SOFTWARE PROCESS IMPROVEMENT BASED ON STATIC PROCESS EVALUATION

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ABSTRACT

SOFTWARE PROCESS IMPROVEMENT

BASED ON STATIC PROCESS EVALUATION

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This study investigates software development process improvement approaches. In particular, the static process evaluation methodology proposed by S. Güceğlioğlu is applied on the requirements analysis and validation process applied in Project X in MYCOMPANY and an improved process is proposed. That methodology is an extension of the ISO/IEC 9126 approach for software quality assessment, and is based on evaluating a set of well-defined metrics on the static model of software development processes.

The improved process proposed for Project X is evaluated using Güceğlioğlu's methodology. The applied and improved process measurement results compared to determine if the improved process is successful or not.

Keywords: Software Process Improvement, Static Process Evaluation.

ÖZ

DURAĞAN SÜREÇ DEĞERLENDİRMESİNE DAYALI

YAZILIM SÜRECİ İYİLEŞTİRMESİ

Seçkin, Haldun

Yüksek Lisans., Elektrik-Elektronik Mühendisliği Bölümü

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Bu çalışma, yazılım geliştirme süreçlerinin iyileştirilmesi alanındadır. Selçuk Güceğlioğlu tarafından önerilen durağan süreç değerlendirme metodolojisi, MYCOMPANY adı verilen firmanın Project X isimli projesinde uygulanan gereksinim çözümleme ve doğrulama süreci üzerinde uygulanmış ve iyileştirilmiş bir süreç önerilmiştir. Bu methodoloji ISO/IEC 9126 yaklaşımının yazılım kalitesi değerlendirmesi konusunda genişletilmiş halidir ve temel olarak yazılım geliştirme süreçlerinin durağan modellerinin iyi tanımlanmış metrik seti kullanarak değerlendirmesidir.

Önerilmiş olan süreç Güceğlioğlu'nun metodologisi kullanılarak değerlendirilmiştir. Uygulanan ve iyileştirilen süreçlerin ölçüm sonuçları iyileştirilmiş sürecin başarılı olup olmadığına karar verilebilmesi için karşılaştırılmıştır.

Anahtar Kelimeler: Yazılım Süreç İyileştirmesi, Durağan Süreç Değerlendirme.

To my wife NAZLI

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LIST OF ABBREVIATIONS

AQAP	Allied Quality Assurance Publication
CMM	The Capability Maturity Model
CMMI	Capability Maturity Model Integration
COTS	Commercial off-the-Shelf
CP	Coding Phase
CTQ	Critical to Quality Characteristics
DCB	Design Control Board
DCWG	Design Control Working Group
DMAIC	Define-Measure-Analyze-Improve-Control
DoD	Department of Defense (US government)
DP	Design Phase
ECP	Engineering Change Proposal
ERP	Enterprise Resource Planning
FP	Function Point
FPA	Function Point Analysis
GQM	Goal, Question, Metric
IEC	International Engineering Consortium
IEEE	Institute of Electrical & Electronics Engineers
IPD-CMM	Integrated Product Development Capability Maturity Model
IPR	In-Process Review
IPT	Integrated Product Teams
ISO	International Organization for Standardization
LOC	Line of Code
NATO	North Atlantic Treaty Organization
NRR	the New Requirement Request
OCD	The Operational Concept Document
OUG	Operational User Group
QMD	Quality Management Department
RA	Requirement Analysis
RDB	Requirement DataBase
RDBCR	The RDB Change Request
RRB	The Requirements Review Board
SCN	Specification Change Notice
SECM	System Engineering Capability Model
SEI	Software Engineering Institute (Carnegie Mellon)
SEIT	Systems Engineering and Integration and Test Process

SPI	Software Process Improvement
SPICE	Software Process Improvement and Capability dEtermination (European software development model)
SPUs	Software Producing Units
SRR	System Requirement Review
SSS	System/subsystem Specification
TP	Test Phase

CHAPTER 1

INTRODUCTION

In order to compete successfully in the international market, the manufacturers need to achieve some organizational goals. Organizational goals can generally be defined in terms of: [33]

• Increasing functionality,

• Reducing cost,

• Reducing time to market (improve timing in schedule), and

• Improving product quality.

To achieve these goals they focus on how to produce the product and they define the stages of production, called processes. Technically, a process, described by ISO/IEC, for a task comprises a sequence of steps that should be followed to execute that task. In 1987, Gabriel Pall defined "a global description of a process as the logical organization of people, materials, energy, equipment, and procedures into work activities designed to produce specified and results." Phillips describes a process as a set of practices performed to achieve a given purpose; it may include tools, methods, materials, and/or people. [1]

However, there are some main differences between manufacturing and software; we can use this description in the software industry. Werth gives us the specific description of 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)". [4]

When organizations achieve some part of the typical organizational goals, they want to measure how well they do. Measurement is the process by which the numbers or symbols are assigned to real world attributes, in such a way as to describe them according to clearly defined rules. Measurement is not just the collection of data/metrics. For general description, measurement is an understanding of a process or product, determining the metrics, collecting data and analyzing them for how the process or product is doing now. Measurements help us to determine strengths and weaknesses of the current process.

When the organizations know the successes/failed points, they start some action to strengthen their weaknesses or to rebuild/recover these processes. Process improvement concepts are started to define. Process improvement benefits fall into one of eight general categories [1]:

- improved schedule and budget predictability
- improved cycle time
- increased productivity
- improved quality (as measured by defects)
- increased customer satisfaction
- improved employee morale
- increased return on investment
- decreased cost of quality

This study aims to propose an improvement to the requirements analysis and validation process applied in MYCOMPANY on Project X. The goals for the improvement are to improve cycle time, to increase productivity, to improve quality, to increase customer satisfaction and to decrease cost of quality.

The AS-IS and TO-BE processes are evaluated using S. Güceğlioğlu's [43] methodology for static process evaluation.

In chapter 2, the relevant literature is reviewed. The software process improvement history and software process improvement models are discussed in section 2.1.1. The software process improvement methodologies, GQM and Six Sigma, are discussed in section 2.1.2. These models and methodologies are compared in section 2.1.3. S. Güceğlioğlu's the static process evaluation methodology are briefly discussed and process measurement metrics are studied.

In chapter 3, the status of firm, project and requirements analysis and validation process are studied. MYCOMPANY and Project X will be briefly introduced in section 3.1.2 and 3.1.3. The current software development approach of Project X is discussed in section 3.2.1. The requirements analysis and validation process of Project X is analyzed as defined in documents and currently used in project in section 3.2.1.1. The measurement of these process models are made in section 3.2.1.2.

In chapter 4, the proposed software requirements analysis and validation process will be defined. The TO-BE model of the requirements analysis and validation process is defined and compared with current processes in section 4.2. The measurement of the TO-BE model is made in section 4.3.

In chapter 5, the evaluation of the proposed requirements analysis and validation process is studied. The model's measurement results will be identified in section 5.2. These results will be analyzed in section 5.3.

In chapter 6, the conclusion of this study is given.

CHAPTER 2

LITERATURE SURVEY

2.1. Software Process Improvement

At the beginning of the 1980s US DoD, the biggest customer of the software industry noticed that the failure rate of the software projects was too high and the quality of the products was low. DoD needed to organize software organizations, started a project, to help the organizations improve processes. In the 1980s, DoD announced the DoD Std 2167 and NATO announced AQAP 13.

2.1.1. Software Process Improvement Models

The Capability Maturity Model (CMM) [6] was developed by the Software Engineering Institute, with assistance from Mitre Corp. to help developers improve their software process and use this improvement to achieve organization maturity. As an organization matures, the software process becomes better defined and more consistently implemented throughout the organization.

Paulk, Curtis, Chrissis and Weber define maturity levels as: [6]

- Level 1 – Initial
- Level 2 – Repeatable
- Level 3 – Defined
- Level 4 - Managed
- Level 5 - Optimizing

The ISO 9000 [15] series were developed by the International Organization for Standardization. The ISO 9000 series software development process standard was coined out of the need to document the process involved in developing software products. It is based on quality and process management of software products. The purpose is to provide guidelines for the application of ISO 9001 standards to the development, supply and maintenance of software.

Traditionally systems and software disciplines have not been well integrated. CMMI [1] integrates systems and software disciplines into one process improvement framework. CMMI is the next generation of CMM.

SPICE (ISO/IEC 15504), Software Process Improvement and Capability dEtermination, is a project, with three principal goals [10]:

- to develop a working draft for a standard for software process assessment
- to conduct industry trials of the emerging standard
- to promote the technology transfer of software process assessment into the software industry world-wide

SPICE combines the best features of CMM and ISO 9000 standards in addition to the notion of assessment. ISO/IEC 15504 is complementary to ISO 9001 and ISO 12207.

2.1.2. Software Process Improvement Methodologies

Unlike the software process improvement models, software process improvement methodologies give guidelines of how to analyze and improve software process. SPI methodologies have mostly originated from manufacturing industry and have been adapted to software.

Two widely studied SPI methodologies, Goal-Question-Metric (GQM) and Six Sigma are outlined below:

The basic idea of GQM is deriving software measures from measurement questions and goals. The GQM method was originated by Basili and Weis as a result of both practical experience and academic research.

"GQM presents a systematic approach for integrating goals to models of the software processes, products, and quality perspectives of interest based upon the specific needs of the project and the organization." [11]

Six Sigma is a quality improvement approach based on statistical models of manufactured goods' quality [23]. It also serves as a slogan that suggests high quality. Six Sigma is used with **"Define-Measure-Analyze-Improve-Control" (DMAIC)** framework.

2.1.3. Comparison of Software Process Improvement Models and Methodologies

In this section, SPI models and methodologies will be comparatively evaluated from the standpoint of the particular firm being studied within scope of this study.

The main difference between software process improvement methodologies, GQM and Six Sigma, is metric selection. Six Sigma methodology's metric selection is based on customer satisfaction. Therefore, basic metrics are about defects.

Starting point of the comparison of models is CMM, because the firm to be studied within the scope of this study has CMM 3 certification, as described later in Chapter III.

According to Ghosh [15] and Paulk [16], IS0 9001 identifies the minimal requirements for a quality system, while CMM underlines the need for continuous process improvement and gets into more details of the technical aspects of software engineering.

CMM focuses strictly on software, while IS0 9001 has a much broader scope that encompasses hardware, software, processed materials, and services. Moreover, CMMI integrates software and system discipline.

Combining the industry practices, CMM and CMMI drive a model to determine how the processes should be. But most of the SPI models like ISO 9001 only evaluates companies and gives the open point. The SPI driven models do not discuss the organizational culture sufficiently.

The Wang, Court, Ross, Staples, King, and Dorling's [9] quantitative differences between CMM, SPICE, BOOTSTRAP and ISO 9000 are in Appendix A.

The main difference between SPI models like CMM, SPICE, and methodologies like GQM, Six Sigma is that; the SPI models analyze the key points of processes and, in some cases, give a model to improve processes according to model specific questionnaires, while SPI methodologies only guide how to analyze and improve software processes with respect to assessor. The basic point of why methodologies are not models is that methodologies cannot define your weakness and open points or cannot determine organizational target with respect to standards and industry practices. Therefore, to reach success with using methodology, the assessment and target definition have to be made successfully.

In the author's opinion, the best way for software process improvement is to use two SPI concepts, models and methodology, together in following way:

- Select how to assess the organization and choose the SPI model to know the organization situation and to compare industry standards
- Define targets or goals from the weaknesses or open points with respect to SPI model

- Use SPI methodology to improve organization to SPI model standards or organizational target in this way:
    - Define metrics with respect to goals to understand the present situation
    - Analyze measurements to know causes of the situation
    - Improve processes to defined target

2.2. Selçuk Güceğlioğlu's Static Process Evaluation Methodology

In this study, the determined process of Project X is evaluated using Selçuk Güceğlioğlu's Static Process Evaluation methodology [43]. Improvements are made using this methodology.

"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." [43]

According to Güceğlioğlu, "he has benefited from close relationships between the software product and the process in the study. While he is developing his model, he adapts or redefines some of the ISO/IEC 9126's software quality metrics to the process concept. He also defines new metrics that can be used for measuring the process quality."

Güceğlioğlu's methodology is based on evaluating processes using following metrics;

1. Maintainability Metrics
    a. Analyzability Metrics

i. Complexity

ii. Coupling

2. Reliability Metrics

   a. Fault Tolerance Metrics

      i. Failure Avoidance

   b. Recoverability Metrics

      i. Restorability

      ii. Restoration Effectiveness

3. Functionality

   a. Suitability Metrics

      i. Functional Adequacy

      ii. Functional Completeness

   b. IT Based Functionality Metrics

      i. IT Usage

      ii. IT Density

   c. Accuracy Metrics

      i. Computational Accuracy

   d. Interoperability Metrics

      i. Data Exchangeability

   e. Security Metrics

      i. Access Auditability

4. Usability

a. Understandability Metrics

    i. Functional Understandability

b. Learnability Metrics

    i. Existence in Documents

c. Operability Metrics

    i. Input Validity Checking

    ii. Undoability

d. Attractiveness Metrics

    i. Attractive Interaction

These metrics are operationally defined in Appendix B.

2.3. Summary

Unlike software process improvement models, software process improvement methodologies give philosophy and road map how to define, to measure and to improve software processes. The comparisons between models and methodologies are studied in section 2.1.3.

Selçuk Güceğlioğlu's static process evaluation methodology is the adaptation and redefinition some of the ISO/IEC 9126's software quality metrics to the process concept. In addition to this, this model contains new metrics for measuring the process quality.

Using knowledge from Chapter 2, in Chapter 3, a particular process within MYCOMPANY's and Project X's development system are analyzed and discussed.

CHAPTER 3

THE STATUS OF FIRM AND PROJECT AND THE CURRENT SOFTWARE REQUIREMENTS ANALYSIS AND VALIDATION PROCESS

3.1. Introduction

In this study, the aim is to evaluate the requirements analysis and validation process of Project X using Selçuk Güceglioğlu's Static Process Improvement Methodology. Moreover, improvements are made using this methodology.

Below, after presenting the research method briefly, MYCOMPANY and Project X shall be introduced before studying the possibility of applying SPI.

In this chapter, Project X current software requirements analysis and validation process are discussed and measured using Selçuk Güceğlioğlu's process quality measurement model.

3.1.1. Research Method

MYCOMPANY's current status, which will be discussed in section 3.2.1, have been collected from QMD of MYCOMPANY by interviews with QMD manager and investigating MYCOMPANY policy document.

PROJECT X's current status, which will be discussed in section 3.2.2, have been collected from Quality management team lead, project manager and functional team members by interviews with them and investigating Project X project documents.

3.1.2. MYCOMPANY

MYCOMPANY is leader of the military software industry. MYCOMPANY has CMM level 3 and the AQAP 500 quality certifications.

MYCOMPANY made many different projects that use many different technologies. All projects has own project management. Projects are collected in departments with respect to specifications.

Projects are organized in groups and groups are divided into teams. Special teams like quality, test, integration etc… exists in some projects. Nevertheless, in most of the projects, other team members make these special tasks.

Quality Management Department (QMD) of MYCOMPANY is responsible of quality activities in MYCOMPANY.

QMD manages MYCOMPANY's quality policy, and most of the projects in MYCOMPANY manage their quality with respect to company's quality policy. In some projects, one of the QMD's staff works in the project to manage the quality and to feedback the project specific or general corrections in quality policy.

QMD works like supervisor of the projects quality teams. QMD publishes the quality policy and periodically assess the projects according to the quality policy and the certifications requirement.

QMD is responsible of organizing and managing the projects reviews periodically. In these reviews, all project metrics, like schedule, budget, defect percentage etc…, are studied.

3.1.3. PROJECT X

This study is conducted on MYCOMPANY's Project X. Project X is one of the biggest projects of military software industry in Turkey.

Project X has four subsystems and all of the subsystems are being developed by different technologies. These subsystems are:

- Subsystem1: It is the ERP project. It contains resource and administration management functions of customer.
- Subsystem2: It is a database application newly developed with Java language. It performs the military operations and intelligence functions.
- Subsystem3: It is a database application newly developed with .Net language. It performs customer's document management functions.
- Subsystem4: It is customized using ready to use software constructing the domain infrastructure and personnel computer.

All subsystem except subsystem4 is organized in technical and functional groups. Subsystem4 has only technical group. These groups are divided into teams with respect to their responsible modules. These modules are defined by functional properties.

3.2. The Current Software Development Approach

3.2.1. In PROJECT X

Quality management team is responsible for quality activities. Quality management team is formed with group leads and subsystem project managers. However, in project X, no quality specialist exists.

The Project X processes are defined in Systems Engineering Management Plan. In this document, the Project X Systems Engineering and Integration and Test Process are defined.

Systems Engineering and Integration and Test Process (SEIT) is composed of six major phases: System Requirements Analysis and Validation, System Architecture and Systems Design, Product Design, Product Development and Qualification, System Integration and Test, and Development and Support. Technical management is a process that underlies the engineering process and provides cohesion throughout the system life cycle. Each of these phases is comprised of activities. An activity is a work effort to be budgeted and tracked. Each activity is composed of a set of tasks.

The SEIT processes and major process activities are shown in Figure 3.

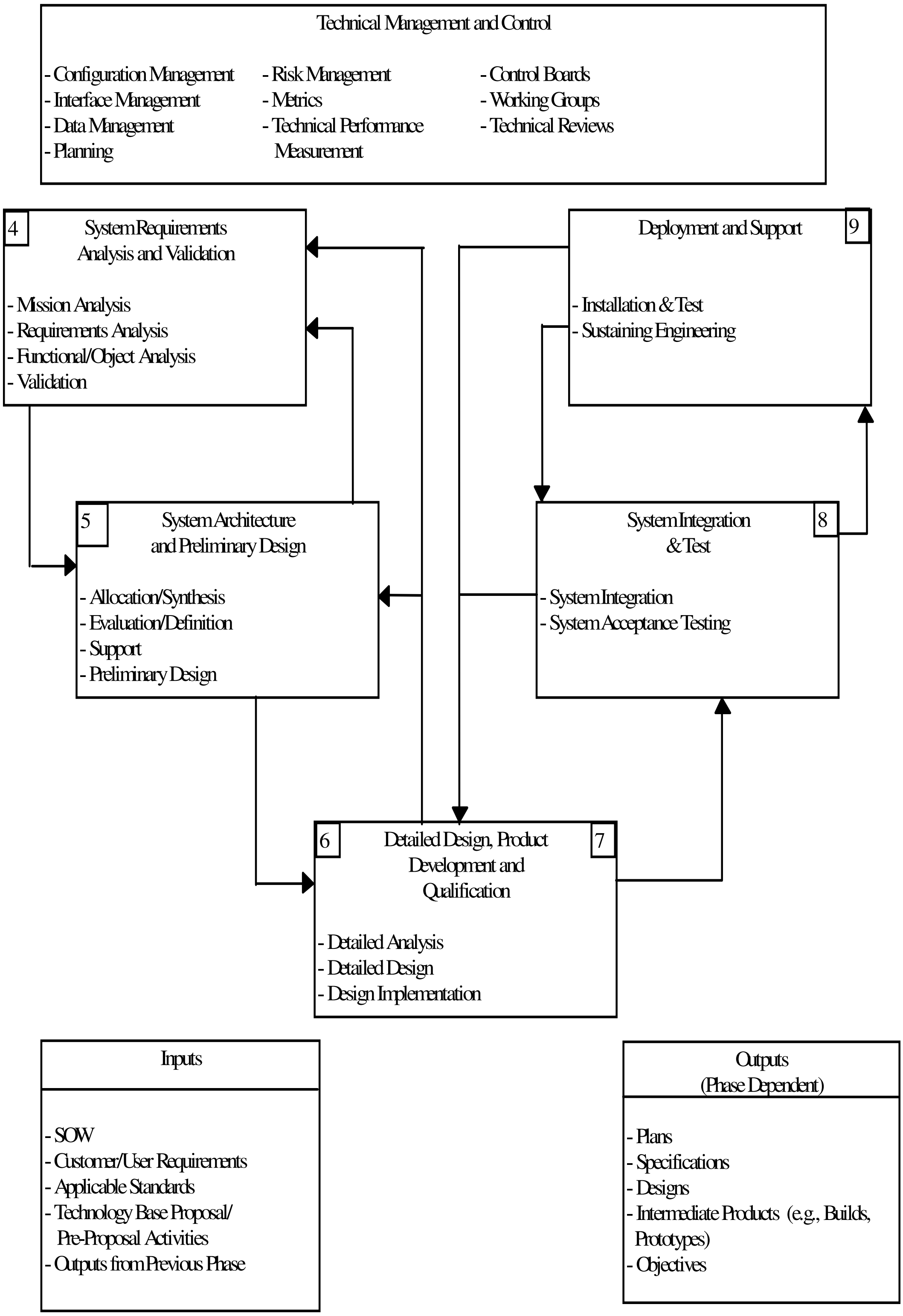

Figure 1 Systems Engineering and Integration and Test Process

3.2.1.1. Requirements Analysis and Validation Process of Project X

The requirements analysis and validation process is analyzed with respect to the process, which defined in documents (hereafter referred as “As Documented”) and the AS-IS process, which is used in practice. These two processes are defined and measured separately.

While defining and modeling these processes, the systems engineering management plan and related document are reviewed and the interviews with project manager, sub-system manager and functional team members of the PROJECT X are made.

3.2.1.1.1. As Documented Model of The Requirements Analysis and Validation Process

The activities of the requirements analysis and validation process in document are described in Table 4 and the model is shown in Figure 4.

Table 1 Requirements Analysis and Validation Process (As Documented)

REQUIREMENTS ANALYSIS AND VALIDATION PHASE (As Documented)					
Act. No	Activity Name	Definition	Staff	Inputs	Outputs
1.	Site survey	The specific functional description for each functional area is provided from the customer and Operational User Group [1] by the requirement teams.	Information Researchers [5]	-	-

Table 1 Requirements Analysis and Validation Process (As Documented) (Continued)

2.	Requirement Analysis	The requirements are analyzed using customer supplied source document like project contract, technical specification document.	Requirement Teams[5]	Project Contract, Technical Specification Document etc.	-
3.	Develop OCD	The Operational Concept Document (OCD) is developed with respect to site survey and requirement analysis.	Integrated Product Teams (IPT)	Site survey and Requirement Analysis Outputs	OCD
4.	Identify System Constraints	The system constraints from requirement analysis like Performance, Reliability/ Maintainability/ Availability, Safety, Security, Technology, Environment are defined	System IPT[2]	OCD	-
5.	Identify Technical Risks and Dependencies	The technical risks which can be cause of the defect/error and technical dependencies are defined	System IPT	OCD	-
6.	Identify Functional Requirements	The functional requirements are defined	Functional IPT[3]	OCD	-

Table 4 Requirements Analysis and Validation Process (As Documented) (Continued)

7.	Define System Interfaces	The conceptual system interfaces, which can be defined from OCD, are defined.	IPT	OCD	-
8.	Document Requirements	The requirements are documented with respect to requirement format. Requirement document contains text, traceability items and test methods.	IPT member	4, 5, 6 and 7th Activities' Outputs	Requirement Document
9.	IPT Internal Review	The requirement documents are reviewed for functional accuracy, for consistency within IPT, verify traceability, and check spelling.	IPT Team or Lead	Requirement Document	Approved or Rejected Requirement Document
10.	Identified Redlines Needed	The corrections of the requirement document are described.	IPT Team or Lead	Requirement Document and IPT Internal Review Outputs	-

Table 4 Requirements Analysis and Validation Process (As Documented) (Continued)

11.	RRB [4]	RRB reviews the approved requirement documents by IPT. RRB reviews for appropriate level, for consistency across IPTs, for design-to-cost issues, for Common Service applicability and for architectural design impact. RRB verifies traceability and testability of the requirement.	RRB	Approved Requirement Documents by IPT	Approved Requirements
12.	Architectural and Design Decisions	According to approved requirement documents, the initial architectural and design decisions are taken. All changes to the approved baselines, requirement and design according to the design decisions will be handled via an Engineering Change Proposal (ECP).	Design IPTs	Approved Requirements	ECP

Table 4 Requirements Analysis and Validation Process (As Documented) (Continued)

13.	Design Control Board [7]	These design changes will be submitted to the DCB for approval.	DCB	-	Approved ECP
14.	Accumulate for each Functional Area	The requirements are accumulated for each functional area. The functional area's requirements are totally defined for each functional area.	Requirement Teams	Approved Requirements	Accumulated Requirement
15.	Conduct IPR [6]	The requirements are reviewed and discussed with customer needs. Any comments that cause a change to the requirements will be documented and will be incorporated by the responsible IPT prior to the release of version 1.0 of the System Specification.	IPTs, MYCOMPANY 's managers, Customer, OUG	Accumulated Requirements	Approved Accumulated Requirements
16.	Consolidate Specification	The requirements documents are consolidated and system/subsystem specifications are defined	Requirement Teams	Approved Accumulated Requirements	System/subsystem Specification (SSS) Document

Table 4 Requirements Analysis and Validation Process (As Documented) (Continued)

17.	Baseline Specification	The SSS documents are defined as baseline of the specification. The changes are required change requests and documented for Configuration Management.	Requirement Teams	SSS	SSS Baseline
18.	Conduct SRR[8]	The total System Engineering Management activity and its output are reviewed. The internally approved ECPs are reviewed and approved and Specification Change Notice (SCN) published.	IPTs, MYCOMPANY 's managers, Customer, OUG	-	Specification Change Notice (SCN)

3.2.1.1.1.1. Terms in Process

- **The Customer and Operational User Group (OUG)** has the responsibility to review all requirements and compare against needs. The customer validates the intent of the requirements and approves the specification as a document that describes the required system.

- **The system IPT** roles include requirement lead and coordinator, who is responsible for the overall requirement activity; requirement authors, who create requirements that, apply across the system.

- **The functional IPTs** roles include requirement authors, who create requirements specific to their area; information researchers, who provide detailed data that assist authors in developing the requirements; requirement reviewers, who examine the written requirements for accuracy and consistency across the IPT and verify traceability; and technical translators, who help to ensure the English and Turkish versions of the requirement are accurate and consistent in meaning.

- **The Requirements Review Board (RRB)** is a collection of team members across the program that is responsible for requirement review and document control of the requirements. The RRB has the authority to approve or reject requirements submitted by the IPTs. RRB evaluates the requirements from a "system view" and programmatic constraints such as cost and schedule.

- **The Requirement Teams and Information Researchers** are the members of IPT

- **In- Process Reviews**

The System Specification In-Process Review is scheduled for a two-week period. Each IPT shall schedule time within this period to meet with representatives of MYCOMPANY, customer, and the OUG to discuss each requirement in their areas. No IPR should last the entire two weeks. Most IPRs should last one to two days. The larger functional systems such as Logistics may continue two or three additional days. Each IPT will be responsible for establishing their IPR schedule with coordination through the System IPT.

During the IPR, the requirements are reviewed and discussed. Any comments that cause a change to the requirements will be documented and will be incorporated by the responsible IPT prior to the release of version 1.0 of the System Specification. Review comments that may apply to all or multiple sections will be forwarded to the System Specification Lead to be resolved through the System IPT or the DCWG. The purpose of the In-Process Review is to reach agreement on the content of the section and document, as action items, any re-work required.

- **The Design Control Board**, chaired by the PROJECT X System Engineering Manager, is responsible for the control of the technical development of the program. This board is the overall technical management board. All technical decision requiring the interaction between disciplines and engineering organizations are candidates for submission to this board. Members of the DCB include the chairs of the various working groups at the next level of the hierarchy and other selected staff personnel. This board approves documents, archives numerous program technical decisions, and is the ultimate arbitrator of design decisions. This board controls the evolving design baseline, but also is the decision making body for controlling engineering approaches and processes and provides continuous direction over in-process review activities. The role of the DCB is to approve requirements and design changes to the TIS program and its decisions constitute contract technical direction. The DCB meets at least once each month.

- **System Requirement Review (SRR)**

The SRR will conform to the requirements of MIL-STD-1521B. The total System Engineering Management activity and its output will be reviewed for responsiveness to the PROJECT X Statement of Work and System/Subsystem requirements. The customer will provide direction to the PROJECT X Team, as necessary, for continuing the technical program and system optimization. The following topics will be covered:

  - Requirements Analysis
  - Operational Flow Analysis
  - Specialty Discipline Studies (i.e., hardware and software reliability analysis, maintainability analysis, electromagnetic compatibility, survivability/vulnerability, environmental considerations)
  - System Interface Studies
  - Specification Generation

- Program Risk Analysis
- Performance Measurement Planning
- Data Management Plans
- Configuration Management Plans
- Human Factors Analysis
- Milestone Schedules
- Demonstrations
- Engineering Notebook

3.2.1.1.1.2. Metrics

The following is an initial list of metrics as specified in the System Engineering Management Plan. In that plan, it is stated that this list will be updated as metric needs become more clearly defined.

- Number of requirements submitted to RRB each week by IPT
- Total number of requirements submitted to RRB each week
- Number of requirements approved or rejected/withdrawn for each IPT
- Total number of requirements approved or rejected/withdrawn each week.
- Number of workflows or source statements analyzed by each IPT each week
- Total number of requirements approved.

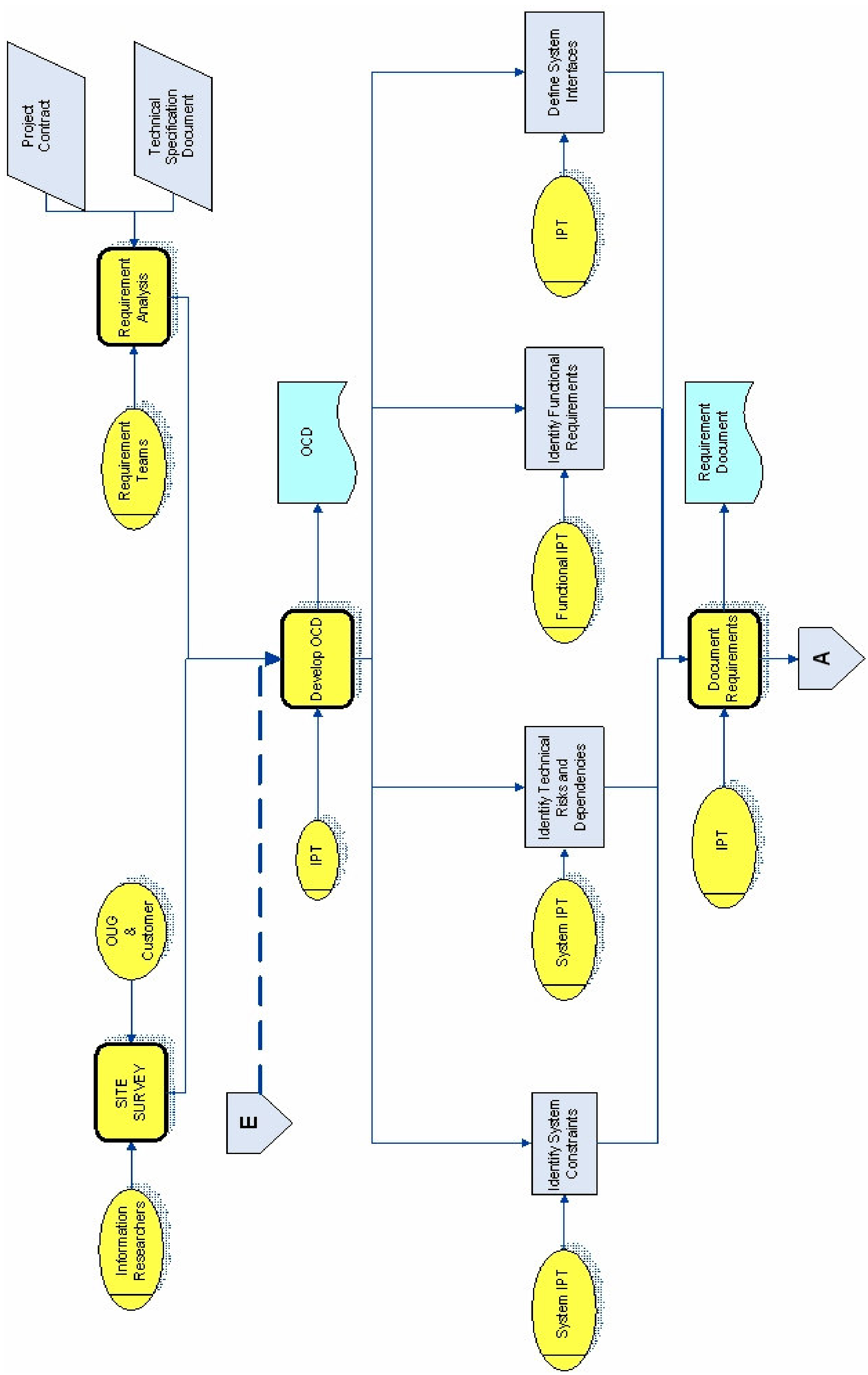

Figure 2 Requirements Analysis and Validation Process (As Documented)

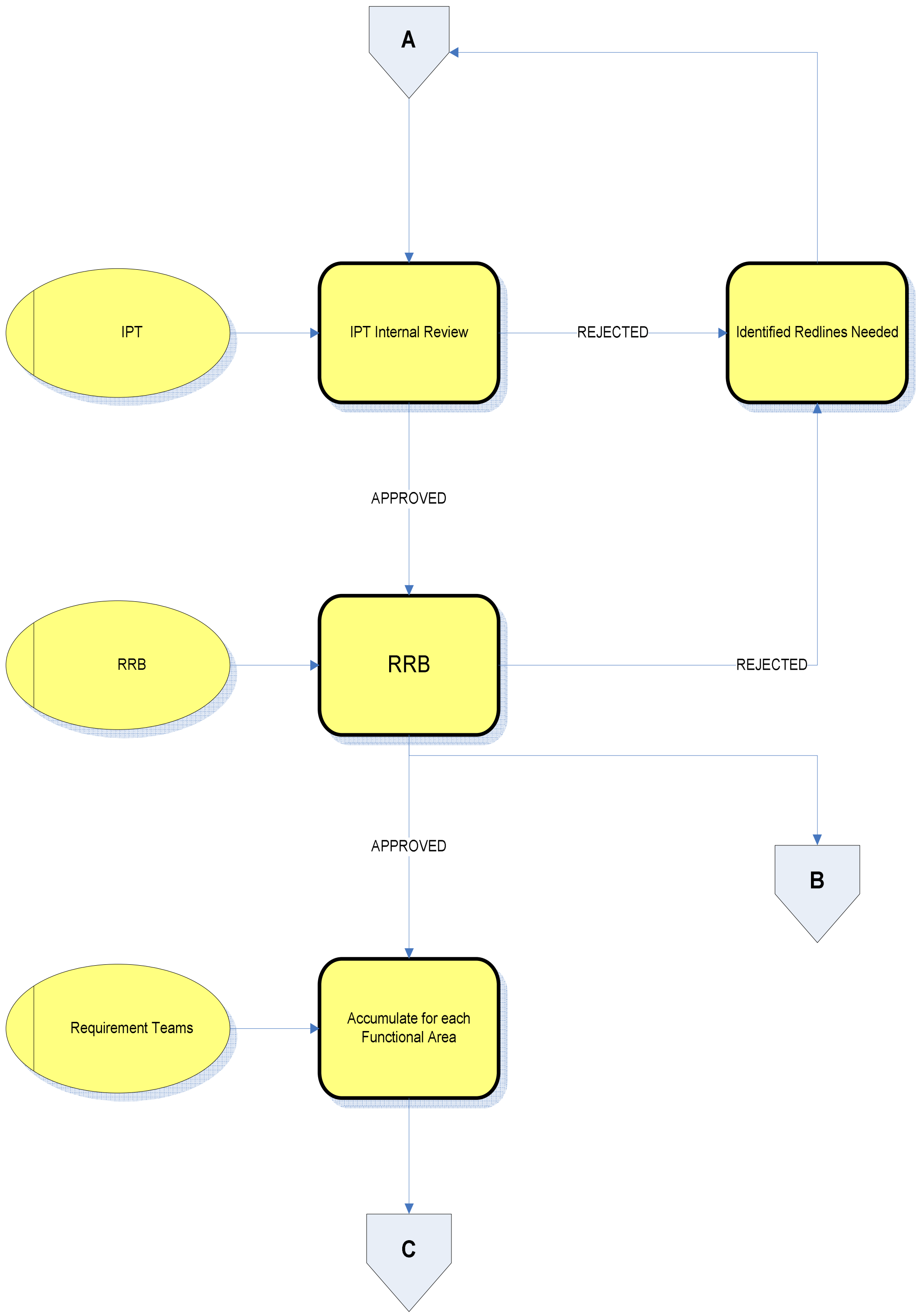

Figure 4 Requirements Analysis and Validation Process (As Documented) (Continued)

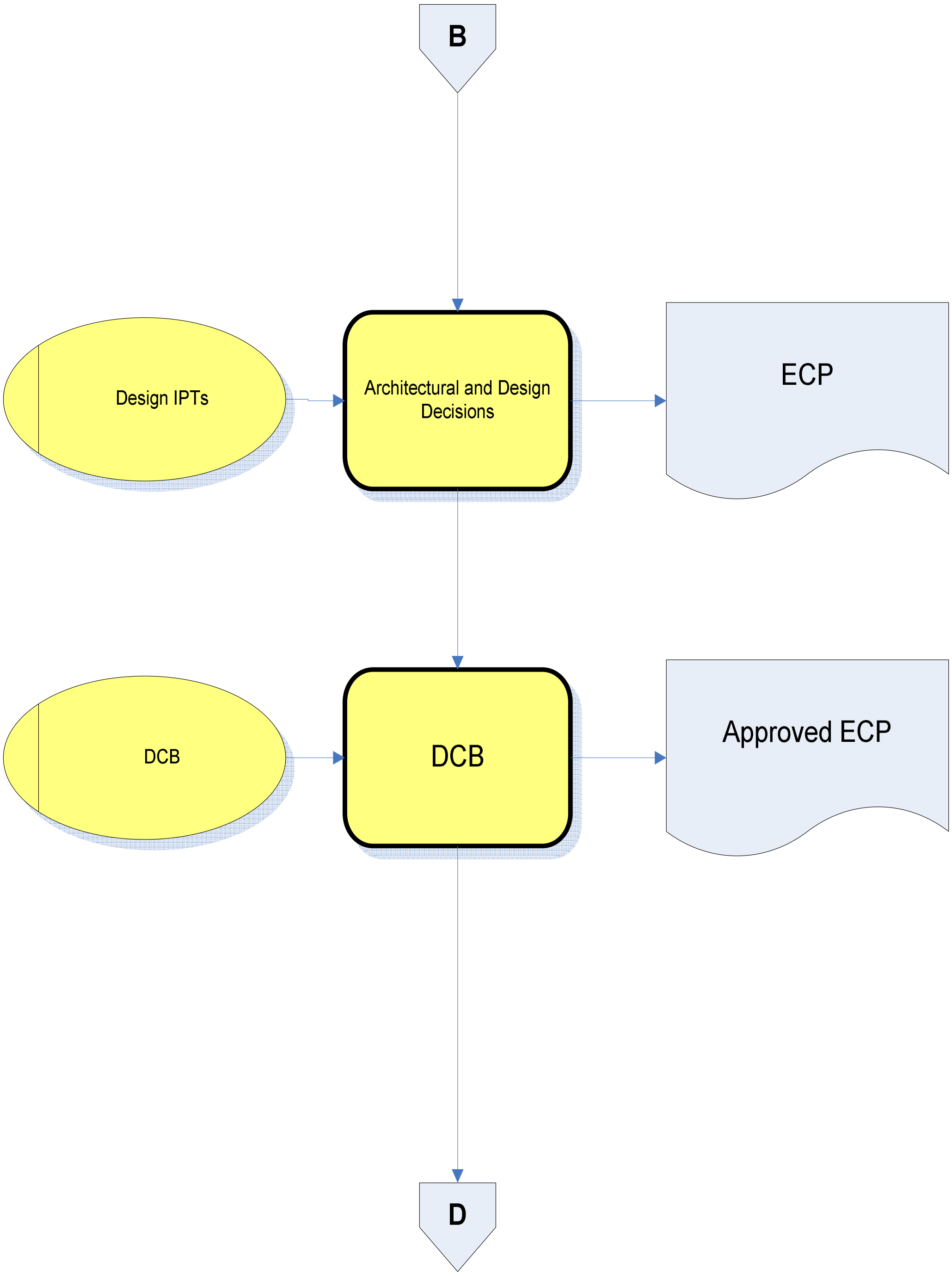

Figure 4 Requirements Analysis and Validation Process (As Documented) (Continued)

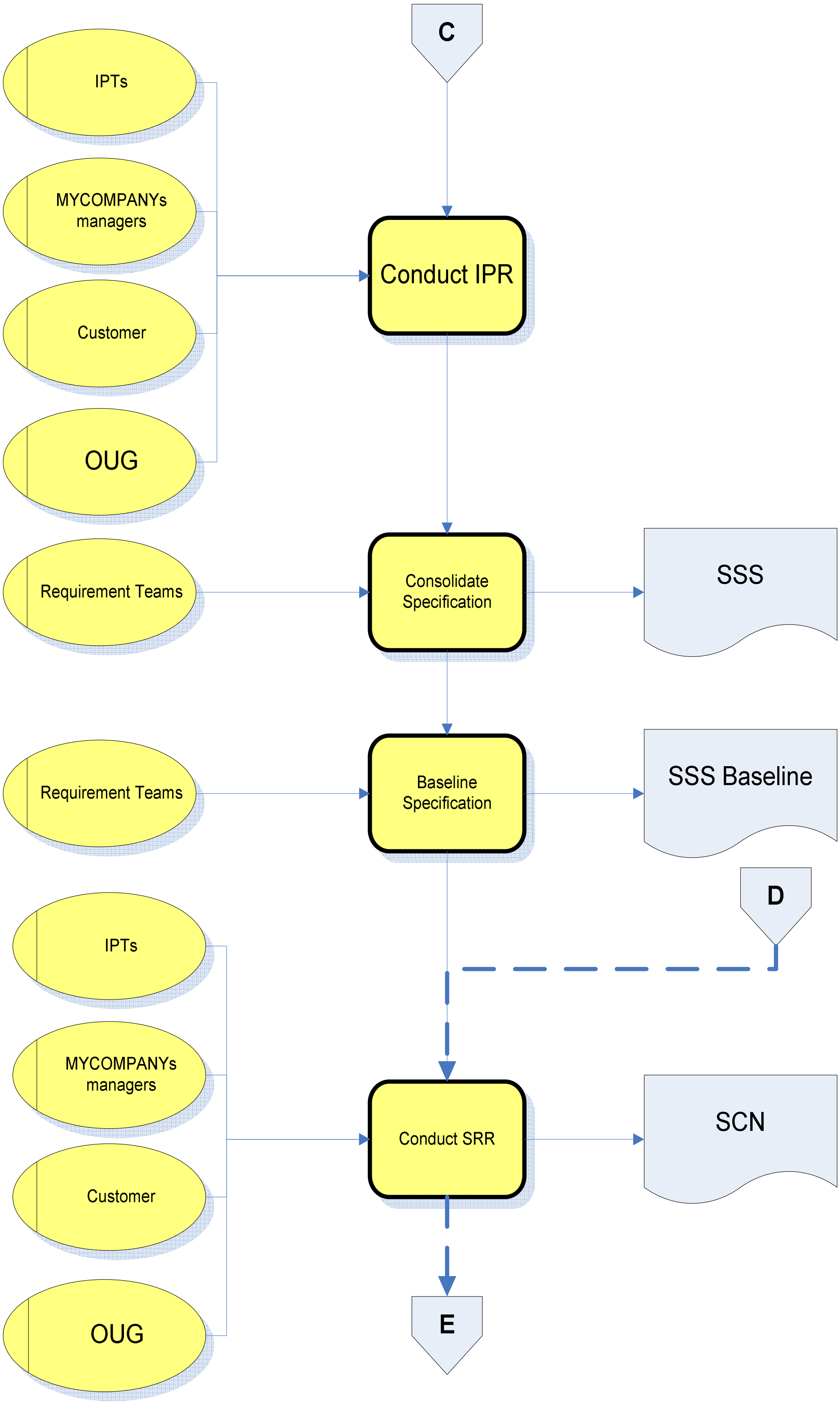

Figure 4 Requirements Analysis and Validation Process (As Documented) (Continued)

3.2.1.1.2. AS-IS Model of Requirements Analysis and Validation Process

The activities of the AS-IS model of the requirements analysis and validation process are described in Table 5 and the model is shown in Figure 5.

The fundamental differences between the As Documented and AS-IS processes are that:

- The activities that aim to identify system constraints and identify technical risks and dependencies from documented process are not made in AS-IS Model.

- The requirement implementation approach activity is not defined in as documented process. When this process was defined, the usage of the ERP tools was not planned. This activity is defined for ready to use package usage in AS-IS model.

- The activities that aim to customize the package is firstly defined in AS-IS model. Same as the previous item, this activity is defined for ready to use package.

- In as documented model, the design process is starting after the RRB. But in AS-IS model, the design process are included in the requirements analysis process. The design is done in document requirements and design activity.

- The IPR is not conducted in AS-IS model. Therefore, customer does not approve the requirements. This activity is excluded by the customer.

- Because of the un-approved requirements, the specifications are not formally defined as baseline. Therefore, the consolidated specifications are assumed as baseline.

- The SRR is not conducted in AS-IS model. The changes are applied to the system without the any approval.

Table 2 System Requirement Analysis and Validation Process (AS-IS Model)

REQUIREMENTS ANALYSIS AND VALIDATION PHASE (AS-IS)					
Act. No	Activity Name	Definition	Staff	Inputs	Outputs
1.	Site survey	The specific functional description for each functional area is provided from the customer and Operational User Group by the requirement teams.	Information Researchers	-	-
2.	Requirement Analysis	The requirements are analyzed using customer supplied source document like project contract, technical specification document.	Requirement Teams	Project Contract, Technical Specification Document etc.	-
3.	Develop OCD	The Operational Concept Document (OCD) is developed with respect to site survey, requirement analysis and Help Desk requests	Integrated Product Teams (IPT)	Site survey and Requirement Analysis Outputs, Help Desk Requests	OCD
4.	Identify Functional Requirements	The functional requirements are defined	Functional IPT	OCD	-
5.	Define System Interfaces	The conceptual system interfaces, which can be defined from OCD, are defined.	IPT	OCD	-
6.	Requirement Implementatio n Approach	How the requirements be implemented with ready-to-use package are defined. The requirements can be implemented by customize the package or by new development.	IPT	-	-

Table 5 System Requirement Analysis and Validation Process (AS-IS Model) (Continued)

7.	Customize the Package	The requirements are implemented by customizing the package.	Functional IPT	-	-
8.	Document Requirements & Design	The requirements are documented and the initial design decisions are taken.	IPT member	4th and 5th Activities' Outputs	Requirement & Design Document
9.	IPT Internal Review	The requirement documents are reviewed for functional accuracy, for consistency within IPT. This activity did not do for every requirement documents.	IPT Team or Lead	Requirement Document	Approved or Rejected Requirement Document
10.	Identified Redlines Needed	The corrections of the requirement document are described.	IPT Team or Lead	Requirement Document and IPT Internal Review Outputs	-
11.	RRB	RRB reviews the approved requirement documents by IPT. RRB reviews for appropriate level, for consistency across IPTs, for design-to-cost issues, for Common Service applicability and for architectural design impact. RRB verifies traceability and testability of the requirement.	RRB	Approved Requirement Documents by IPT	Approved Requirements
12.	Accumulate for each Functional Area	The requirements are accumulated for each functional area. The functional area's requirements are totally defined for each functional area.	Requirement Teams	Approved Requirements	Accumulated Requirement

Table 5 System Requirement Analysis and Validation Process (AS-IS Model) (Continued)

13.	Consolidate Specification	The requirements documents are consolidated and system/subsystem specifications are defined. These specifications are defined as baseline.	Requirement Teams	Approved Accumulated Requirements	System/ subsystem Specification (SSS) Document
14.	Coding Test Deployment	The system/subsystem are coded, tested and deployed with respect to SSS document.	Project Teams	-	-
15.	Support	After the system/subsystem is deployed to use, the user feedbacks are collecting using Help Desk tools. The Help desk requests are analyzed with OUG members and the defects or new requirements are send to IPTs. These requests are sent to coding process or to use as input of the OCD development	End User, OUG Members	-	Help Desk Requests

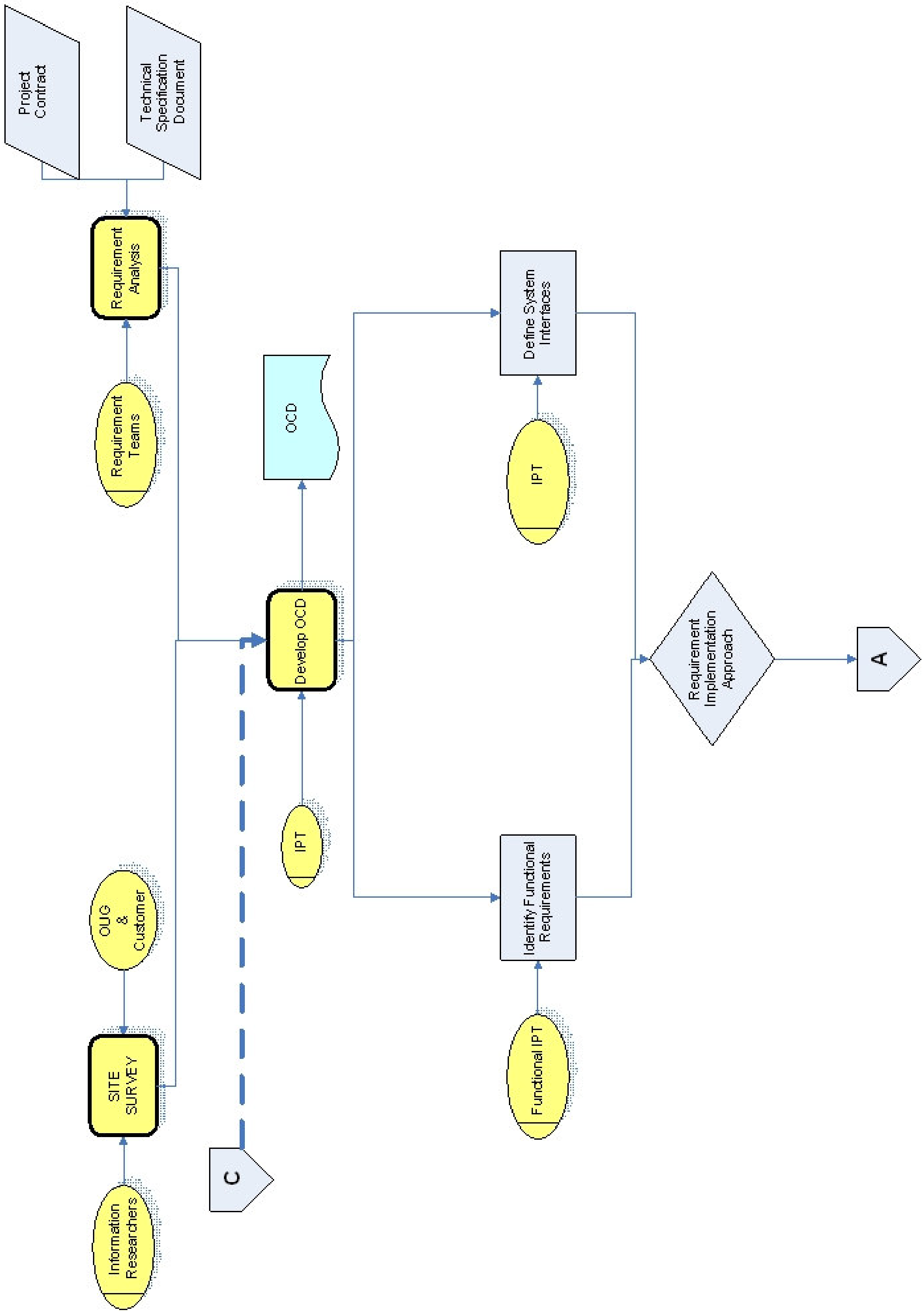

Figure 3 AS-IS Model of the Requirements Analysis and Validation Process

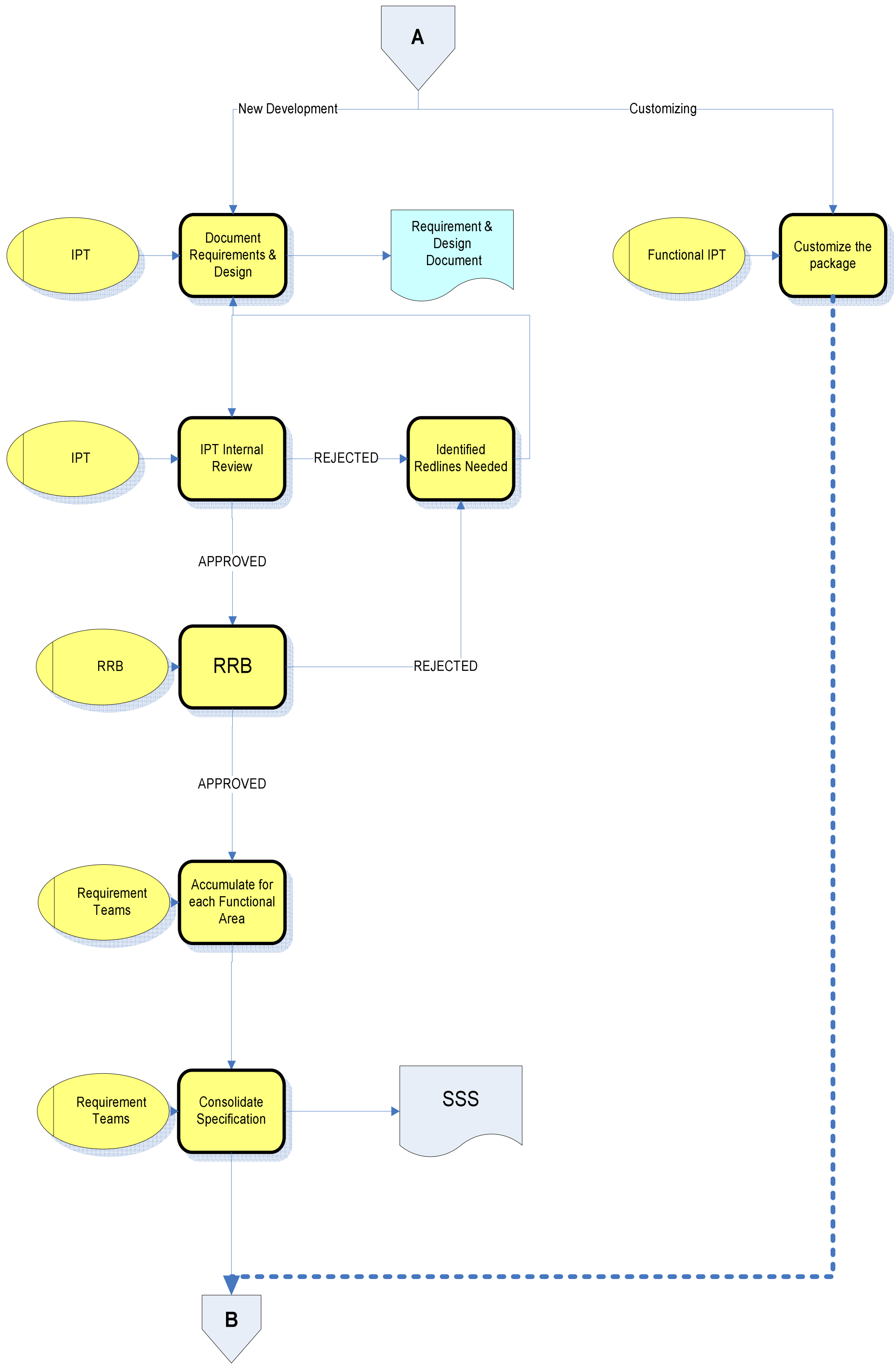

Figure 5 AS-IS Model of the Requirements Analysis and Validation Process (Continued)

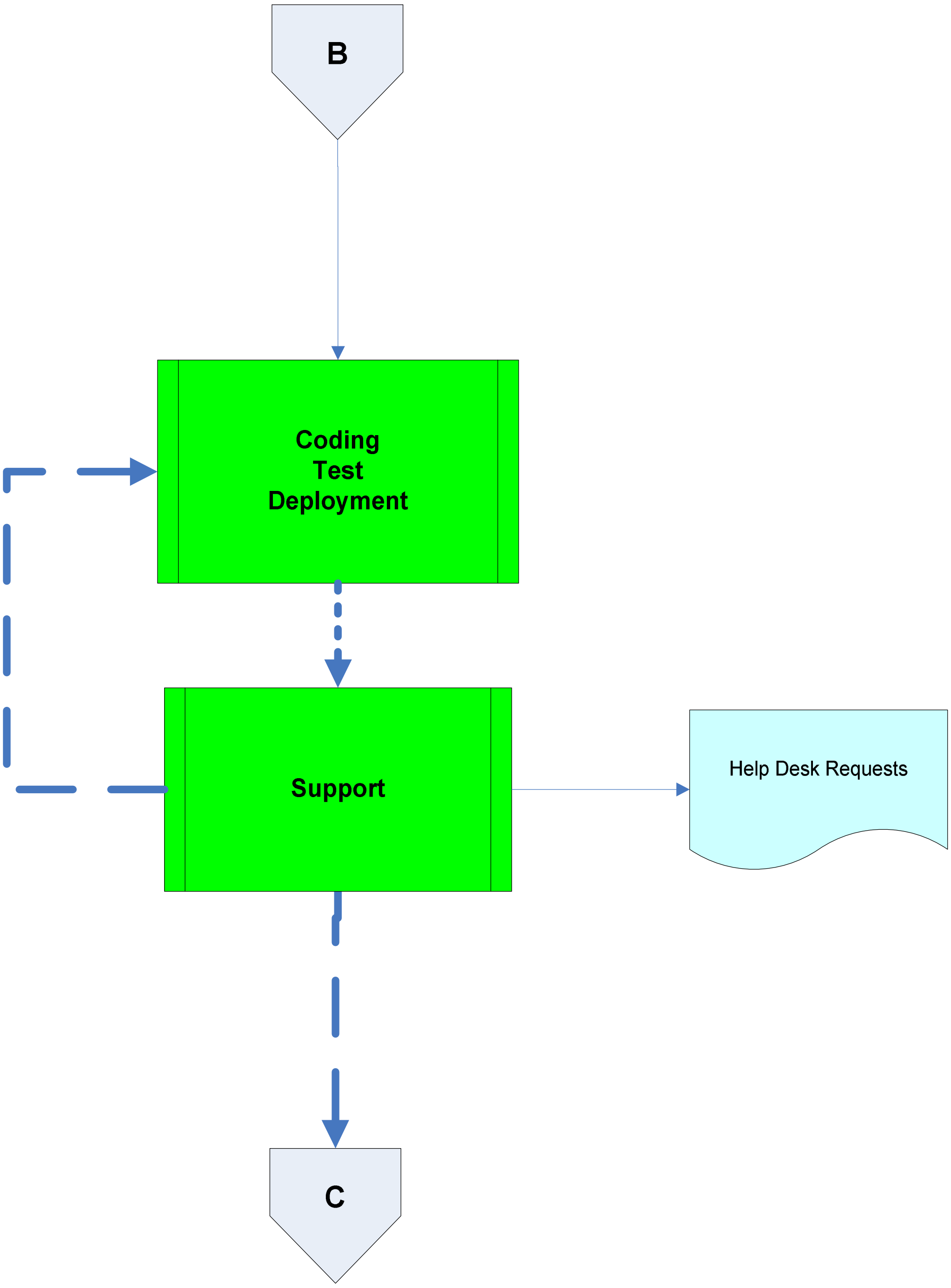

Figure 5 AS-IS Model of the Requirements Analysis and Validation Process (Continued)

3.2.1.2. Measurement of The Requirements Analysis and Validation Process of Project X

3.2.1.2.1. Measurement of The As Documented Model of The Requirements Analysis and Validation Process of Project X

Table 6 presents the measurements on the AS-IS Model of the Requirements Analysis and Validation process of Project X.

Table 3 The Measurement of The As Documented Model

Activity No	Maintainability		Reliability
	Analyzability		Fault Tolerance
	Complexity	Coupling	Failure Avoidance
1-7,10,12,14-15	No Decision	No interaction	No review, inspection, checkpoint or similar techniques
8	No Decision	No interaction	IPT internal review and RRB reviews the documented requirements
9	Unstructured decision for approving or refusing the requirement document. IPT team or lead uses information written in the document, information from other requirement documents and their judgment while taking a decision. It is a complex decision. It requires mostly human opinion.	No interaction	IPT team or lead reviews the requirement document prepared by IPT member. When they find mistakes in document, they identify redlines needed and IPT member corrects them
11	Unstructured decision for approving or refusing the requirement document. RRB members use information written in the document, information from other requirement documents and their judgment while taking a decision. It is a complex decision. It requires that RRB members must be dominated the whole functionality. it is mostly human opinion.	No interaction	RRB reviews the requirement document prepared by IPT member. When they find mistakes in document, they identify redlines needed and IPT member corrects them

Table 6 The Measurement of The As Documented Model (Continued)

Activity No	Maintainability		Reliability
	Analyzability		Fault Tolerance
	Complexity	Coupling	Failure Avoidance
13	Unstructured decision for approving or refusing the requirement document. IPR members use information written in the document, their functional knowledge and their judgment while taking a decision. It is a complex decision. It requires human opinion.	No interaction	IPR reviews the accumulated requirement document with respect to functional completeness
16	Semi-structured decision for changing or refusing ECPs. SRR member uses ECPs, SSS baseline, their functional and technical knowledge and their judgment. It is a complex decision. It requires human opinion.	Interaction with DCB activity of Design process	SRR reviews the SSS baseline using ECPs.

Table 6 The Measurement of The As Documented Model (Continued)

Activity No	Reliability		Functionality
	Recoverability		Suitability
	Restorability	Restoration Effectiveness	Functional Adequacy
1-2, 4-7,10, 13	Not Recorded	No Restoration	Adequate
3	Recorded in OCD	Restoration from OCD backup	Adequate
8	Recorded in Requirement Document	Restoration from Requirement Document	Adequate
9	Recorded in Approved/Rejected Requirement Document	Restoration from Requirement Document	Adequate

Table 6 The Measurement of The As Documented Model (Continued)

Activity No	Reliability		Functionality
	Recoverability		Suitability
	Restorability	Restoration Effectiveness	Functional Adequacy
11	Recorded in Approved/Rejected Requirement Document	Restoration from Requirement Document	Adequate
12	Recorded in Accumulated Requirement Documents	Restoration from Requirement Document	Adequate
14	Recorded in SSS	No Restoration	Adequate
15	Recorded in SSS Baseline	No Restoration	Adequate
16	Recorded in SCN	Restoration from ECPs and SCN documents	Adequate

Table 6 The Measurement of The As Documented Model (Continued)

Activity No	Functionality		
	Suitability	IT Based Functionality	
	Functional Completeness	IT Usage	IT Density
1-2,6-7,10	Complete	Not IT Usage	No forms, documents, archival records or other similar documents that are prepared, updated, deleted or searched
3,8-9,11-12,14	Complete	Not IT Usage	No forms, documents, archival records or other similar documents that are prepared, updated, deleted or searched by IT tools
4-5	Not Complete	Not IT Usage	No forms, documents, archival records or other similar documents that are prepared, updated, deleted or searched
13,15-16	Not Complete	Not IT Usage	No forms, documents, archival records or other similar documents that are prepared, updated, deleted or searched by IT tools

Table 6 The Measurement of The As Documented Model (Continued)

Activity No	Functionality	
	Accuracy	**Interoperability**
	Computational Accuracy	**Data Exchangeability**
1-3,6,10, 14-15	No specific accuracy requirement	No interaction
4	Accuracy Requirement: System IPT should be sure to check the overall system. This requirement is implemented in the activity.	No interaction
5	Accuracy Requirement: System IPT should be sure to check the overall system. This requirement is implemented in the activity.	No interaction
7	Accuracy Requirement: Functional IPT should be sure to define applicable interfaces. This requirement is not implemented in the activity.	No interaction
8	Accuracy Requirement: The previous activities outputs must be totally considered. This requirement is implemented in the activity. IPT member study with all outputs.	No interaction
9	Accuracy Requirement: The IPT team or lead should be sure the requirements not overloaded to other requirements which defined by this IPT. This requirement is implemented in the activity. IPT team or lead goes over the entire requirement document.	No interaction
11	Accuracy Requirement: The RRB members should be sure that the requirements meet the all functional requirements and reality of the customer. This requirement is implemented in the activity. The RRB members have special knowledge about the functionality.	No interaction
12	Accuracy Requirement: The Requirement team member should be sure to collect all requirements. This requirement is not implemented in the activity.	No interaction
13	Accuracy Requirement: The IPR members should be sure that requirement meets the functionality. This requirement is implemented in the activity. The functionally specified customer are the members of the IPR	No interaction
16	Accuracy Requirement: SRR members should be sure SCN does not affect the overall system. This requirement is implemented in the activity. The system IPTs are included the SRR.	Approved ECPs are received from DCB. The data in the ECPs are used without applying any changes in this activity.

Table 6 The Measurement of The As Documented Model (Continued)

Activity No	Functionality	Usability	
	Security	Understandability	Learnability
	Access Auditability	Functional Understandability	Existence in Documents
1	Access auditability Only specified researchers for specified functionality can collect the customer site data.	No difficulties or misunderstandings	Described
2	No access auditability Project Contract and Technical Specification Document can be accessible via project intranet.	No difficulties or misunderstandings	Described
3	No access There is no access to data	The concept and preparation of the OCD has some difficulties	Described
4-7,10	No access There is no access to data	No difficulties or misunderstandings	Described
8	No access There is no access to data	Preparation of the requirement document and definition of the parts of them has some difficulties	Described
9	Access auditability Only IPT review team access the requirement documents which will be reviewed	The review of the requirement document is very difficult.	Described
11	Access auditability Only RRB members access the requirement documents which will be reviewed	The review of the requirement document is very difficult.	Described
12	No access auditability the whole requirement documents are accessible via intranet or share folders.	To accumulate the whole requirement document are very difficult.	Described
13	No access auditability the whole requirement documents are accessible via intranet or share folders.	To compare the needed and implemented functionality are very difficult.	Described
14-15	No access auditability the whole requirement documents are accessible via intranet or share folders.	No difficulties or misunderstandings	Described

Table 6 The Measurement of The As Documented Model (Continued)

Activity No	Functionality	Usability	
	Security	Understandability	Learnability
	Access Auditability	Functional Understandability	Existence in Documents
16	Access auditability Only SRR members are access the approved ECPs. SSS baseline is accessible via intranet or share folders.	No difficulties or misunderstandings	Described

Table 6 The Measurement of The As Documented Model (Continued)

Activity No	Usability		
	Operability		Attractiveness
	Input Validity Checking	Undoability	Attractive Interaction
1	Input validity checking for customer site data with comparing OUG and customer's interviews	Not recorded	No interaction with forms, reports, archival records or similar other documents, only interviews
2	Input validity checking for Project Contract and Technical Specification Document are organized via functional topics	Not recorded	No interaction with forms, reports, archival records or similar other documents, only readings
3	No input validity checking The inputs are undocumented outputs of the previous activities	Recorded, undoability of preparing OCD	Attractive interaction in preparing OCD
4-7	No input validity checking The OCD is assumed to be true	Not recorded	No interaction with forms, reports, archival records or similar other documents
8	No input validity checking The inputs are undocumented outputs of the previous activities	Recorded, undoability of preparing Requirement Document	Attractive interaction in preparing Requirement document
9	The inputs are validated with respect to format and readiness.	Recorded, undoability of reviewing of the requirement document	Attractive interaction in reviewing Requirement Document
10	No input validity checking The inputs are undocumented outputs of the IPT review	Not recorded	No interaction with forms, reports, archival records or similar other documents

Table 6 The Measurement of The As Documented Model (Continued)

Activity No	Usability		
	Operability		Attractiveness
	Input Validity Checking	Undoability	Attractive Interaction
11-12	No input validity checking The inputs are reviewed requirement documents	Recorded, undoability of reviewing of the requirement document	Attractive interaction in reviewing Requirement Document
13-14	No input validity checking The inputs are reviewed and accumulated requirement documents	Not recorded	No interaction with forms, reports, archival records or similar other documents
15	No input validity checking The inputs are SSS	Not recorded	No interaction with forms, reports, archival records or similar other documents
16	No input validity checking The inputs are SSS baseline and approved ECPs.	Recorded, undoability of SCN document	No interaction with forms, reports, archival records or similar other documents

3.2.1.2.2. Measurement of The AS-IS Model of The Requirements Analysis and Validation Process of Project X

Table 7 presents the measurements on the AS-IS Model of the Requirements Analysis and Validation process of Project X.

Table 4 The Measurement of The AS-IS Model

Activity No	Maintainability		Reliability
	Analyzability		Fault Tolerance
	Complexity	Coupling	Failure Avoidance
1-2,4-5,8,10,12	No Decision	No interaction	No review, inspection, checkpoint or similar techniques
3	No Decision	Interaction with Support Process	No review, inspection, checkpoint or similar techniques
6	Unstructured decision for requirement implementation approach. The IPT member uses their judgment. It is not a complex decision. It requires mostly the system knowledge.	No interaction	No review, inspection, checkpoint or similar techniques
7	No Decision	No interaction	IPT internal review and RRB reviews the documented requirements
9	Unstructured decision for approving or refusing the requirement document. IPT team or lead uses information written in the document, information from other requirement documents and their judgment while taking a decision. It is a complex decision. It requires mostly human opinion.	No interaction	IPT team or lead reviews the requirement document prepared by IPT member. When they find mistakes in document, they identify redlines needed and IPT member corrects them
11	Unstructured decision for approving or refusing the requirement document. RRB members use information written in the document, information from other requirement documents and their judgment while taking a decision. It is a complex decision. It requires that RRB members must be dominated the whole functionality. It is mostly human opinion.	No interaction	RRB reviews the requirement document prepared by IPT member. When they find mistakes in document, they identify redlines needed and IPT member corrects them

Table 7 The Measurement of The AS-IS Model (Continued)

Activity No	Reliability		Functionality
	Recoverability		Suitability
	Restorability	Restoration Effectiveness	Functional Adequacy
1-2,3-4,10	Not Recorded	No Restoration	Adequate
3	Recorded in OCD	Restoration from OCD backup	Adequate
6,8	Not Recorded	No Restoration	Not Adequate
7	Recorded in Requirement & Design Document	Restoration from Requirement & Design Document	Adequate
9-11	Recorded in Approved/Rejected Requirement Document	Restoration from Requirement Document	Adequate
12	Recorded in SSS	No Restoration	Adequate

Table 7 The Measurement of The AS-IS Model (Continued)

Activity No	Functionality		
		IT Based Functionality	
	Functional Completeness	IT Usage	IT Density
1-2,4-6,8,10	Complete	Not IT Usage	No forms, documents, archival records or other similar documents that are prepared, updated, deleted or searched
3,7,9,11-12	Complete	Not IT Usage	No forms, documents, archival records or other similar documents that are prepared, updated, deleted or searched by IT tools

Table 7 The Measurement of The AS-IS Model (Continued)

Activity No	Functionality	
	Accuracy	Interoperability
	Computational Accuracy	Data Exchangeability
1-2,4,10,12	No specific accuracy requirement	No interaction
3	No specific accuracy requirement	The Help Desk Request is received from Support Process. The data in The Help Desk Request is used without applying any changes in this activity
5	Accuracy Requirement: Functional IPT should be sure to define applicable interfaces. This requirement is not implemented in the activity.	No interaction
6	Accuracy Requirement: Functional IPT should be sure can the requirement be implemented via customizing the package. This requirement is not implemented in the activity.	No interaction
7	Accuracy Requirement: The previous activities outputs must be totally considered. This requirement is implemented in the activity. IPT member study with all outputs.	No interaction
8	Accuracy Requirement: The Functional IPT should be sure not to disturb the previous customizing. This requirement is not implemented in the activity.	No interaction
9	Accuracy Requirement: The IPT team or lead should be sure the requirements not overloaded to other requirements which defined by this IPT. This requirement is implemented in the activity. IPT team or lead goes over the entire requirement document.	No interaction
11	Accuracy Requirement: The RRB members should be sure that the requirements meet the all functional requirements and reality of the customer. This requirement is implemented in the activity. The RRB members have special knowledge about the functionality.	No interaction

Table 7 The Measurement of The AS-IS Model (Continued)

Activity No	Functionality	Usability	
	Security	Understandability	Learnability
	Access Auditability	Functional Understandability	Existence in Documents
1	Access auditability Only specified researchers for specified functionality can collect the customer site data.	No difficulties or misunderstandings	Described
2	No access auditability Project Contract and Technical Specification Document can be accessible via project intranet.	No difficulties or misunderstandings	Described
3	No access There is no access to data	The concept and preparation of the OCD has some difficulties	Described
4	No access There is no access to data	No difficulties or misunderstandings	Described
5,7,10	No access There is no access to data	No difficulties or misunderstandings	Described
6	No access There is no access to data	No difficulties or misunderstandings	Not described
8	No access There is no access to data	Customizing of the package has some difficulties	Not described
9	Access auditability Only IPT review team access the requirement documents which will be reviewed	The review of the requirement document is very difficult.	Described
11	Access auditability Only RRB members access the requirement documents which will be reviewed	The review of the requirement document is very difficult.	Described
12	No access auditabilitythe whole requirement documents are accessible via intranet or share folders.	No difficulties or misunderstandings	Described

Table 7 The Measurement of The AS-IS Model (Continued)

Activity No	Usability		
	Operability		Attractiveness
	Input Validity Checking	Undoability	Attractive Interaction
1	Input validity checking for customer site data with comparing OUG and customer's interviews	Not recorded	No interaction with forms, reports, archival records or similar other documents, only interviews
2	Input validity checking for Project Contract and Technical Specification Document are organized via functional topics	Not recorded	No interaction with forms, reports, archival records or similar other documents, only readings
3	No input validity checking The inputs are undocumented outputs of the previous activities and the Help Desk Requests	Recorded, undoability of preparing OCD	Attractive interaction in preparing OCD
4-5	No input validity checking The OCD is assumed to be true	Not recorded	No interaction with forms, reports, archival records or similar other documents
6,8	No input validity checking The inputs are undocumented outputs of the previous activities	Not recorded	No interaction with forms, reports, archival records or similar other documents
7	No input validity checking The inputs are undocumented outputs of the previous activities	Recorded, undoability of preparing Requirement & Design Document	Attractive interaction in preparing Requirement & Design document
9	The inputs are validated with respect to format and readiness.	Recorded, undoability of reviewing of the requirement document	Attractive interaction in reviewing Requirement Document
10	No input validity checking The inputs are undocumented outputs of the IPT review	Not recorded	No interaction with forms, reports, archival records or similar other documents
11	No input validity checking The inputs are reviewed requirement documents	Recorded, undoability of reviewing of the requirement document	Attractive interaction in reviewing Requirement Document
12	No input validity checkingThe inputs are approved accumulated requirement documents	Not recorded	No interaction with forms, reports, archival records or similar other documents

CHAPTER 4

THE PROPOSED SOFTWARE REQUIREMENTS ANALYSIS AND VALIDATION PROCESS

4.1. Introduction

In this chapter, the proposed software requirement analysis and validation process will be defined. While making this proposal, the basic concepts of the software process improvement models and methodologies, briefly discussed in chapter 2, are used.

4.2. The TO-BE Software Requirement Analysis and Validation Process

While defining the TO-BE model, Selçuk Güceglioğlu's evaluation model's results are used and the problems, determined in the interviews, are studied.

The main improvements in the proposed process are that:

- The activities that aim to identify system constraints and identify technical risks and dependencies from documented process are not included into the TO-BE process. Because these activities are not applicable for Project X organization. The system and functional teams are divided in the Project X organization. The feedbacks of the system IPTs to the OCD take long times.
- The requirement implementation approach activity is not defined in

AS Documented process. When this process was defined, the usage of the ERP tools was not planned. This activity is defined for ready to use package usage. This activity is not changed.

- The output of the document requirements and design activity, requirement and design document is divided into requirement document and design document. Because in the coding process, this document is very complicated for programmers. The programmers just need the design decisions, not the requirements of the functionality.

- To customize the package activity in AS-IS process has no output. This activity is not documented. Like new developments, in TO-BE model, the customizing document and requirement document are defined as the output of this activity. Because according to interviews with the functional team members of the Project X, the customized packages are re-customized for different functionality and this re-customization can disturb the other functionality. When all the customization is documented, the undoability of the activity is decreased and the error rate of the re-customization can be increased.

- For the same reason as the previous item, the customizing of the package activities is inserted to the IPT internal review activity. After this change, the errors, caused by wrong customizing and re-customizing, can be prevented.

- The insert/change requirement in RDB activity, which is not defined in both AS-IS process and in documented process, is defined in TO-BE model. The RDB tool will be defined to automation of the requirement tracking. RDB is a tool for requirements tracking and management used to capture the requirements baselines at the systems and sub-systems levels. It is used to trace requirements to design components of the system. It can create reports to support document generation. When the requirements are approved by RRB, they are loaded into the RDB requirements database and controlled by RDB. RDB establishes two-way traceability and exposes that traceability whenever requirements changes occur or are proposed. In addition, RDB allows attributes to be affixed to individual requirements such that a requirements analyst can quickly determine the entire set of requirements affected by a change in a particular attribute.

- The conduct IPR activity, which is defined in documented process but not used in AS-IS model, is re-inserted into the TO-BE model. The requirements are approved with the customer and the baseline of the requirements can be defined. The differentiation of the new requirements and change request can be made with respect to this approval.

- The baseline specification activity, which is defined in documented process but not used in AS-IS model, is re-inserted into the TO-BE model. This activity is just for the documentation of approval. The SSS document, which is approved in IPR, is published as approved and as baseline.

The feedbacks of the support process are entered to the new activities before the input of the OCD. The aim of these activities is to differentiate the new requirements and the changes of the requirements.

The activities of the TO-BE model of the requirements analysis and validation process are described in Table 8 and the model is shown in Figure 6.

Table 5 Requirement Analysis and Validation Process (TO-BE Model)

REQUIREMENTS ANALYSIS AND VALIDATION PHASE (TO-BE)					
Activity No	Activity Name	Definition	Staff	Inputs	Outputs
1.	Site survey	The specific functional description for each functional area is provided from the customer and Operational User Group by the requirement teams.	Information Researchers	-	-
2.	Requirement Analysis	The requirements are analyzed using customer supplied source document like project contract, technical specification document.	Requirement Teams	Project Contract, Technical Specification Document etc.	-
3.	Develop OCD	The Operational Concept Document (OCD) is developed with respect to site survey, requirement analysis and analyzed Help Desk requests	Integrated Product Teams (IPT)	Site survey and Requirement Analysis Outputs, Analyzed Help Desk Requests	OCD
4.	Identify Functional Requirements	The functional requirements are defined	Functional IPT	OCD	-

Table 8 Requirement Analysis and Validation Process (TO-BE Model) (Continued)

5.	Define System Interfaces	The conceptual system interfaces, which can be defined from OCD, are defined.	IPT	OCD	-
6.	Requirement Implementation Approach	How the requirements be implemented with ready-to-use package are defined. The requirements can be implemented by customize the package or by new development.	IPT	-	-
7.	Document Requirements & Customize the Package	The requirements are documented. The initial customization of the package are done and documented.	Functional IPT	-	Customizing Document, Design Document
8.	Document Requirements & Design	The requirements are documented and the initial design decisions are taken.	IPT member	4th and 5th Activities' Outputs	Requirement Document, Design Document
9.	IPT Internal Review	The requirement documents are reviewed for functional accuracy, for consistency within IPT. This activity did not do for every requirement documents.	IPT Team or Lead	Requirement Document	Approved or Rejected Requirement Document

Table 8 Requirement Analysis and Validation Process (TO-BE Model) (Continued)

10.	Identified Redlines Needed	The corrections of the requirement document are described.	IPT Team or Lead	Requirement Document and IPT Internal Review Outputs	-
11.	RRB	RRB reviews the approved requirement documents by IPT. RRB reviews for appropriate level, for consistency across IPTs, for design-to-cost issues, for Common Service applicability and for architectural design impact. RRB verifies traceability and testability of the requirement.	RRB	Approved Requirement Documents by IPT	Approved Requirements
12.	Insert/Change Requirement in RDB[1]	The requirements are inserted into Requirement DataBase or previously identified requirements are changed. The changes can be traced by RDB.	Requirement Teams	Approved Requirements	RDB

Table 8 Requirement Analysis and Validation Process (TO-BE Model) (Continued)

13.	Accumulate for each Functional Area	The requirements are accumulated for each functional area. The functional area's requirements are totally defined for each functional area.	Requirement Teams	Approved Requirements	Accumulated Requirement
14.	Conduct IPR	The requirements are reviewed and discussed with customer needs. Any comments that cause a change to the requirements will be documented and will be incorporated by the responsible IPT prior to the release of version 1.0 of the System Specification.	IPTs, MYCOMPANY's managers	Accumulated Requirements	Approved Accumulated Requirements
15.	Consolidate Specification	The requirements documents are consolidated and system/subsystem specifications are defined. These specifications are defined as baseline.	Requirement Teams	Approved Accumulated Requirements	System/ subsystem Specification (SSS) Document

Table 8 Requirement Analysis and Validation Process (TO-BE Model) (Continued)

16.	Baseline Specification	The SSS documents are defined as baseline of the specification. The changes are required change requests and documented for Configuration Management.	Requirement Teams	SSS	SSS Baseline
17.	Coding Test Deployment	The system/subsystem are coded, tested and deployed with respect to SSS document.	Project Teams	-	-
18.	Support	After the system/subsystem is deployed to use, the user feedbacks are collecting using Help Desk tools. The Help desk requests are analyzed with OUG members and the defects or new requirements are send to IPTs. These requests are sent to coding process or to use as input of the OCD development	End User, OUG Members	-	Help Desk Requests

Table 8 Requirement Analysis and Validation Process (TO-BE Model) (Continued)

19.	Can requests be applicable to system?	The OUG analyze whether the help desk requests can be applicable to system or not. If the request is not applicable, the OUG reject the request.	OUG	Help Desk Request	-
20.	Is the Request new requirement or change request	The OUG analyze the help desk request whether it is a new requirement or it is a requirement change request. To find the requirement, the RDB tool is used.	OUG	Help Desk Request	-
21.	Change specification	The specification changes are requested by the help desk request. The RDB change request (RDBCR) documents are prepared for RDB record, which in RDB record identifier.	Requirement Teams	RDB Record Identifier	RDBCR
22.	Insert request to RDB	The RDBCR are inserted to the RDB. The requirement can be analyzed using RDB.	Requirement Teams	RDBCR	RDB

Table 8 Requirement Analysis and Validation Process (TO-BE Model) (Continued)

23.	New Requirement	If the help desk request includes the new requirements, The OUG prepares the New Requirement Request document.	OUG	Help Desk Request	NRR

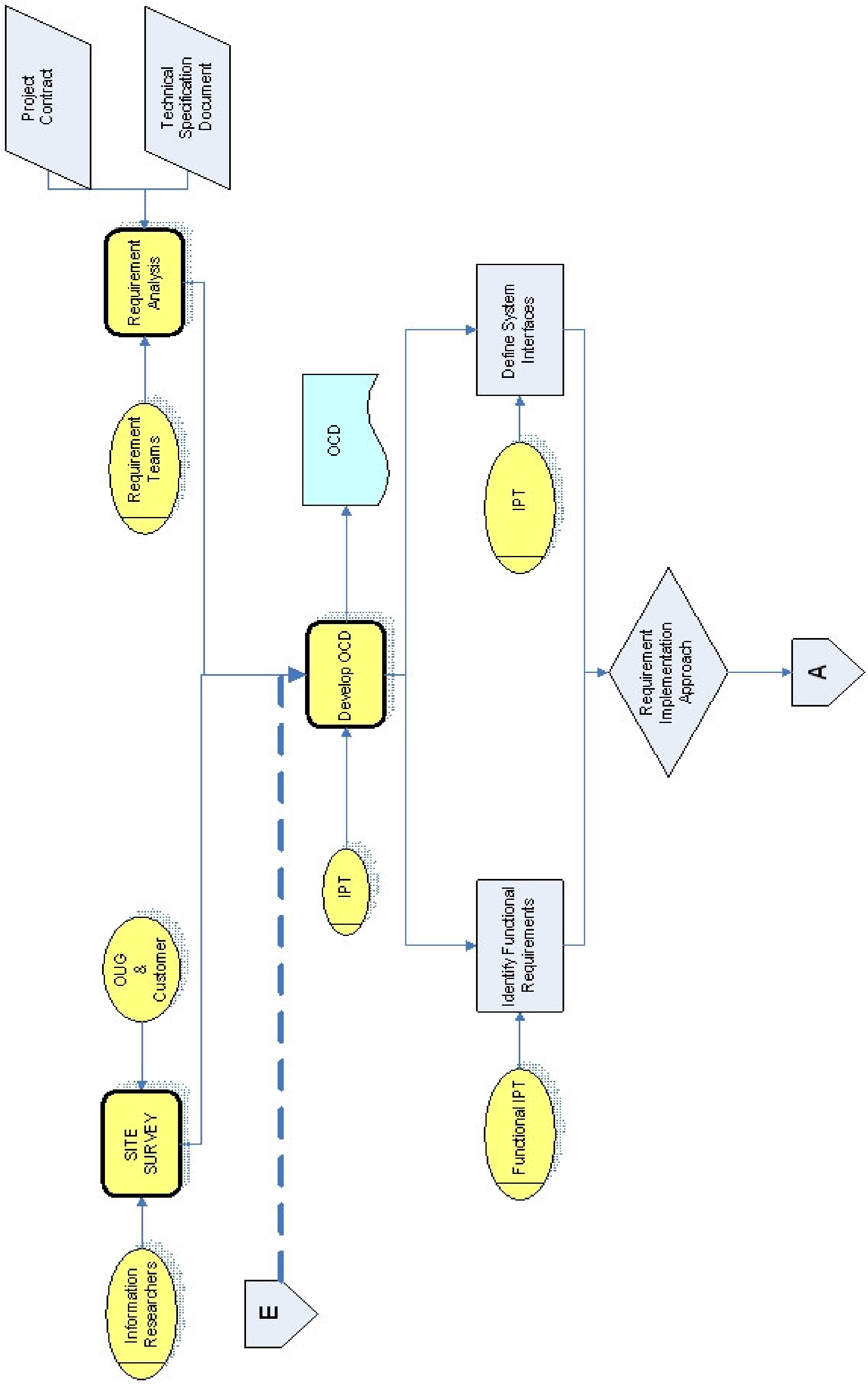

Figure 4 TO-BE Model of the Requirements Analysis and Validation Process

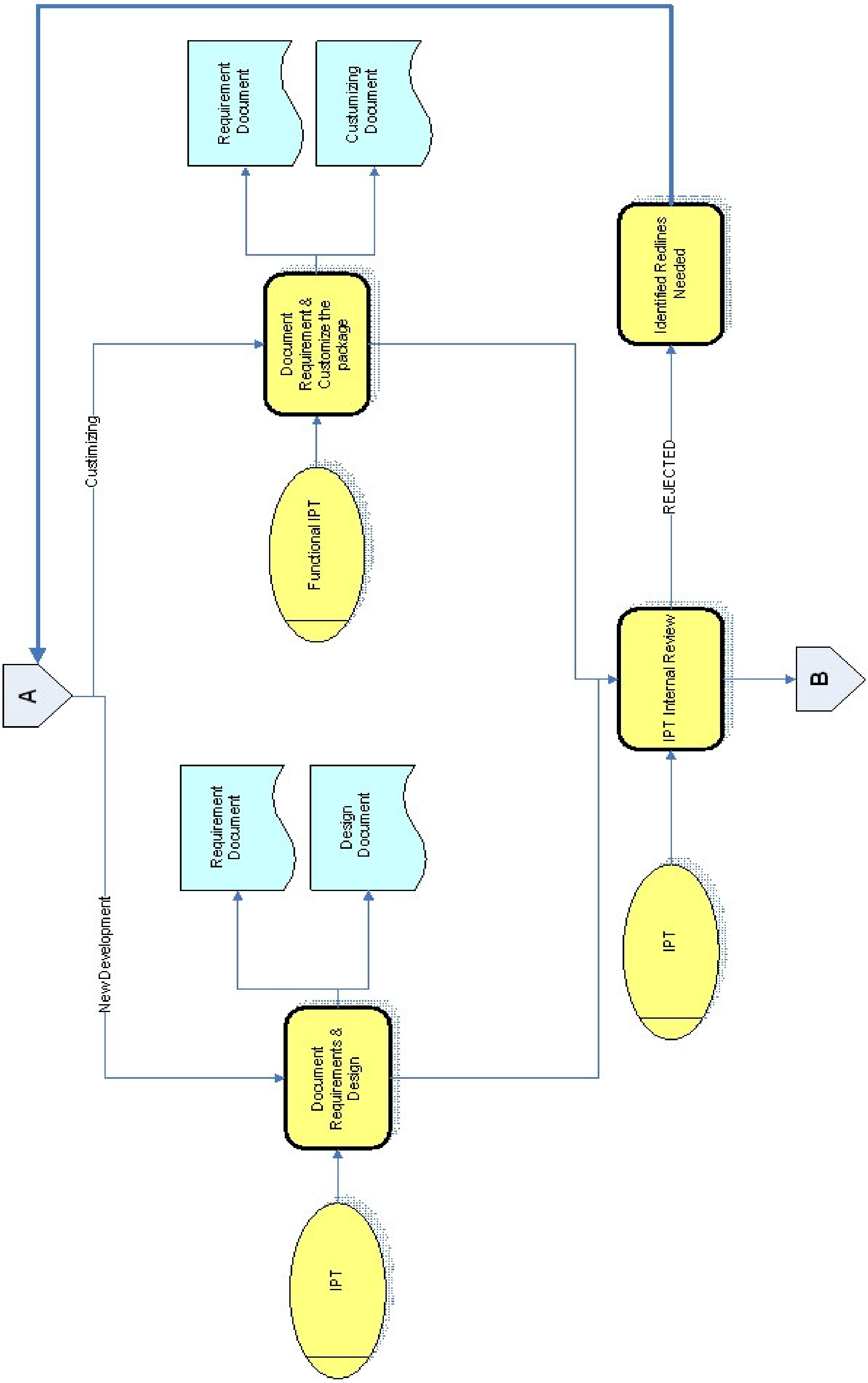

Figure 6 TO-BE Model of the Requirements Analysis and Validation Process (Continued)

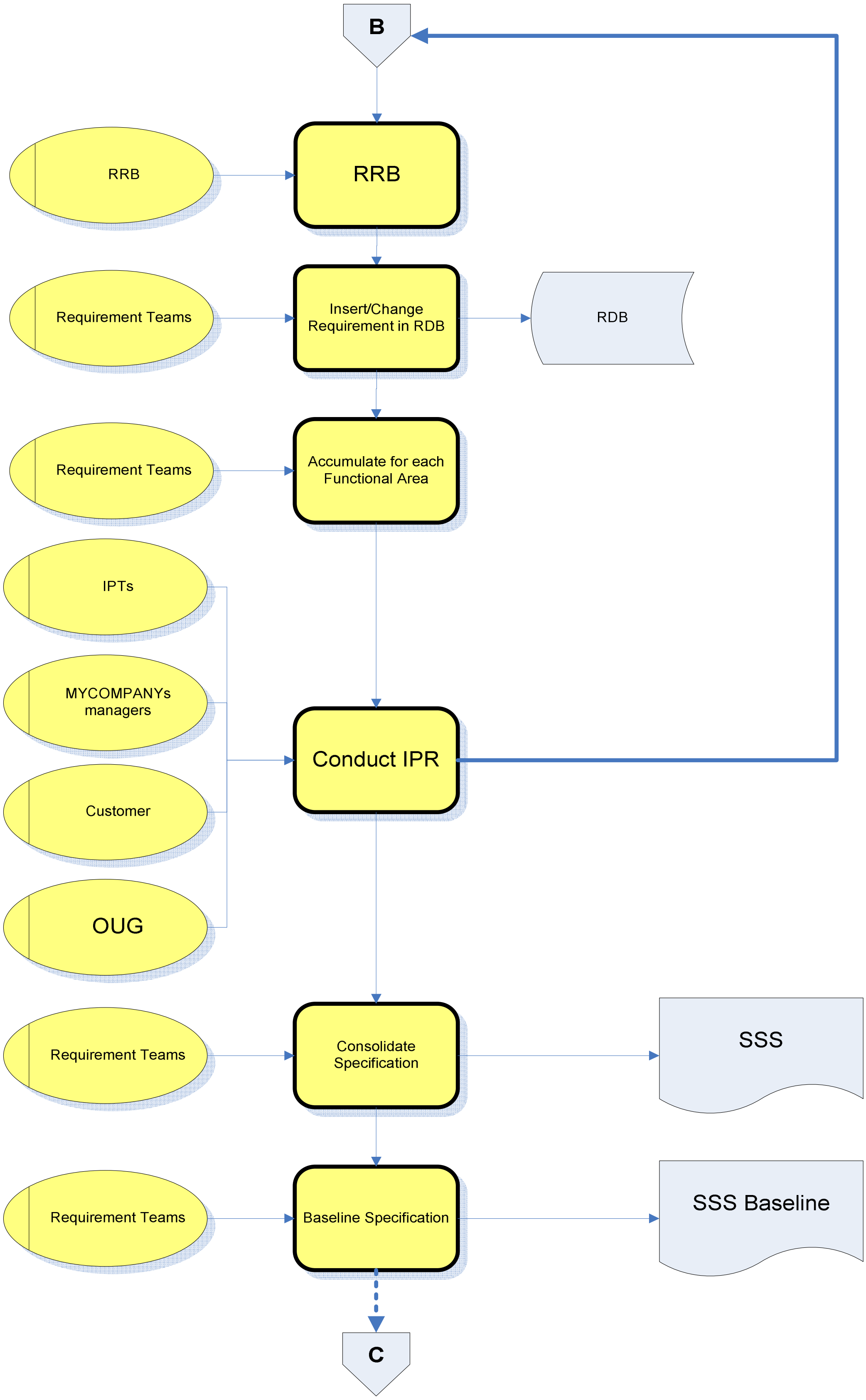

Figure 6 TO-BE Model of the Requirements Analysis and Validation Process (Continued)

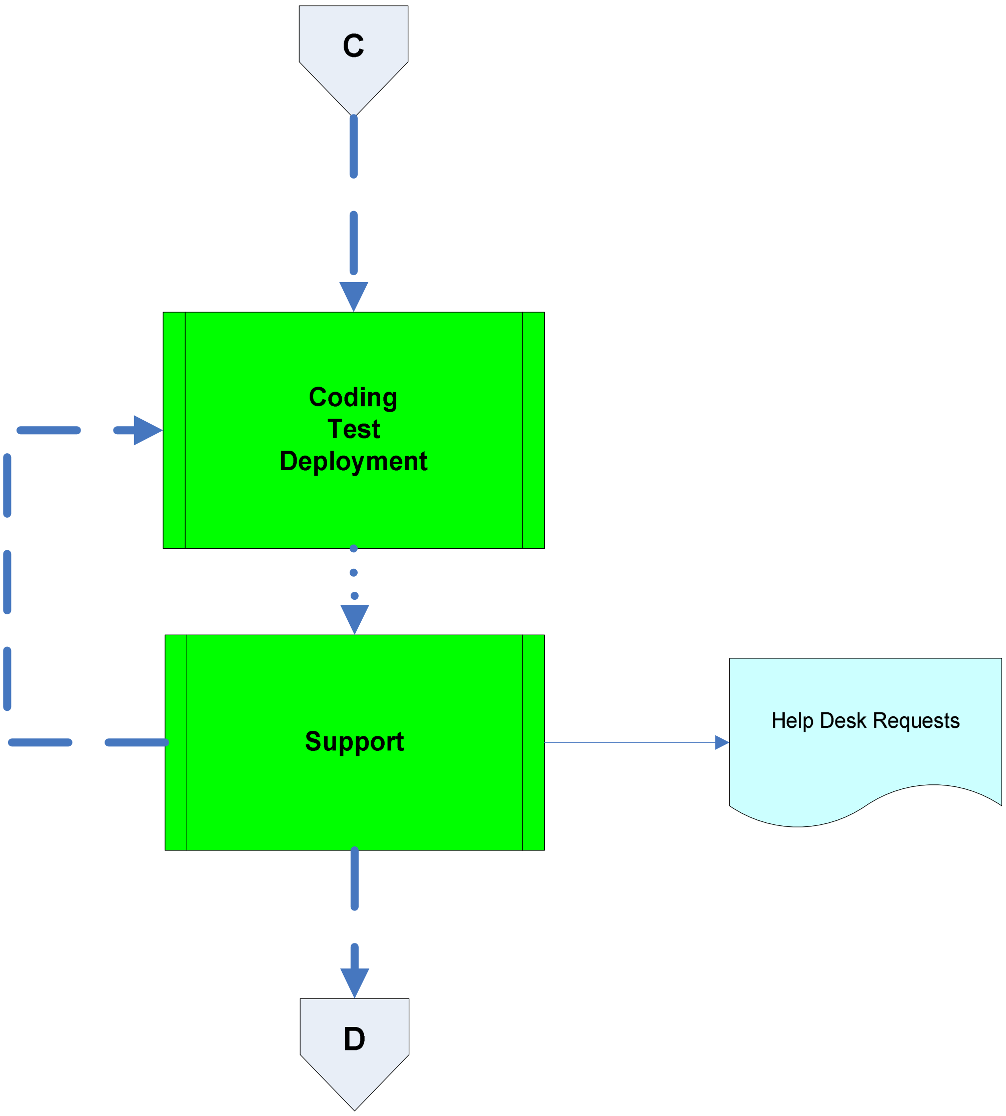

Figure 6 TO-BE Model of the Requirements Analysis and Validation Process (Continued)

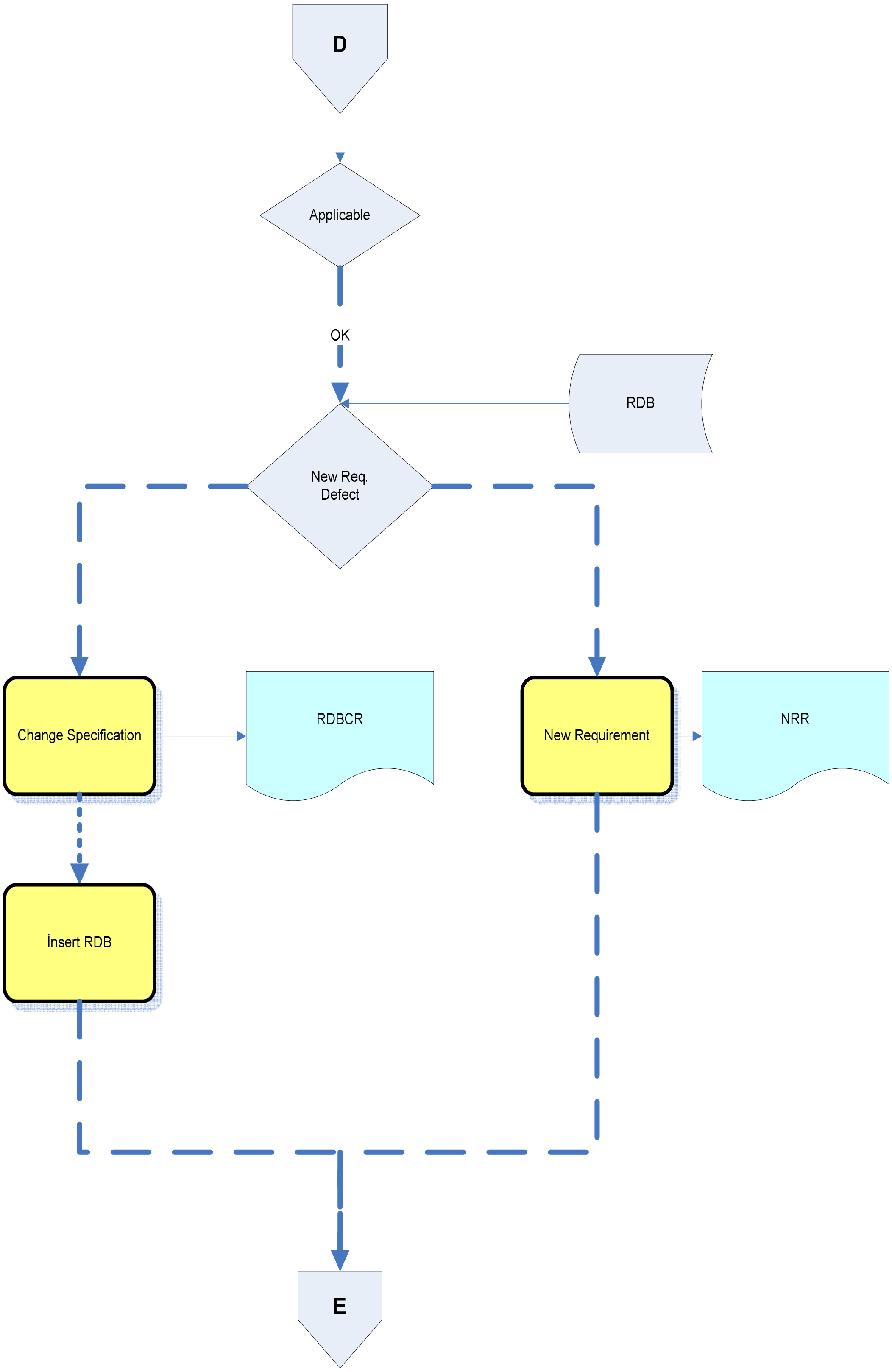

Figure 6 TO-BE Model of the Requirements Analysis and Validation Process (Continued)

4.2.1. Measurement of The TO-BE Model of The Requirements Analysis and Validation Process of Project X

Table 9 presents the measurements on the TO-BE Model of the Requirements Analysis and Validation process of Project X.

Table 6 The Measurement of The TO-BE Model

Activity No	Maintainability		Reliability
	Analyzability		Fault Tolerance
	Complexity	Coupling	Failure Avoidance
1-2,4-5,11-12,14-15,18-20	No Decision	No interaction	No review, inspection, checkpoint or similar techniques
3	No Decision	Interaction with Support Process	No review, inspection, checkpoint or similar techniques
6	Unstructured decision for requirement implementation approach. The IPT member uses their judgment. It is not a complex decision. It requires mostly the system knowledge.	No interaction	No review, inspection, checkpoint or similar techniques
7	No Decision	No interaction	IPT internal review and RRB reviews the documented requirements
8	No Decision	No interaction	IPT internal review and RRB reviews the documented requirements
9	Unstructured decision for approving or refusing the requirement document. IPT team or lead uses information written in the document, information from other requirement documents and their judgment while taking a decision. It is a complex decision. It requires mostly human opinion.	No interaction	IPT team or lead reviews the requirement document prepared by IPT member. When they find mistakes in document, they identify redlines needed and IPT member corrects them

Table 9 The Measurement of The TO-BE Model (Continued)

Activity No	Maintainability		Reliability
	Analyzability		Fault Tolerance
	Complexity	Coupling	Failure Avoidance
10	Unstructured decision for approving or refusing the requirement document. RRB members use information written in the document, information from other requirement documents and their judgment while taking a decision. It is a complex decision. It requires that RRB members must be dominated the whole functionality. It is mostly human opinion.	No interaction	RRB reviews the requirement document prepared by IPT member. When they find mistakes in document, they identify redlines needed and IPT member corrects them
13	Unstructured decision for approving or refusing the requirement document. IPR members use information written in the document, their functional knowledge and their judgment while taking a decision. It is a complex decision. It requires human opinion.	No interaction	IPR reviews the accumulated requirement document with respect to functional completeness
16	Unstructured decision for deciding the help desk request is applicable or not. OUG members use information in help desk requests and system/functional knowledge. It is not a complex decision.	No interaction	No review, inspection, checkpoint or similar techniques
17	Structured decision for deciding the help desk request is new requirement or change request. The OUG members uses RDB, help desk requests and system/functional knowledge. It is not complex decision.	No interaction	No review, inspection, checkpoint or similar techniques

Table 9 The Measurement of The TO-BE Model (Continued)

Activity No	Reliability		Functionality
	Recoverability		Suitability
	Restorability	Restoration Effectiveness	Functional Adequacy
1-2,4-6,12-13,16-17	Not Recorded	No Restoration	Adequate
3	Recorded in OCD	Restoration from OCD backup	Adequate
7	Recorded in Requirement Document & Design Document	Restoration from Requirement Document & Design Document	Adequate
8	Recorded in Requirement Document & Customizing Document	No Restoration	Adequate
9-10	Recorded in Approved/Rejected Requirement Document	Restoration from Requirement Document	Adequate
11	Recorded in RDB	Restoration from RDB backups	Adequate
14	Recorded in SSS	No Restoration	Adequate
15	Recorded in SSS Baseline	No Restoration	Adequate
18	Recorded in RDBCR	No Restoration	Adequate
19	Not Recorded	Restoration from RDB backups	Adequate
20	Recorded in NRR	No Restoration	Adequate

Table 9 The Measurement of The TO-BE Model (Continued)

Activity No	Functionality		
	Suitability	IT Based Functionality	
	Functional Completeness	IT Usage	IT Density
1,2,4-6,8,12,16	Complete	Not IT Usage	No forms, documents, archival records or other similar documents that are prepared, updated, deleted or searched
3,7,9-10,14	Complete	Not IT Usage	No forms, documents, archival records or other similar documents that are prepared, updated, deleted or searched by IT tools
11	Not Complete	IT Usage in inserting / changing requirement in RDB	The requirement data and archival records are prepared, updated, deleted and searched by IT tools.
12	Complete	Not IT Usage	No forms, documents, archival records or other similar documents that are prepared, updated, deleted or searched
13,15,18,20	Not Complete	Not IT Usage	No forms, documents, archival records or other similar documents that are prepared, updated, deleted or searched by IT tools
17	Not Complete	IT Usage in searching requirement in RDB	The requirement data are searched by IT tools.
19	Not Complete	IT Usage in changing requirement in RDB	The requirement data are changed by IT tools.

Table 9 The Measurement of The TO-BE Model (Continued)

Activity No	Functionality	Functionality
	Accuracy	Interoperability
	Computational Accuracy	Data Exchangeability
1-2,4,12, 14-17,	No specific accuracy requirement	No interaction
3	No specific accuracy requirement	The Help Desk Request is received from Support Process. The data in The Help Desk Request is used without applying any changes in this activity
5	Accuracy Requirement: Functional IPT should be sure to define applicable interfaces. This requirement is not implemented in the activity.	No interaction
6	Accuracy Requirement: Functional IPT should be sure can the requirement be implemented via customizing the package. This requirement is not implemented in the activity.	No interaction
7	Accuracy Requirement: The previous activities outputs must be totally considered. This requirement is implemented in the activity. IPT member study with all outputs.	No interaction
8	Accuracy Requirement: The Functional IPT should be sure not to disturb the previous customizing. This requirement is implemented in the activity. The Functional IPT trace customizing document for previous customizing.	No interaction
9	Accuracy Requirement: The IPT team or lead should be sure the requirements not overloaded to other requirements which defined by this IPT. This requirement is implemented in the activity. IPT team or lead goes over the entire requirement document.	No interaction
10	Accuracy Requirement: The RRB members should be sure that the requirements meet the all functional requirements and reality of the customer. This requirement is implemented in the activity. The RRB members have special knowledge about the functionality.	No interaction

Table 9 The Measurement of The TO-BE Model (Continued)

Activity No	Functionality	Functionality
	Accuracy	Interoperability
	Computational Accuracy	Data Exchangeability
11	Accuracy Requirement: The Requirement teams should be sure to insert correct data in correct form. This requirement is implemented in the activity. The RDB tool just accepts the correct formatted entries.	No interaction
13	Accuracy Requirement: The IPR members should be sure that requirement meets the functionality. This requirement is implemented in the activity. The functionally specified customer are the members of the IPR	No interaction
18	Accuracy Requirement: The Requirement teams should be sure the requirement record in RDB to change. This requirement is implemented in the activity. Previous activity send the RDB record identifier	No interaction
19	Accuracy Requirement: The Requirement teams should be sure to insert correct data in correct form. This requirement is implemented in the activity. The RDB tool just accepts the correct formatted entries.	No interaction
20	Accuracy Requirement: The Requirement teams should be sure to correctly and completely define new requirement request	No interaction

Table 9 The Measurement of The TO-BE Model (Continued)

Activity No	Functionality	Usability	
	Security	Understandability	Learnability
	Access Auditability	Functional Understandability	Existence in Documents
1	Access auditability Only specified researchers for specified functionality can collect the customer site data.	No difficulties or misunderstandings	Described
2	No access auditability Project Contract and Technical Specification Document can be accessible via project intranet.	No difficulties or misunderstandings	Described
3	No access There is no access to data	The concept and preparation of the OCD has some difficulties	Described
4-6,12,18,20	No access There is no access to data	No difficulties or misunderstandings	Described
7	No access There is no access to data	Preparation of the requirement Document & Design document has some difficulties	Described
8	No access There is no access to data	Customizing of the package has some difficulties	Not described
9	Access auditability Only IPT review team access the requirement documents which will be reviewed	The review of the requirement document is very difficult.	Described
10	Access auditability Only RRB members access the requirement documents which will be reviewed	The review of the requirement document is very difficult.	Described
11	Access auditability Only authorized requirement team members access the RDB tool database	No difficulties or misunderstandings	Not described
13	No access auditability the whole requirement documents are accessible via intranet or share folders.	To compare the needed and implemented functionality are very difficult.	Described
14-15	No access auditability the whole requirement documents are accessible via intranet or share folders.	No difficulties or misunderstandings	Described
16	Access auditability Just specified OUG members access the Help desk request to analyze.	No difficulties or misunderstandings	Not described

Table 9 The Measurement of The TO-BE Model (Continued)

Activity No	Functionality	Usability	
	Security	Understandability	Learnability
	Access Auditability	Functional Understandability	Existence in Documents
17	Access auditability Just specified OUG members access the Help desk request to analyze and access the RDB.	No difficulties or misunderstandings	Not described
19	Access auditability Only authorized requirement team members access the RDB tool database	No difficulties or misunderstandings	Not described

Table 9 The Measurement of The TO-BE Model (Continued)

Activity No	Usability		
	Operability		Attractiveness
	Input Validity Checking	Undoability	Attractive Interaction
1	Input validity checking for customer site data with comparing OUG and customer's interviews	Not recorded	No interaction with forms, reports, archival records or similar other documents, only interviews
2	Input validity checking for Project Contract and Technical Specification Document are organized via functional topics	Not recorded	No interaction with forms, reports, archival records or similar other documents, only readings
3	No input validity checking The inputs are undocumented outputs of the previous activities and the Help Desk Requests	Recorded, undoability of preparing OCD	Attractive interaction in preparing OCD
4-5	No input validity checking The OCD is assumed to be true	Not recorded	No interaction with forms, reports, archival records or similar other documents
6	No input validity checking The inputs are undocumented outputs of the previous activities	Not recorded	No interaction with forms, reports, archival records or similar other documents

Table 9 The Measurement of The TO-BE Model (Continued)

Activity No	Usability		
	Operability		Attractiveness
	Input Validity Checking	Undoability	Attractive Interaction
7	No input validity checking The inputs are undocumented outputs of the previous activities	Recorded, undoability of preparing Requirement Document & Design Document	Attractive interaction in preparing Requirement Document & Design document
8	No input validity checking The inputs are undocumented outputs of the previous activities	Not recorded	Attractive interaction in preparing Requirement Document & Customizing document
9	The inputs are validated with respect to format and readiness.	Recorded, undoability of reviewing of the requirement document	Attractive interaction in reviewing Requirement Document
10	No input validity checking The inputs are reviewed requirement documents	Recorded, undoability of reviewing of the requirement document	Attractive interaction in reviewing Requirement Document
11	Input validity checking The RDB tool validate the input format.	Recorded, undoability of the database record	Attractive interaction in inserting / changing RDB
12	No input validity checking The inputs are undocumented outputs of the IPT review	Not recorded	No interaction with forms, reports, archival records or similar other documents
13	No input validity checking The inputs are reviewed and accumulated requirement documents	Not recorded	No interaction with forms, reports, archival records or similar other documents
14	No input validity checking The inputs are approved accumulated requirement documents	Not recorded	No interaction with forms, reports, archival records or similar other documents
15	No input validity checking The inputs are SSS	Not recorded	No interaction with forms, reports, archival records or similar other documents
16	No input validity checking The inputs are Help Desk Requests	Not recorded	No interaction with forms, reports, archival records or similar other documents

Table 9 The Measurement of The TO-BE Model (Continued)

Activity No	Usability		
	Operability		Attractiveness
	Input Validity Checking	Undoability	Attractive Interaction
17	No input validity checking The inputs are Help Desk Requests	Not recorded	No interaction with forms, reports, archival records or similar other documents
18	No input validity checking The inputs are RDB record identifier	Not recorded	Attractive interaction in preparing RDBCR
19	Input validity checking The RDB tool validate the input format.	Not recorded	Attractive interaction in changing RDB
20	No input validity checking The inputs are undocumented outputs of the previous activities	Not recorded	Attractive interaction in preparing NRR

CHAPTER 5

THE EVALUATION OF THE PROPOSED REQUIREMENTS ANALYSIS AND VALIDATION PROCESS

5.1. Introduction

In this chapter, measurement results of the AS-IS and TO-BE process models will be analyzed.

The effort spent for modeling the processes and measuring and analyzing the models have taken 54 person-days. In detail:

- 27 person-days for collecting required information and project documentation,
- 5 person-days for defining the improvements,
- 10 person-days for modeling the process,
- 6 person-days for measurement of the models,
- 6 person-days for analyzing and documenting the measurement results,

As shown in detailed schedule, just 11% of the whole work is used for measurement.

5.2. The Model's Measurement Results

Table 10 presents the quantitative measurement values.

Table 7 The Model's Measurement Results

Process Name			As Documented	AS-IS	TO-BE
Maintainability	Analyzability	Complexity	X(1)=0	X(1)=0	X(1)=1/20
			X(2)=3/16	X(2)=3/12	X(2)=5/20
			X(3)=1/16	X(3)=0	X(3)=0
		Coupling	X=1/16	X=1/12	X=1/20
Reliability	Fault Tolerance	Failure Avoidance	X=5/16	X=3/12	X=5/20
	Recoverability	Restorability	X=8/16	X=5/12	X=10/20
		Restoration Effectiveness	X=6/16	X=4/12	X=6/20
Functionality	Suitability	Functional Adequacy	X=16/16	X=10/12	X=20/20
		Functional Completeness	X=16/16	X=11/12	X=16/20
	IT Based Functionality	IT Usage	X=0	X=0	X=3/20
		IT Density	X=0	X=0	X=3/20
	Accuracy	Computational Accuracy	X=7/9	X=3/6	X=9/11
	Interoperability	Data Exchangeability	X=1/1	X=1/1	X=1/1
	Security	Access Auditability	X=4/9	X=3/4	X=9/11
Usability	Understandability	Functional Understandability	X=9/16	X=7/12	X=14/20
	Learnability	Existence in Documents	X=16/16	X=10/12	X=20/20
	Operability	Input Validity Checking	X=3/16	X=3/12	X=5/20
		Undoability	X=3/16	X=4/12	X=5/20
	Attractiveness	Attractive Interaction	X=5/16	X=4/12	X=9/20

5.3. Analysis of the Model's Measurement Results

- **Complexity:** For better analyzability, the measurement results should be lower. TO-BE model has more decision points. According to Güceğlioğlu's models, the high number of decision points makes analyzability of the process difficult. The increase in the number of decision points adds new branches to the process, which results in higher complexity and consequently reduced analyzability. In the project considered in this study, many decisions have a character that does not increase process complexity.

- **Coupling:** In this study, the scope is limited only to the requirement analysis and validation subprocess and as such, there are no complex interactions.

- **Failure Avoidance:** TO-BE model has more failure avoidance properties. The more important one is RDB. This database comes with self-failure avoidance methods, which is a basic database property.

- **Restorability:** The restorability of databases (RDB) is more reliable than restorability of the documents.

- **Restoration Effectiveness:** Although the measure of the metric is equal, the restorability of databases (RDB) is more effective than restorability of the documents.

- **Functional Adequacy:** One of the main ideas of the TO-BE model is adequate for performing the tasks as prescribed in the regulatory documents. As-Documented process is defined from the regulatory documents. AS-IS model is not totally adequate, which can be shown by the differences from As-Documented. Therefore, TO-BE model is more adequate then AS-IS model. TO-BE and As-Documented model have equal adequacy measurement result. The un-conducted IPR is the most important example.

- **Functional Completeness:** This measurement output is shown that TO-BE model's measurement result is lower than AS-IS model's. It shows that TO-BE model is less complete. Because, some of the activities in TO-BE model are newly defined, and their documentations are not ready. This measurement is made using current documentations. But, TO-BE model is defined using the general policy of the MYCOMPANY. These undocumented activities are defined for being complete with the regulatory documents. Using these assumptions, TO-BE model has more functional completeness property.

- **IT Usage:** TO-BE model uses IT more than AS-IS model, which the most important one is RDB. This avoids of the human factor, that is, through automation, human neglect and inconsistencies may be avoided.

- **IT Density:** TO-BE model use IT more than AS-IS model, like RDB.

- **Computational Accuracy:** TO-BE model has more implemented accuracy requirements. Like insert/change RDB activity, which defined in TO-BE model, the accuracy requirement is implemented in the activity.

- **Data Exchangeability:** As shown in measurement results of coupling metric, there are no complex interactions. Therefore, the complex data was not exchanged through processes.

- **Access Auditability:** TO-BE model's access auditability result is higher than AS-IS and As-Documented model's. Therefore, TO-BE model has more audit action and it is safer. For example, the RDB tool requires authentication and it records the audit logs of the changes.

- **Functional Understandability:** While the functional understandability measurement results are compared, TO-BE model's result is higher than AS-IS and As-Documented model's. The activities, such as insert/change RDB activity, are more understandable for staff.

- **Existence in Documents:** There are some undocumented activities in AS-IS model. These activities are not well planned. Therefore, the probability of error, caused by these activities, is high. While defining the TO-BE model, the applicability and completeness of the activities are noticed. The measurement result can not be shown in real values, because TO-BE model is implemented with own documentation is assumed. In this measurement, the AS-IS model's documentation, which is As-Documented model, is assumed as the TO-BE model's documentation.

- **Input Validity Checking:** The measurement results of TO-BE and AS-IS models are same and low. In addition, in both models, the inputs are not complex. The inputs of most of the activities are assumed as valid. The validity checking of the inputs are not necessary.

- **Undoability:** Because of the characteristics of the process, the activities are not needed to undone. Most of the activities, which may need to undone, have review activity. Therefore, the activities are repeated whether to be undone. In all models, the undoability metric result is very low, but these situations is not important.

- **Attractive Interaction:** According to measurement results of the models, TO-BE model has more attractive interactions properties. Nevertheless, in all model, most of the interactions are about preparing documentation. Therefore, these interactions do not affect the usability of the TO-BE model.

Based on the measurement results, the improved process is seen to be less complex and more understandable. It is proposed that IT is used in managing the project, a facility like RDB tool will be used for requirement tracing and requirement analyzing. The most important improvement of the TO-BE model is, like the As-Documented model, customer approves all requirements. This approval is used to separate new requirements and rework. Therefore, customer satisfaction and the quality of process and project can be increased. The project delays are prevented. In the TO-BE model, the deficiencies of As-Documented model in using ERP implementation are removed. The incompletely defined activities of AS-IS model are re-defined and the confusions are prevented. Definition of activities has been completed and documented.

CHAPTER 6

CONCLUSION

This study has aimed to propose an improvement to the requirements analysis and validation process applied in MYCOMPANY on Project X. To propose this improvement, the static process evaluation methodology proposed by S. Güceğlioğlu is applied to this process. The results are investigated and an improvement is proposed using that methodology. In addition to this, the interviews with Project X project manager, quality team lead and project staff are used in putting forward this proposal.

To reach this aim, the quality policies of MYCOMPANY have been studied using firm documents and interviews with quality department manager of MYCOMPANY. After this, the project documents of Project X were studied to model the software requirements and validation process, as defined in formal documents. To define general problems in Project X, especially problems in this process, interviews with Project X staff were made. Using the information obtained in these interviews, the software requirements and validation process, applied in this project, is defined and modeled as AS-IS model. The static process evaluation methodology proposed by S. Güceğlioğlu is applied to this model. The measurement results are used for defining the improved process. The measurement methodology is applied on the TO-BE model, too. The improvement is discussed using these measurement results.

Based on the measurement results, the improved process is seen to be less complex and more understandable. It is proposed that IT is used in managing the project. Therefore, the probability of the defects is decreased. With this improvement, customer satisfaction and the quality of process and project can be increased.

According to author, Güceğlioğlu's static process evaluation methodology can be the first step for software process improvement activities. With this methodology, the failure rate of software process improvement projects can be decreased. The outputs of these projects can be predicted without applying the improvement to the project and the project times can be decreased.

This methodology is not enough for determining whether the improvement is applicable or not. This methodology just measures the characteristic of the model. It predicts a quantitative level of expectancy of improvement.

As shown in previous chapter, applying the methodology has just taken 11% of the whole improvement effort. The most important property of this methodology is its ease-of-use. The methodology can be applied to the project with straightforward metrics.

While doing this study, the main deficiencies were,

- This work did not cover the whole development process of Project X. Actually; the real improvements can be obtained by improving the whole development process, which exceeds the limitations of source of data and time.

- This work did not cover all projects of MYCOMPANY and MYCOMPANY quality policy. This study focuses only on PROJECT X.

- The proposed improvements cannot be applied to Project X, because Project X is at the last stage and there is not enough time to see the outputs of the improvements. In addition to this, the project managers do not want to try any systematic changes.

Future works:

The scope of this study can be extended to cover the whole processes of Project X. These improvements can be applied to Project X, or another project which has been going on or will start. The results of model's measurement can be compared with the actual results.

The scope of this study can be extended to cover the other projects of MYCOMPANY and MYCOMPANY quality policies. With this extension, the software process improvement ideas can be extended to the technology and project independent process improvement, because MYCOMPANY carries out projects with different technologies.

The software process improvement studies can be specialized for projects, which use the ready to use packages. In literature, there are not enough documents for these projects' process improvements.

The static process evaluation methodologies can be compared with software process improvement frameworks. The static process evaluation methodology studies can be directed to software process frameworks integration.

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APPENDIX – A

THE QUANTITATIVE DIFFERENCES BETWEEN CMM, SPICE, BOOTSTRAP AND ISO 9000

Table 8 The Quantitative Differences between CMM, SPICE, BOOTSTRAP and ISO 9000 [9]

		CMM	SPICE	ISO 9000	BOOTSTRAP
Model		the most management oriented model;	the most organization oriented model		the most technical oriented model
Organization processes	**Organizational structure**	puts fewer emphases on both of the processes	more orientated to organization definition and is focused on project organization	relatively less oriented to these processes	puts more emphases on both processes
	Organization process	on organization process improvement	on both processes of organization process definition and organization process improvement	NONE	on the process of organization process definition
	Customer services	on the process of customer relations	on customer support and system delivery processes	on the processes of system delivery and service evaluation	on customer relations and software system delivery processes
Software engineering processes	**Software engineering methodologies**	on technology innovation process	on the process of reuse methodologies	NONE	on the process of software engineering modeling
	Software development processes	on process control	on all the processes except the requirement analysis	on process control and requirement analysis	on integration system testing, process control and module testing

Table 11 The Quantitative Differences between CMM, SPICE, BOOTSTRAP and ISO 9000 [9] (continued)

Software engineering processes	**Software development environments**	NONE	on environment management and facilities management processes	on facilities management process	on the processes of software development environment and facilities
Management processes	**Software quality assurance (SQA)**	on defect control process	on the processes of peer reviews and defect control	on the process of SQA procedure definition	on the process of SQA procedure definition
	Project planning	on general project plan	on the processes of general project plan and project risks avoidance	on general project plan	on project risks avoidance process
	Project management	on almost all the processes especially process tracking	on configuration management process	on configuration management	on process tracking, change control and process review
	Contracts and requirements management	on subcontractor management	on the processes of requirements management and subcontractor management	on contract and subcontract management processes	on purchasing management although the absolute value is relatively low
	Document management	on process database	on general documentation process	on the processes of general documentation	on the general documentation process
	Human resource management	on the training process	on the training process	on the training process	on the processes of staff selection allocation and training

APPENDIX – B

THE METRICS OF THE S. GÜCEĞLIOĞLU'S STATIC PROCESS EVALUATION METHODOLOGY [43]

1. Maintainability Metrics

a. Analyzability Metrics

i. Complexity

Table 9 Complexity Metric

Method of application	Count number of decisions which necessitate different branches in the process flow and compare with number of activities
Measurement, formula and data element computations	Each decision type is counted separately. • X (1) = A / B, for structured decisions(1) A = Number of structured decisions B = Number of activities • X (2) = A / B, for unstructured decisions(2) A = Number of unstructured decisions B = Number of activities • X (3) = A / B, for semi-structured decisions(3) A = Number of the semi-structured decisions B = Number of activities
Interpretation of measured value	0 < = X < = 1 The lower value of X (1), X (2), X (3), the better analyzability

ii. Coupling

Table 10 Coupling Metric

Method of application	Count number of interactions with other processes and comparing with number of activities
Measurement, formula and data element computations	X = A / B A = Number of interactions B = Number of activities
Interpretation of measured value	0 < = X < = 1 The lower value of X, the better analyzability

2. Reliability Metrics

a. Fault Tolerance Metrics

i. Failure Avoidance

Table 11 Failure Avoidance Metric

Method of application	Count the number of activities in which review, inspection, checkpoint or similar techniques are applied and compare with the number of activities
Measurement, formula and data element computations	X = A / B A = Number of activities in which review, inspection, checkpoint or similar techniques are applied B = Number of activities
Interpretation of measured value	0 < = X < = 1 The higher value of X, the better failure avoidance

b. Recoverability Metrics

i. Restorability

Table 12 Restorability Metric

Method of application	Count the number of activities which are recorded and compare with the number of activities
Measurement, formula and data element computations	X = A / B A = Number of activities which are recorded in paper or magnetic environment B = Number of activities
Interpretation of measured value	0 < = X < = 1 The higher value of X, the better restorability

ii. Restoration Effectiveness

Table 13 Restoration Effectiveness Metric

Method of application	Count the number of activities which can be restored by using the records in paper based or magnetic environment when an abnormal event occurs and compare with the number of activities
Measurement, formula and data element computations	X = A / B A = Number of activities which can be restored B = Number of activities Another formula for measuring the restoration effectiveness can be given as below: X = A / B A = Number of activities which can be restored B = Number of recorded activities
Interpretation of measured value	0 < = X < = 1 The higher value of X, the better restorability effectiveness

3. Functionality

a. Suitability Metrics

i. Functional Adequacy

Table 14 Functional Adequacy Metric

Method of application	Count the number of activities that are adequate for performing the tasks as prescribed in the regulatory documents and compare with the number of activities
Measurement, formula and data element computations	X = A / B A = Number of adequate activities with their definitions in regulatory documents B = Number of activities
Interpretation of measured value	0 < = X < = 1 The higher value of X, the better functional adequacy

ii. Functional Completeness

Table 15 Functional Completeness Metric

Method of application	Count the number of missing activities detected in practice and compare with the number of activities described in the regulatory documents (as “activities in theory”)
Measurement, formula and data element computations	X = 1- A / B A = Number of activities which are defined in the regulatory documents of the organization, but forgotten in practice, B = Number of activities
Interpretation of measured value	0 < = X < = 1 The higher value of X, the better functional completeness

b. IT Based Functionality Metrics

i. IT Usage

Table 16 IT Usage Metric

Method of application	Count the number of activities in which IT applications are used and compare with the number of activities
Measurement, formula and data element computations	X = A / B A = Number of activities in which IT applications are used for preparation, deletion, updating or searching purposes B = Number of activities
Interpretation of measured value	0 < = X < = 1 The higher value of X, the more IT usage

ii. IT Density

Table 17 IT Density Metric

Method of application	Count the number of forms, reports, archival records or other similar documents prepared, updated, deleted or searched by using IT applications and compare with the number of forms, reports, archival records or other similar documents in the process
Measurement, formula and data element computations	X = A / B A = Number of forms, reports, archival records or similar other documents that are prepared, updated, deleted or searched by using IT applications B = Number of forms, documents, archival records or similar other documents in the process
Interpretation of measured value	0 < = X < = 1 The higher value of X, the more IT density

c. Accuracy Metrics

i. Computational Accuracy

Table 18 Computational Accuracy Metric

Method of application	Count the number of activities in which accuracy requirements have been implemented as defined in the regulatory document and compare with the number of activities which have specific accuracy requirements
Measurement, formula and data element computations	X = A / B A = Number of activities in which specific accuracy requirements have been implemented, as defined in regulatory document B = Number of activities which have specific accuracy requirements
Interpretation of measured value	0 < = X < = 1. The closer to 1, the more accurate

d. Interoperability Metrics

i. Data Exchangeability

Table 19 Data Exchangeability Metric

Method of application	Count the number of activities in which no operation such as parsing or extracting is performed on the received data (“input parameters to the activity”) before using it and compare with the number of activities which have interactions with other processes

Table 22 Data Exchangeability Metric (Continued)

Measurement, formula and data element computations	X = A / B A = Number of activities in which no change is performed on the received data before using it (using the data as it has been transferred) B = Number of activities which have interactions with other processes If B equals to 0, it means that there are no interactions in the process activities with other processes. The result is set as “No interaction” without dividing by zero.
Interpretation of measured value	0 <= X <= 1. The closer to 1, the more data exchangeability

e. Security Metrics

i. Access Auditability

Table 20 Access Auditability Metric

Method of application	Count the number of the activities in which there is access to data and the access can be audited and compare with the number of the activities which have accesses to data sources
Measurement, formula and data element computations	X = A / B A = Number of activities which have access to the data and this access can be audited with its actor B = Number of activities which have accesses to the data sources
Interpretation of measured value	0 < = X < = 1. The closer to 1, the more auditable

4. Usability

a. Understandability Metrics

i. Functional Understandability

Table 21 Functional Understandability Metric

Method of application	Count the number of activities of which purposes and tasks are understood by the staff and compare with number of process activities
Measurement, formula and data element computations	X = A / B A = Number of activities in which staff do not encounter difficulties in understanding the tasks to be performed, B = Number of process activities
Interpretation of measured value	0 <= X <= 1 The closer to 1, the better understandability

b. Learnability Metrics

i. Existence in Documents

Table 22 Existence in Document Metric

Method of application	Count the number of activities described in the available documents and compare with the number of activities
Measurement, formula and data element computations	X = A / B A = Number of activities which are described in the available documents, B = Number of activities
Interpretation of measured value	0 <= X <= 1 The closer to 1, the more complete documentation

c. Operability Metrics

i. Input Validity Checking

Table 23 Input Validity Checking Metric

Method of application	Count the number of activities in which checking for valid data is provided for input parameters and compare with the number of process activities
Measurement, formula and data element computations	X = A / B A = Number of activities in which validity checking can be performed for input parameters B = Number of activities
Interpretation of measured value	0 <= X <= 1 The closer to 1, the better input validity checking in the activities

ii. Undoability

Table 24 Undoability Metric

Method of application	Count the number of the recorded activities which can be undone after they are completed and compare with the number of process activities
Measurement, formula and data element computations	X = A / B A=Number of activities which can be undone, B= Number of activities
Interpretation of measured value	0 <= X <= 1 The closer to 1, the better undoability

d. Attractiveness Metrics

i. Attractive Interaction

Table 25 Attractive Interaction Metric

Method of application	Count the number of activities which have attractive appearance and provide staff with easiness in preparation, deletion or updating forms, reports, archival record or similar other documents and compare with the number of activities
Measurement, formula and data element computations	X = A / B A = Number of activities in which staff can prepare, delete or update forms, reports, archival records or similar other documents with no difficulties B = Number of activities Another formula for measuring the attractive interaction can be given as below: X = A / B A = Number of activities in which staff can prepare, delete or update forms, reports, archival records or similar other documents with no difficulties B = Number of recorded activities The former formula measures the attractive interaction by considering all activities whether recorded or not, while the latter formula measures the attractive interaction by considering only recorded activities.
Interpretation of measured value	0 <= X <= 1 The closer to 1, the more attractive interaction

(1) **Structured Decision:** This type of decision is defined as programmable decision as its' situation is fully understood. Structured decisions are routine and repetitive decisions. Therefore, a well-

defined and standard solution can be formed to perform necessary actions.

(2) **Unstructured Decision:** In unstructured decision, situation is not clear and requires creative decision. Sometimes, it is a complex problem and necessitates fuzzy logic.

(3) **Semi-structured Decision:** This type of decision has characteristics of both structured and unstructured decisions. It may be repetitive and routine, but requires human intuition.