RCD SCRS	Interaction with SCR process	No review, inspection, checkpoint or similar techniques	Recorded by SCR Management Tool	Restoration from backup for SCR database.
8	Structured decision on verifying partially implemented RCD SCRs and opening new SCRs	Interaction with SCR process	No review, inspection, checkpoint or similar techniques	Recorded by SCR Management Tool	Restoration from backup for SCR database.
9	Structured decision on closing RCS SCRs	Interaction with SCR process	SCR is reviewed in SCCB meeting before closing.	Recorded by SCR Management Tool	Restoration from backup for SCR database.
10	No decision	No interaction	No review, inspection, checkpoint or similar techniques	Recorded by Requirements management Tool	Restoration from Requirement Database backup.

Table 3-18 Results of process receiving requirement DB for metrics 6-10

Activity Number	Functional Adequacy (6)	Functional Completeness (7)	IT Usage (8)	IT Density (9)	Computational Accuracy (10)
1	Adequate	-	IT usage in importing received package	Requirement Database is updated using IT applications.	No specific accuracy requirement
2	Adequate	-	IT usage in informing group leader by e-mail	No forms, documents, archival records or other similar documents that are prepared, updated, deleted or searched	No specific accuracy requirement
3	Adequate	-	IT usage in completeness review.	No forms, documents, archival records or other similar documents that are prepared, updated, deleted or searched	Accuracy requirement, groups leaders should check database if it is acceptable as a baseline.
4	Adequate	-	IT usage in requesting another requirement database export and generating list of errors.	Formal Letter is prepared using IT application	No specific accuracy requirement
5	Adequate	-	No IT usage during analyst assignment	No forms, documents, archival records or other similar documents that are prepared, updated, deleted or searched	No specific accuracy requirement
6	Inadequate no report is generated	-	IT usage in detailed review	Detailed review results are generated and saved using IT application.	Accuracy requirement, analyst should include all RCDs and accurately compare RCDs with requirement database.
7	Adequate	-	IT usage in verifying RCD SCRs	SCR verify form is filled using IT application.	No specific accuracy requirement

Table 3-18 Results of process receiving requirement DB for metrics 6-10 cont'd

Activity Number	Functional Adequacy (6)	Functional Completeness (7)	IT Usage (8)	IT Density (9)	Computational Accuracy (10)
8	Adequate	-	IT usage in verifying RCD SCRs	SCR verify form is filled using IT application.	No specific accuracy requirement
9	Adequate	-	IT usage in closing SCRs	SCR close form is filled using IT application.	No specific accuracy requirement
10	Adequate	-	IT usage in updating Local requirement database	Local requirement database is updated using IT application.	Accuracy requirement, local requirement database should be updated according to RCD SCR which are still open.

Table 3-19 Results of process receiving requirement DB for metrics 11-15

Activity Number	Data Exchangeability (11)	Access Auditability (12)	Functional Understandability (13)	Completeness of Documentation (14)	Input Validity Checking (15)
1	Received package is automatically converted by SCR Management tool	Modify audit ability Only PMG can edit Requirement database	No difficulties or misunderstandings	Described	Automatic Input validity check performed by SCR management tool.
2	No interaction	There is no access to data	No difficulties or misunderstandings	Described	No input validity check is performed
3	No interaction	Non auditable read access.	No difficulties or misunderstandings	Not described.	Input validity checks are performed on requirement database by group leaders.
4	No interaction	There is no access to data	No difficulties or misunderstandings	Not described.	No input validity check is performed
5	No interaction	There is no access to data	No difficulties or misunderstandings	Described.	No input validity check is performed

Table 3-19 Results of process receiving requirement DB for metrics 11-15 cont'd

Activity Number	Data Exchangeability (11)	Access Auditability (12)	Functional Understandability (13)	Completeness of Documentation (14)	Input Validity Checking (15)
6	No interaction	Non auditable read access.	No difficulties or misunderstandings	Described	Input validity checks are performed by analysts
7	The report is used without applying any changes.	Auditable modify access	No difficulties or misunderstandings	Described	No input validity check is performed
8	The report is used without applying any changes.	Auditable modify access	Difficulties in opening new RCD SCR contents.	Described	No input validity check is performed
9	The report is used without applying any changes.	Auditable modify access	No difficulties or misunderstandings	Described	Input validity check is performed on SCR verify and close forms.
10	No interaction	Modify auditability Only PMG can edit Requirement database	No difficulties or misunderstandings	Described	No input validity check is performed

Table 3-20 Results of process receiving requirement DB for metrics 16-17

Activity Number	Undo ability (16)	Attractive Interaction (17)
1	Undo ability, generated SCRs may be canceled deleted by configuration manager	Attractive interaction while importing requirement database.
2	Undo ability, another mail could be sent	No interaction with forms, reports, archival records or similar other documents, only e-mail
3	Not recorded.	No interaction with forms, reports, archival records or similar other documents, only e-mail
4	Undo ability, minutes of meeting form could be updated.	Not attractive interaction while preparing minutes of meeting form.
5	Not recorded	No interaction with forms, reports, archival records or similar other documents, only e-mail
6	Not recorded	Not attractive interaction while preparing detailed review report.
7	Undo ability, verification comment could be changed; configuration manager could change SCR state to “HOLD”.	Attractive interaction while verifying incorporated RCD SCRs
8	Undo ability, verification comment could be changed; configuration manager could change SCR state to “HOLD”.	Attractive interaction while verifying partially incorporated RCD SCRs and opening new SCRs.
9	Undo ability, closed SCR could be re-opened by configuration manager.	Attractive interaction while closing RCD SCRs.
10	Undo ability, changes performed on requirement database could be reverted.	Attractive interaction while updating local requirement database.

CHAPTER 4

PROPOSED PROCESSES

For the purpose of proposing an improved process, first several interviews with the members of the project development team, who have been working in different positions, were made. Their thoughts about the current requirement change process were gathered and its affects on their routine tasks were determined. Each interviewee was asked if they would like to see an additional functionality in the requirement change process, which will improve their routine duties. Then interview results were reviewed to determine problems, drawbacks, and improvement suggestions to the current requirement change process. The results of this study are presented in section 4.1. Afterwards the literature has been reviewed for requirements management process suggestions in distribute software development environments, and similar studies on the subject were reviewed. The suggested improvements are summarized in section 4.2. Next suggested requirement change processes is modeled and measured according to static process evaluation model proposed by Güçeğlioğlu in section 4.3. Finally a brief descriptions of the forms used during these activates are given in section 4.4.

4.1 Drawbacks of Current Requirement Change Process

In this section, problems of the current requirement change process are listed. The list is generated according to interviews with the members of the development team.

1. The process of exporting requirements from requirement database to a worksheet. Then performing necessary changes according to predefined format. Analyzing change requests using sheet editors, and finally updating requirements in requirement database is a complicated process. A tool capable of allowing

users to propose change requests without a need of another tool will reduce the time, complexity and productivity of requirement change process

2. Requirements and change request are stored and managed using different databases. This setup complicates the traceability from requirement to pending change request and it is not possible to associate different change request to a single set. A tool capable of storing both requirements and change requests will improve traceability from requirements to change requests. Furthermore a tool capable of merging multiple change requests into a single set will improve the analyzability of the requested changes.
3. In the current process requirements change requests are submitted, and analyzed in section wise, such that some requirement change request documents contain hundreds of requirement change request. As a result analyzing and approving the RCD document takes too much time. Overall change time will be much smaller if change requests were submitted per requirement. A tool capable of supporting requirement change requests per requirement will improve the time delays in requirement change process.
4. The rationales of the performed changes are stored in the RCD document as attachments to SCRs. Further clarification discussions are generally performed by e-mails and teleconferences. Since e-mails are personal items, and generally discussions in the telecoms are not recorded, rationales that result in requirement modifications are generally difficult to attain. Furthermore in some cases e-mails are not sent to all people related with the requirement or people are not notified or else could not attend to telecom meetings. As a result some engineers are not aware of the changes performed over change request as a result of e-mail discussions or telecoms. Change rationales and discussion should easily be available to project members.
5. Requirements change process does have many interactions with software change request process. Change requests document is exchanged through SCR process which complicates the requirements change process. Engineers have to fill forms which are not related or not suitable for requirements change process.
6. Since there are two different requirement databases managed at Company X and Company Y, after each release of the requirements database from CY to CX, engineers at CX have to check database for;

a. Requested changes which are incorporated.
b. Requested changes which are not-incorporated.
c. Requirement changes which are performed without a notification.
d. Updating new requirement database according to RCD SCRs which are not incorporated.

7. In the current process software development activities, such as coding, unit test, and test case documentation are performed according to requirement change request without waiting for an approval, because of the reason that it takes too much time to get response to the change requests. This introduces to several rework risks to the project.

4.2 Suggested Improvements

1. As Yamaç suggested [18] requirements management tool with the capability of submitting, analyzing, approving or rejecting change requests against requirements, will eliminate the need of generating a RCD document, and will improve the pending change request traceability capability. Yamaç also pointed out that if requirement change requests are submitted per each requirement; analyze times of change requests will improve significantly because simple change request will be approved quicker. Software developers will be aware of the submitted change requests, and will be able to focus on development of approved changes and will be able to defer development process of pending change requests. Moreover this tool will eliminate the coupling between SCR processes and reduce the number of forms filled by engineers.
2. Requirements management tool with the capability of multi site access will eliminate the need of multiple requirement databases, and will reduce the synchronization efforts spent after each release.
3. For the purpose of separating requirement change process and requirement analysis activities, it is suggested to only focus on requirement change process so if change proposal has problems other those grammatical or spelling errors, it is suggested to reject the change request, resolve the issues using requirement analysis activities and then resubmit change proposal.
4. Many fields of expert also suggest performing requirement analysis using internet forums of wiki like online resource tools. It is suggested to use php

forums of wiki like structure to discuss requirements changes. Forums are preferred over e-mails and telecoms for discussion of changes because they are easy to access, better structured and implemented with recording functionality. In other words every discussion in the forums is stored, very easily organized and accessible to many users. Furthermore if it is desired to restrict users from accessing all of the requirements, access rights of the users can be altered to allow users to only access sections of the forum to which they have right to discuss. Also PHP forums have the capability to generate e-mail notifications to many users upon initiation of a new discussion.

5. For the purpose of this thesis, it is suggested to use a requirements management tool that gives remote users Web access for reviewing and basic editing of requirement held in Telelogic DOORS. Bussman presented and analyzed different solutions in her study [25]. It is suggested that CX manages master copy of the Requirement Database, and engineers working at CY will access the database using this tool instead of generating RCD documents submit change proposals using directly to the requirement database. By using this tool,
    a. There will not be a need of preparing RCD document to change requirements. Engineers will access requirements database managed at Company X and propose change request on individual requirements.
    b. Each requirement could be analyzed and approved or rejected independently which will improve the response time of change requests.
    c. Developers will be aware of status of requirement change requests, and will be able to defer development of requirements which have pending change requests and focus on other requirements which have been approved.
    d. There will not be a need of releasing master copy of requirements database at regular intervals, and activities performed after each release will not be performed.

4.3 Static Processes Definitions (To Be)

In this section static process definitions of the improved requirement change management process are modeled and measured according to Güçeğlioğlu's

proposed modeling schema. Section 4.3.1 contains the proposed activities to be performed by Company X to request requirement change. Section 4.3.2 contains the proposed activities to be performed by engineers to submit a change proposal Section 4.3.3 contains proposed activities to be performed by Company-Y to analysis requirements change requests. Section 4.3.4 contains the proposed activities to be performed by Company Y to update requirement database with approved requirement change requests.

4.3.1 Change Request Initiation

4.3.1.1 Process No

Process number is 1.

4.3.1.2 Short Description

Subsystem Requirement Specification is a set of requirements, which are derived from system level requirements, defines the requirements to be fulfilled by subsystems. Master copy of the requirement database is managed by CY. CX engineers remotely access to CY copy using a tool that gives remote users Web access for reviewing and basic editing of requirement, here after referred as Web access Requirements Management Tool (WRMT), and propose modification to requirements using Change Proposal System provided with DOORS product. After submitting change request, submitter will send an e-mail to the point of contact at CY to inform that new change requests are submitted.

4.3.1.3 Activities

Activities employed in requirement change initiation process are given in Table 4-1 and Figure 4-1. Measurement results of the process are given in Table 4-2, Table 4-3, Table 4-4, and Table 4-5.

Table 4-1 Activities involved in change request initiation

No	Activity Name	Activity Definition	Staff	Forms/ Records Documents/ Archival Tools/ Applications/ Other Medias
1	Submit Change Request	An engineer submits Change Proposals to the master copy of requirement database managed by CY using WRMT.	Assigned Engineer	WRMT Change Proposal Submit Form
2	Notification of Change Request	An engineer sends a notification e-mail to point of contact at the CY to indicate that new change request is initiated, Alternatively a CY engineer may periodically check the requirement database for new change requests.	Assigned Engineer	E-Mail WRMT
3	Analysis Assignment	Change Control Board (CCB) assigns an Engineer for review of the change request. Alternatively sections of the SRS may be divided among several engineers, who will be responsible of reviewing the change requests without any assignment.	Change Control Board	CCB Meeting Form RMT
4	Change Request Review	Assigned reviewer reviews the change request, and will “Approve”, “Reject” or “Defer” the change proposal.	Assigned Reviewer	RMT

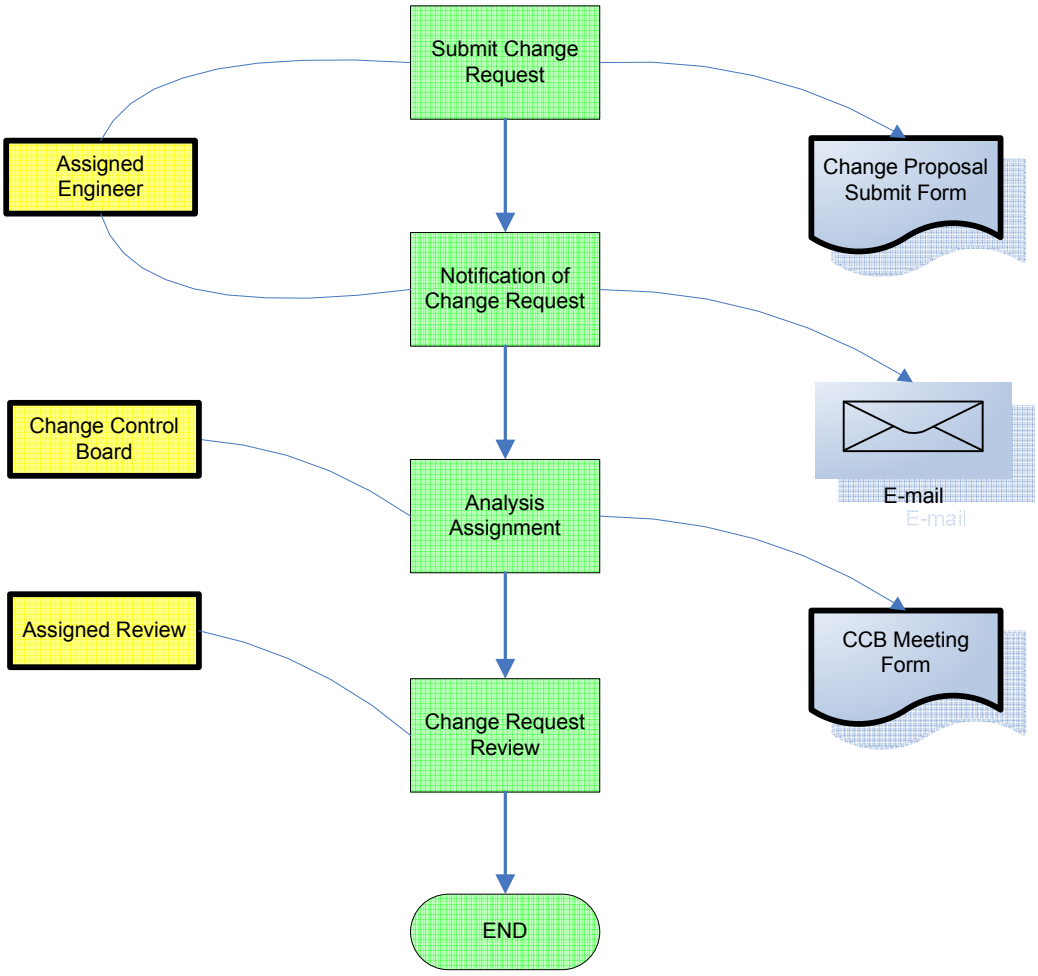

Figure 4-1 Change request initiation

Table 4-2 Results of change request initiation for metrics 1-4

Activity Number	Complexity (1)	Coupling (2)	Failure Avoidance (3)	Restorability (4)
1	No decision	No interaction	No review, inspection, checkpoint or similar techniques	Submitted Change proposals are recorded by the proposed tool.
2	No decision	No interaction	No review, inspection, checkpoint or similar techniques	E-mails are recorded by mail servers.
3	Semi-unstructured decision for assigning analyst.	No interaction	No review, inspection, checkpoint or similar techniques	Assigned analyst is recorded to the CCB Minutes of Meeting Form
4	Unstructured Decision on review of change proposal.	No interaction	Assigned Reviewer, reviews the change proposal request, correct any grammatical or spelling errors. If there are more serious problems change proposal is rejected.	Review comments are recorded by the proposed tool.

Table 4-3 Results of change request initiation for metrics 5-8

Activity Number	Restoration Effectiveness (5)	Functional Adequacy (6)	Functional Completeness (7)	IT Usage (8)
1	Restoration from disk backup.	Adequate	-	Change proposal is submitted using IT application.
2	Restoration from server backup.	Adequate	-	E-mails are used.
3	Restoration from electronic copy of minutes of meeting.	Adequate	-	CCB Meetings Form is created and stored on IT application, and distributed using e-mails.
4	Restoration from disk backup.	Adequate	-	Change proposal is reviewed using IT application.

Table 4-4 Results of change request initiation for metrics 9-13

Activity Number	IT Density (9)	Computational Accuracy (10)	Data Exchangeability (11)	Access Audit ability (12)	Functional Understand- ability (13)
1	Change Proposal form is filled using WRMT	No specific accuracy requirement	No interaction	Access auditability Change proposal form contains the user name of submitter.	No difficulties or misunderstandings
2	No forms, documents, archival records or other similar documents that are prepared, updated, deleted or searched	No specific accuracy requirement	No interaction	No access There is no access to data.	No difficulties or misunderstandings
3	CCB Meeting form is filled using standard predefined Word Template Document.	No specific accuracy requirement	No interaction	Access auditability CCB meeting form contains the list of participants.	No difficulties or misunderstandings
4	Change Proposal is reviewed and review comments are generated using RMT	Change proposals should be consistent with overall system design, worded suitable, unambiguous.	No interaction	Access auditability Only users with CP reviewer role can review change proposals.	No difficulties or misunderstandings

Table 4-5 Results of change request initiation for metrics 14-17

Activity Number	Completeness of Documentation (14)	Input Validity Checking (15)	Undo ability (16)	Attractive Interaction (17)
1	Described	No input validity check for submitting change proposal.	Another change proposal can be submitted to undo changes.	Attractive interaction during submitting change proposal
2	Described	No input validity checking is necessary for sending notification for change proposals.	Another e-mail could be sent to cancel notification.	Not attractive interaction during submitting notification e-mail
3	Described	No input validity check for assigning analyst	Another analyst could be assigned in following meeting.	Not attractive interaction during analyst assignment.
4	Described	Input validity is checked during review of the change proposal.	Review operation can be repeated to undo change proposal review.	Attractive interaction during change proposal analysis.

4.3.2 Submitting Change Request

4.3.2.1 Process No

Process number is 2.

4.3.2.2 Short Description

Change proposals will be submitted by CX to the requirements database using remote access or may be submitted by CY directly accessing the database. Submitting Change Proposal is straight forward using Change Proposal System, it is possible to submit change proposal to remove current requirements, create new requirements, and modify text or attributes of existing requirements. Also with change proposal system, it is possible to submit changes per requirement, which will increase the response time for small changes. Furthermore by using change proposal system, it is possible to submit multiple change requests per requirement.

4.3.2.3 Activities

Activities employed in requirement change initiation process are given in Table 4-6 and Figure 4-2. Measurement results of the process are given in Table 4-7, Table 4-8, Table 4-9, and Table 4-10

Table 4-6 Activities involved in change request initiation

No	Activity Name	Activity Definition	Staff	Forms/ Records Documents/ Archival Tools/ Applications/ Other Medias
1	Select requirement to be changed	Log in to CY Managed requirements database using WRMT. Select the requirement, which will be modified or removed. In case of a new object to be inserted, select an object at the same level or one level below the proposed object.	Assigned Engineer	WRMT
2	Fill the change proposal form	Open the change proposal submit form and enter the values to be changed to new section of the change proposal form. Select the type of change proposal, and submit change proposal when all of the new values are entered	Assigned Engineer	WRMT Change Proposal Submit Form

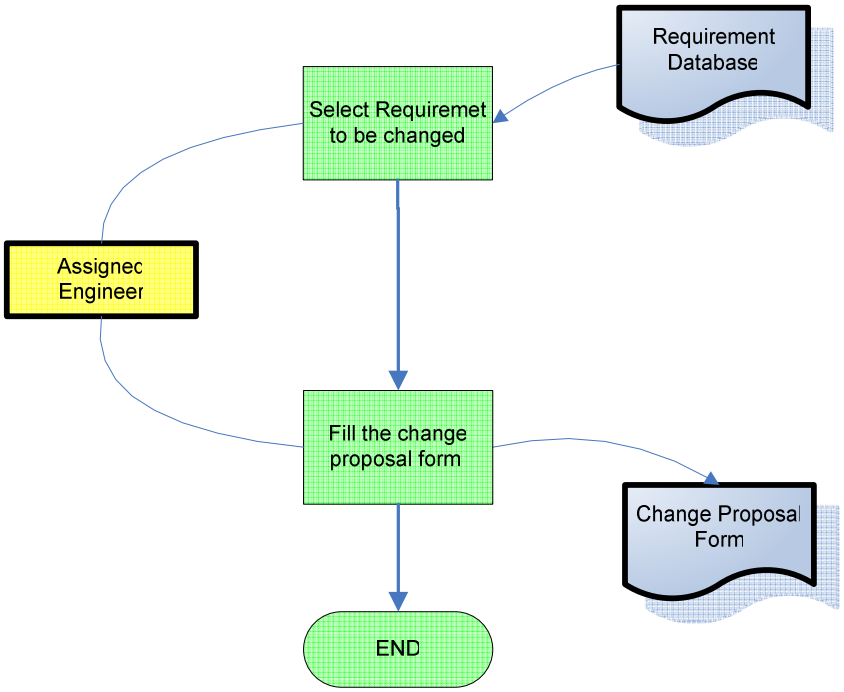

Figure 4-2 Submitting change request

Table 4-7 Results of submitting change request for metrics 1-4

Activity Number	Complexity (1)	Coupling (2)	Failure Avoidance (3)	Restorability (4)
1	No decision	No interaction	No review, inspection, checkpoint or similar techniques	Not recorded
2	No decision	No interaction	No review, inspection, checkpoint or similar techniques	Submitted Change proposals are recorded by the proposed tool.

Table 4-8 Results of submitting change request for metrics 5-8

Activity Number	Restoration Effectiveness (5)	Functional Adequacy (6)	Functional Completeness (7)	IT Usage (8)
1	No restoration	Adequate	-	Requirement is selected using IT application
2	Restoration from disk backup	Adequate	-	Change Proposal for is filled using IT application

Table 4-9 Results of submitting change request for metrics 9-13

Activity Number	IT Density (9)	Computational Accuracy (10)	Data Exchangeability (11)	Access Audit ability (12)	Functional Understand- ability (13)
1	No forms, documents, archival records or other similar documents that are prepared, updated, deleted or searched	No specific accuracy requirement	No interaction	Access auditability Only Users with read write can access to requirements database	No difficulties or misunderstandings
2	Change Proposal Form is filled using IT application	No specific accuracy requirement	No interaction	Access auditability When a change proposal is submitted, submitter user name is captured by application.	No difficulties or misunderstandings

Table 4-10 Results of submitting change request for metrics 14-17

Activity Number	Completeness of Documentation (14)	Input Validity Checking (15)	Undo ability (16)	Attractive Interaction (17)
1	Described	No input validity check is performed for selecting requirement to be changed.	Another requirement could be selected	Attractive interaction during selecting requirement to be changed
2	Described	Input validity is checked during filling change proposal form.	Another change proposal can be submitted to undo changes. Alternatively an e-mail could be sent to reviewer to reject the change	Attractive interaction filling change proposal form.

4.3.3 Change Request Analysis

4.3.3.1 Process No

Process number is 3.

4.3.3.2 Short Description

Change control board may assign analyst after investigating the change proposal or alternatively sections of the requirement database may be divided among software engineers, who will be responsible of periodically checking database for new change proposals and in case of new change proposals, will be responsible of analyzing change request. Change proposals are expected to have short live cycle, when a change proposal is submitted, it is status will be automatically assigned to "New". After initial analysis the status of analysis should be changed to;

- "Accept" if change proposal is acceptable. Assigned analyst may perform grammatical or spelling corrections on change proposal
- "Reject" if change proposal is not acceptable, such as not consistent with system, wording is not suitable or clear, not applicable to general requirement rules.
- "Defer" if no immediate response can be given, i.e. more investigation has to be performed on analysis of change proposal.

4.3.3.3 Activities

Activities employed in requirement change initiation process are given in Table 4-11 and Figure 4-3. Measurement results of the process are given in Table 4-12, Table 4-13, Table 4-14, and Table 4-15

Table 4-11 Activities involved in change request analysis

No	Activity Name	Activity Definition	Staff	Forms/ Records Documents/ Archival Tools/ Applications/ Other Medias
1	Change Request Review	Assigned CY engineer review the change proposals, with the aid of other system engineers, asserts if the requested changes are in the scope of the project, if requested changes are consistent with the overall system design, if the wording is suitable, and clear.	Assigned Engineer, System Engineers, Costumer, Field of Experts,	RMT E-Mail Minutes of Meeting
2	Defer Change Request	For "New" proposal which could not be approved immediately change the status of the proposal to "Defer"	Assigned Engineer	Change proposal Review Form RMT Status change E-mail
3	Reject Change Request	If there is an inconsistency with a higher level requirement, or overall system design, or the requested changes are not in the scope of the system or there has to be corrections in the structure or meaning of the change proposal, assigned analyst should "Reject" change proposal with comments indicating the problems.	Assigned Engineer	Change proposal Review Form RMT Status change E-mail
4	Accept Change Request	If the change proposal is acceptable the status of the change proposal is changed to "Approved". Assigned analyst is only allowed to correct punctuation errors.	Assigned Engineer	Change proposal Review Form RMT Status change E-mail

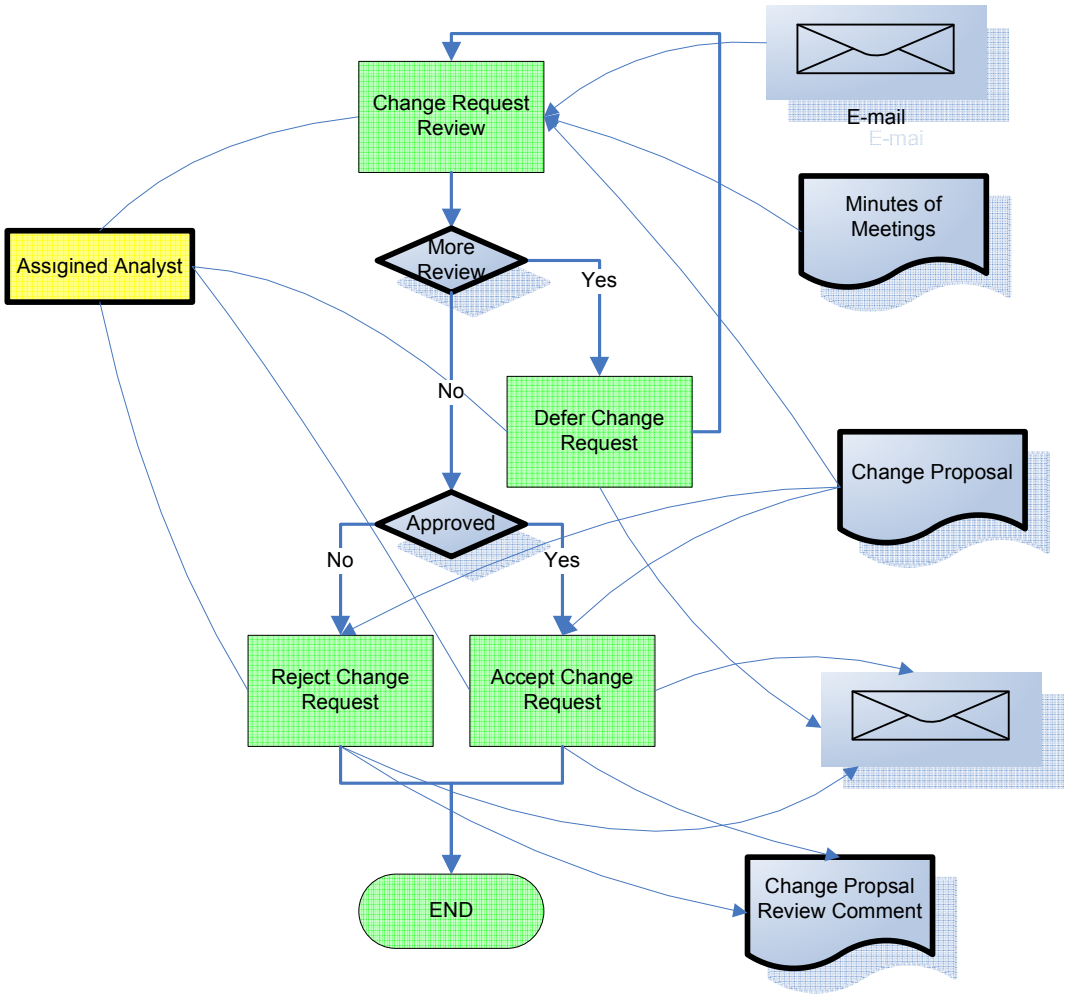

Figure 4-3 Change request analysis

Table 4-12 Results of change request analysis for metrics 1-4

Activity Number	Complexity (1)	Coupling (2)	Failure Avoidance (3)	Restorability (4)
1	Unstructured decision on review meetings, teleconferences etc.	No interaction	Change proposal is reviewed by Assigned analyst	E-mails are recorded by mail servers.
2	Semi-Unstructured decision on Deferring changes.	No interaction	Change proposal is reviewed by Assigned analyst	Review comments and CP status are recorded by the proposed tool. E-mails are recorded by mail servers.
3	Semi-Unstructured decision on Rejecting changes.	No interaction	Change proposal is reviewed by Assigned analyst	Review comments and CP status are recorded by the proposed tool. E-mails are recorded by mail servers.
4	Semi-Unstructured decision on Approving changes.	No interaction	Change proposal is reviewed by Assigned analyst	Review comments and CP status are recorded by the proposed tool. E-mails are recorded by mail servers.

Table 4-13 Results of change request analysis for metrics 5-8

Activity Number	Restoration Effectiveness (5)	Functional Adequacy (6)	Functional Completeness (7)	IT Usage (8)
1	Restoration from server backup.	Adequate	-	IT applications are generally used during Change Proposal Review. E-mails are used in discussions; minutes of meetings are created during meetings.
2	Restoration from disk backup. Restoration from server backup.	Adequate	-	Change proposal “Defer” is performed on IT application.
3	Restoration from disk backup. Restoration from server backup.	Adequate	-	Change proposal “Reject” is performed on IT application.
4	Restoration from disk backup. Restoration from server backup.	Adequate	-	Change proposal “Approve” is performed on IT application.

Table 4-14 Results of change request analysis for metrics 9-13

Activity Number	IT Density (9)	Computational Accuracy (10)	Data Exchangeability (11)	Access Audit ability (12)	Functional Understand- ability (13)
1	There is no formalized method for review however during review operations IT applications are used for search, prepare and update purposes.	Accuracy requirements during review of the requirement change proposal. Suggested change proposals should be consistent with overall system design, worded suitable, unambiguous.	No interaction	Access auditability Users with at least Reviewer change proposal role can review the change proposal.	No difficulties or misunderstandings
2	CP review comment is filled using IT Application	No specific accuracy requirement	No interaction	Access auditability Users with at least Reviewer change proposal role can review the change proposal.	No difficulties or misunderstandings
3	CP review comment is filled using IT Application	No specific accuracy requirement	No interaction	Access auditability Users with at least Reviewer change proposal role can review the change proposal.	No difficulties or misunderstandings
4	CP review comment is filled using IT Application	No specific accuracy requirement	No interaction	Access auditability Users with at least Reviewer change proposal role can review the change proposal.	No difficulties or misunderstandings

Table 4-15 Results of change request analysis for metrics 14-17

Activity Number	Completeness of Documentation (14)	Input Validity Checking (15)	Undo ability (16)	Attractive Interaction (17)
1	Described	Input validity is checked during review of the change proposal.	Review operation can be repeated to undo change proposal review	Attractive interaction during review of change proposal.
2	Described	Input validity is checked before deciding deferring change proposal.	Review operation can be repeated to undo change proposal review	Attractive interaction in deferring change proposal.
3	Described	Input validity is checked before deciding rejecting change proposal.	Review operation can be repeated to undo change proposal review	Attractive interaction rejecting change proposal
4	Described	Input validity is checked before deciding rejecting change proposal.	Review operation can be repeated to undo change proposal review	Attractive interaction approving change proposal.

4.3.4 Applying Approved Changes

4.3.4.1 Process No

Process number is 4.

4.3.4.2 Short Description

After analyst accepts the change proposals, change control board have to review and apply them to the requirements database. For this purpose change control board may periodically meet or alternatively change control board may meet on a request from analysts. Change control board will review each approved requirement and will apply them to the requirement database by either one by one or as a whole.

4.3.4.3 Activities

Activities employed in requirement change initiation process are given in Table 4-16 and Figure 4-4. Measurement results of the process are given in Table 4-17, Table 4-18, Table 4-19, and Table 4-20

Table 4-16 Activities involved in applying approved changes

No	Activity Name	Activity Definition	Staff	Forms/ Records Documents/ Archival Tools/ Applications/ Other Medias
1	Apply Approved Changes	CCB may apply all of the changes without reviewing, or may go through all change requests one by one. Alternatively CCB may only review change requests which are specifically asked to be reviewed by analyst of the change request, and approve all other change.	Change Control Board	RMT

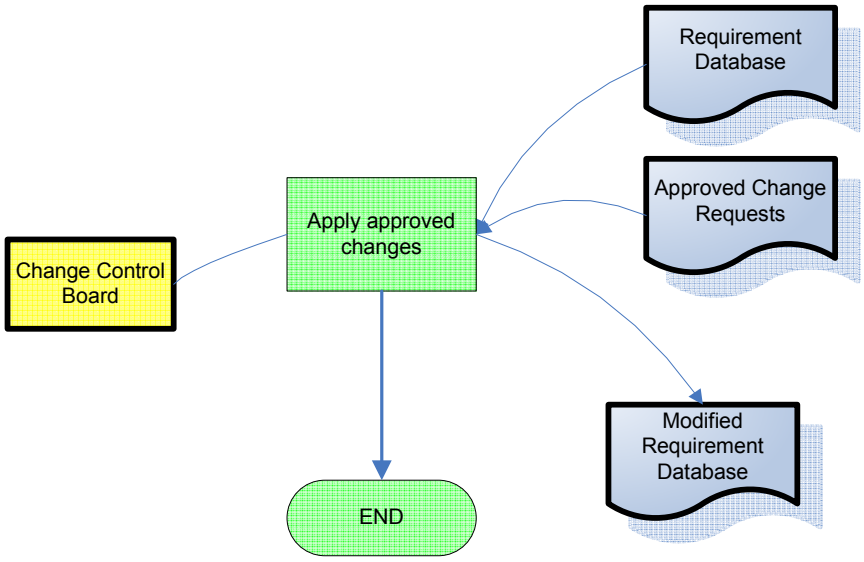

Figure 4-4 Applying approved changes

Table 4-17 Results of applying approved changes for metric 1-4

Activity Number	Complexity (1)	Coupling (2)	Failure Avoidance (3)	Restorability (4)
1	No decision	No interaction	Final form of change proposals are reviewed by Change Control Board	Approved changes are recorded by software tool.

Table 4-18 Results of applying approved changes for metric 5-8

Activity Number	Restoration Effectiveness (5)	Functional Adequacy (6)	Functional Completeness (7)	IT Usage (8)
1	Restoration from disk backup	Adequate	-	Approved changes are applied using IT application.

Table 4-19 Results of applying approved changes for metric 9-13

Activity Number	IT Density (9)	Computational Accuracy (10)	Data Exchangeability (11)	Access Audit ability (12)	Functional Understand- ability (13)
1	IT application is used to update requirement database from approved change proposals.	No specific accuracy requirement	No interaction	Access auditability Users with at least Manager change proposal role can review the change proposal. Approved change can be audited using the log file.	No difficulties or misunderstandings

Table 4-20 Results of applying approved changes for metric 14-17

Activity Number	Completeness of Documentation (14)	Input Validity Checking (15)	Undo ability (16)	Attractive Interaction (17)
1	Described	Input validity is checked during applying approved changes.	Approved change may only be undoing by another change proposal, or manually editing requirements database.	Attractive interaction during applying approved changes.

4.4 Forms/Documents/Tools/Applications

4.4.1 Change Proposal Submit Form

An example of "change proposal submit" form is presented in Figure 4-5 [28]. Change proposal submit form should display current text and attributes of requirement, and should contain fields to submit change requests against each text and attribute. The form should be available to users who access database remotely.

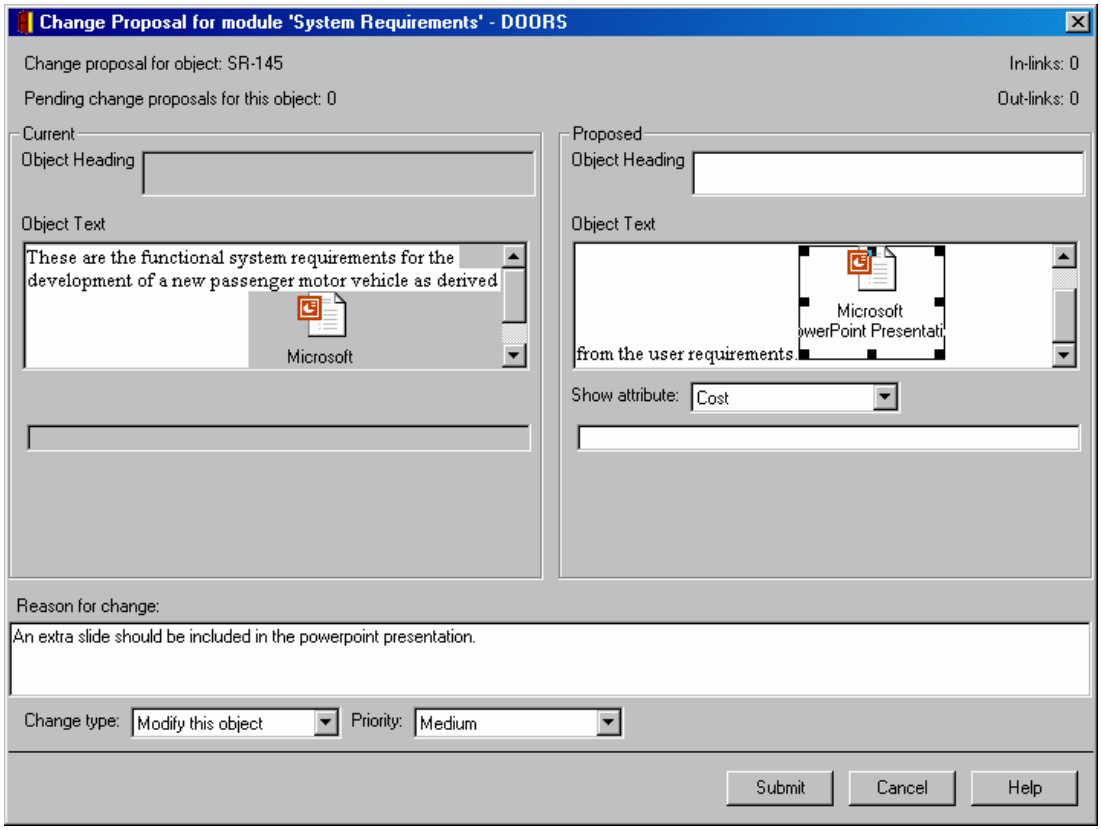

Figure 4-5 Change proposal submit form example

4.4.2 Change Proposal Review Form

An example of change proposal review form is presented in Figure 4-6 [28]. Change proposal review form should display the current and proposed text and attributes of the requirements. Change proposal review form should have a field to allow analyzer enter comments; also change proposal review form should allow analyzer to change state of the proposed change request to "Accept", "Reject" of "Defer" states.

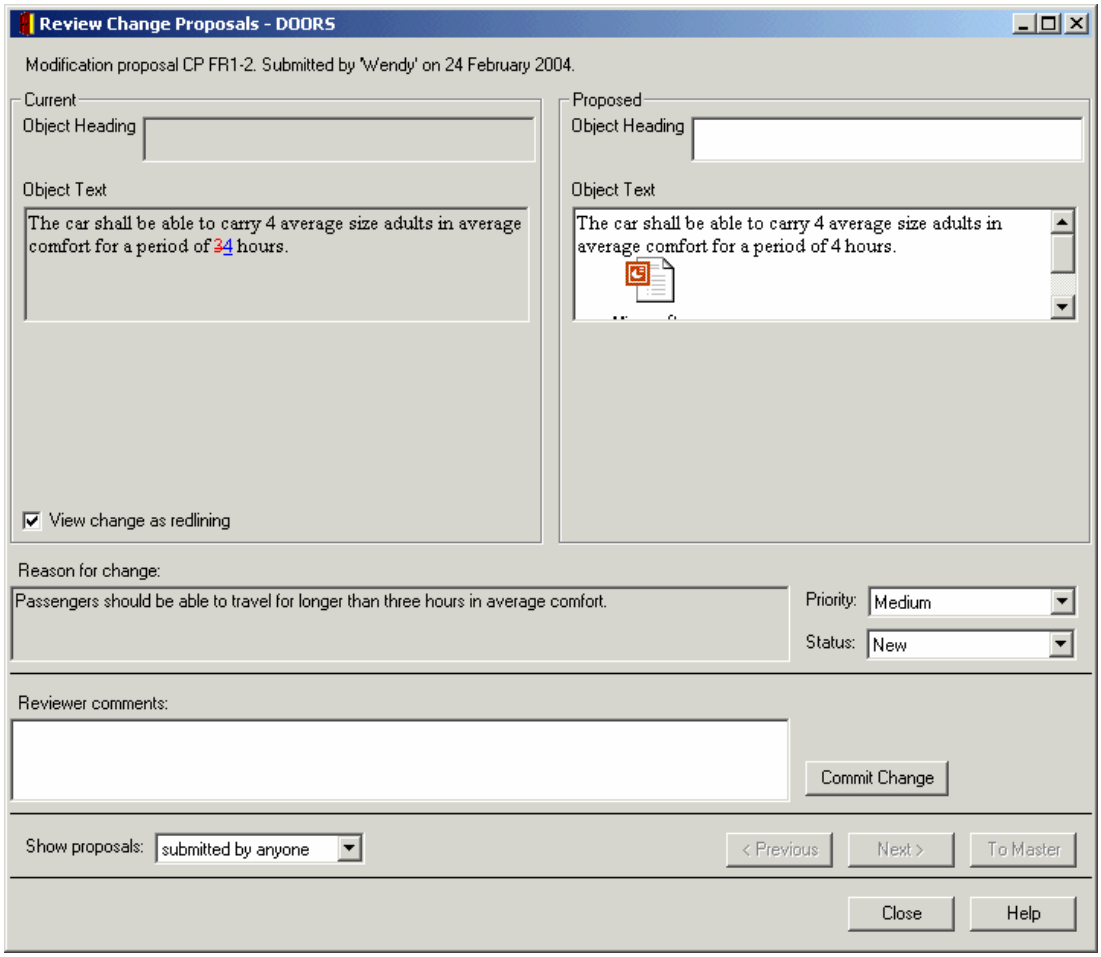

Figure 4-6 Change proposal review form example

4.5 Summary of Measurement Results

First observation from the Table 4-21 and Table 4-22 is the significant improvement in the "Coupling" metric. Since requirement change requests are submitted and analyzed using change proposal system, interactions with the SCR process have been eliminated. Another level of verification is achieved in the processes with the introduction of the change control board; consequently "Failure Avoidance" metric has been improved.

Since most of the activities of the current process are also recorded, "Restorability" and "Restoration Effectiveness" metric has not been changed much.

Proposed process uses IT applications in all of the activities, which increases not only “IT Usage” and “It Density” metrics but also “Access Auditability” and “Undoability”. The use of “change proposal submit” and “change proposal review” forms, increases attractiveness of the proposed process.

Since proposed process could not be applied to the project, “Functional Adequacy”, “Functional Completeness”, “Functional understandability”, and “Existence in Document” metrics are not applicable to proposed process. Also “Data Exchange ability” metric is not applicable to proposed process because it does not have any interactions with other processes.

Summary of the measurement results are given in Table 4-21 and Table 4-22.

Table 4-21 Summary of the measurement results metrics 1-9

Process	Number of Activity	Complexity	Coupling	Failure Avoidance	Restorability	Restoration Effectiveness	Functional Adequacy	Functional Completeness	IT Usage	IT Density
RCD Initiation (AS-IS)	8	X(1) = 0 X(2) = 2 / 8 X(3) = 3 / 8 X(2) = 0.25 X(3) = 0.375	X = 4 / 8 X = 0.5	X = 4 / 8 X = 0.5	X = 7 / 8 X = 0.875	X = 7 / 8 X = 0.875	X = 6 / 8 X = 0.675	X = 1 -0/8 X = 1	X = 7 / 8 X = 0.875	X = 7 / 7 X = 1
CP Initiation (TO-BE)	4	X(1) = 0 X(2) = 1 / 4 X(3) = 1 / 4 X(2) = 0.25 X(3) = 0.25	X = 0 / 4 X = 0	X = 1 / 4 X = 0.25	X = 4 / 4 X = 1	X = 4 / 4 X = 1	X = 4 / 4 X = 1	X = 1- 0/4 X = 1	X = 4 / 4 X = 1	X = 3 / 3 X = 1
RCD Generation (AS-IS)	10	X(1) = 0 X(2) = 0 X(3) = 0	X = 0 / 10 X = 0	X = 1 / 10 X = 0.1	X = 10 / 10 X = 1	X = 10 / 10 X = 1	X = 10/10 X = 1	X = 1-0/10 X = 1	X = 10/10 X = 1	X = 9 / 9 X = 1
Submitting CP (TO-BE)	2	X(1) = 0 X(2) = 0 X(3) = 0	X = 0 / 2 X = 0	X = 0 / 2 X = 0	X = 1 / 2 X = 0.5	X = 1 / 2 X = 0.5	X = 2 / 2 X = 1	X = 1- 0/2 X = 1	X = 2 / 2 X = 1	X = 1 / 1 X = 1
RCD Analysis and Update (AS-IS)	16	X(1) = 0 X(2) = 5/16 X(3) = 3/16 X(2) = 0.313 X(3) = 0.188	X = 8 / 16 X = 0.5	X = 13 / 16 X = 0.813	X = 15 / 16 X = 0.938	X = 15 / 16 X = 0.938	X = 8 / 16 X = 0.5	X = 1- 2/16 X = 0.875	X = 15 /16 X = 0.938	X = 10/12 X = 0.833
CP Analysis (TO-BE)	4	X(1) = 0 X(2) = 1 / 4 X(3) = 3 / 4 X(2) = 0.25 X(3) = 0.75	X = 0 / 4 X = 0	X = 4 / 4 X = 1	X = 4 / 4 X = 1	X = 4 / 4 X = 1	X = 4 / 4 X = 1	X = 1- 0/4 X = 1	X = 4 / 4 X = 1	X = 4 / 4 X = 1

Table 4-21 Summary of the measurement results metrics 1-9 cont'd

Process	Number of Activity	Complexity	Coupling	Failure Avoidance	Restorability	Restoration Effectiveness	Functional Adequacy	Functional Completeness	IT Usage	IT Density
Receiving new Requirement Database (AS-IS)	10	X(1) = 3 / 10 X(2) = 1 / 10 X(3) = 0 X(1) = 0.3 X(2) = 0.1	X = 4 / 10 X = 0.4	X = 3 / 10 X = 0.3	X = 7 / 10 X = 0.7	X = 7 / 10 X = 0.7	X = 9/ 10 X = 0.9	X = 1-0/10 X = 1	X = 9 / 10 X = 0.9	X = 7 / 7 X = 1
Applying Approved Changes (TO-BE)	1	X(1) = 0 X(2) = 0 X(3) = 0	X = 0 / 1 X = 0	X = 1 / 1 X = 1	X = 1 / 1 X = 1	X = 1 / 1 X = 1	X = 1 / 1 X = 1	X = 1- 0/1 X = 1	X = 1 / 1 X = 1	X = 1 / 1 X = 1

Table 4-22 Summary of the measurement results metrics 10-17

Process	Number of Activity	Computational Accuracy	Data Exchangeability	Access Auditability	Functional Understandability	Existence in Documents	Input Validity Checking	Undoability	Attractive Interaction
RCD Initiation (AS-IS)	8	X = 1 / 1 X = 1	X = 2 / 4 X = 0.5	X = 5 / 7 X = 0.714	X = 8 / 8 X = 1	X = 7 / 8 X = 0.875	X = 4 / 8 X = 0.5	X = 6 / 8 X = 0.75	X = 3 / 6 X = 0.5
CP Initiation (TO-BE)	4	X = 1 / 1 X = 1	No interaction	X = 3 / 3 X = 1	X = 4 / 4 X = 1	X = 4 / 4 X = 1	X = 1 / 4 X = 0.25	X = 4 / 4 X = 1	X = 2 / 4 X = 0.5
RCD Generation (AS-IS)	10	X = 8 / 8 X = 1	No interaction	X = 10 / 10 X = 1	X = 10 / 10 X = 1	X = 10 / 10 X = 1	X = 0 / 10 X = 0	X = 9 / 10 X = 0.9	X = 1 / 10 X = 0.1
Submitting CP (TO-BE)	2	No accuracy requirement	No interaction	X = 2 / 2 X = 1	X = 2 / 2 X = 1	X = 2 / 2 X = 1	X = 1 / 2 X = 0.5	X = 2 / 2 X = 1	X = 2 / 2 X = 1

Table 4-22 Summary of the measurement results metrics 10-17 cont'd

Process	Number of Activity	Computational Accuracy	Data Exchangeability	Access Auditability	Functional Understandability	Existence in Documents	Input Validity Checking	Undoability	Attractive Interaction
RCD Analysis and Update (AS-IS)	16	X = 5 / 6 X = 0.833	X = 5 / 8 X = 0.625	X = 9 / 16 X = 0.5625	X = 14 / 16 X = 0.875	X = 16 / 16 X = 1	X = 3 / 16 X = 0,184	X = 7 / 16 X = 0.4375	X = 7 / 15 X = 0,467
CP Analysis (TO-BE)	4	X = 1 / 1 X = 1	No interaction	X = 4 / 4 X = 1	X = 4 / 4 X = 1	X = 4 / 4 X = 1	X = 4 / 4 X = 1	X = 4 / 4 X = 1	X = 4 / 4 X = 1
Receiving new Requirement Database (AS-IS)	10	X = 3 / 3 X = 1	X = 3 / 4 X = 0.75	X = 5 / 7 X = 0.714	X = 9 / 10 X = 0.9	X = 8 / 10 X = 0.8	X = 4 / 10 X = 0.4	X = 7 / 10 X = 0.7	X = 5 / 7 X = 0.714
Applying Approved Changes (TO-BE)	3	No accuracy requirement	No interaction	X = 1 / 1 X = 1	X = 1 / 1 X = 1	X = 1 / 1 X = 1	X = 1 / 1 X = 1	X = 1 / 1 X = 1	X = 1 / 1 X = 1

CHAPTER 5

DISCUSSION AND CONCLUSION

In this chapter, first a brief summary of the work carried out within the scope of this thesis is given. First literature is reviewed for software process improvement methodologies in practice, requirements management activities, importance of the requirement traceability in software development, support tools for requirement management activities and distributed software development methodologies. Subsequently Güçeğlioğlu's methodology and similar software process improvement studies using his methodology are studied. Then current requirement change management process of the project studied is modeled according to static process evaluation model proposed by Güçeğlioğlu. Afterwards, interviews with the members of the development team are made. Their opinion, improvement suggestions about current requirements management process are obtained. Together with the literature survey on the requirements management tools in practice, and similar studies in the subject, it has been concluded to use another tool; with the capabilities of multi-site access, and integrated change request system. Afterwards requirement change management process is re-modeled with the suggested tools, interview comments and proposed improvements. Finally current and proposed processes are compared, and further research possibilities are discussed.

5.1 Comparison of the Processes

- With utilization of change proposal system, the process of generating RCD document is eliminated. Engineers no longer have to spend time on preparation of change request document. Change proposal submit and analysis forms are used during in submission and analyze of change requests.
- Since requirements and change request are managed using same application, traceability from requirements to change requests and change rationales is significantly improved. As a result, development activities of the pending

change requests may be deferred, which will reduce the risk involved in implementing change requirement before consumer approval.

- In the proposed requirement change management processes, change requests are submitted per each requirement. This will significantly reduce the average life time of change requests.
- Proposed process introduces change control board to the process, whose duty is to apply approved changes to the requirement database. CCB introduces an additional level of failure avoidance to the requirement change management process.
- With the introduction of a tool capable of allowing remote users to access database managed in Company Y, there will not be a need to manage another requirement database at Company X. This eliminates the synchronization and management efforts spent by Company X.
- Some of the change requests for different requirements have to be analyzed together. For example, a statement would have been removed from a requirement and inserted to another one. Since in the proposed process requirements will be analyzed individually special care must be given for requirements which should be considered together. In the current process since change request are submitted in section wise this case is unnecessary.
- In current process all change request to software artifacts were stored in same database, where as in the proposed process requirement change requests will be stored in a different database, this will reduce the traceability between requirement change requests against different software artifacts. Note that traceability from requirements to other software artifacts is not change in anyway.

The results of this study clearly illustrated that for requirement management activities in a globally distributed software development, managing single database, and allowing remote users to access this database using remote access capable tools, is significantly better approach than managing and synchronizing multiple requirement databases. Furthermore, Güceğlıoğlu's static process evaluation method enables users to evaluate proposed improvement before applying them to projects thus the maturity of improvements could be improved before applying them to the

real projects. Thus, the deficiencies in the improvements could be identified earlier without effecting work in practice.

5.2 Future Work and Limitations

The proposed requirement change process could not be applied to the project because the project is at the last iterations. Furthermore interviews are only made with employees of Company X; and the proposed process is not reviewed by Company Y. There is the possibility that the proposed process may not be accepted by Company Y and will never be applied to the project. This study could be applied to another multi-national global development environment to observe the results in a real development environment.

The scope of this thesis was only limited to requirement change management process of a particular project in a major software development company, it could be extended to include other software development practices in the project or even other projects of the company.

In the study, current requirements management activities are taken as a baseline, which is centered on requirements management tool Telelogic DOORS, this study could be extended to include other requirements management tools.

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