A PRE-ENACTMENT MODEL FOR MEASURING PROCESS QUALITY

A THESIS SUBMITTED TO

THE GRADUATE SCHOOL OF INFORMATICS

OF

THE MIDDLE EAST TECHNICAL UNIVERSITY

BY

A.SELÇUK GÜCEĞLİOĞLU

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

IN

THE DEPARTMENT OF INFORMATION SYSTEMS

JUNE 2006

Approval of the Graduate School of Informatics

Assoc.Prof.Dr. Nazife BAYKAL
Director

I certify that this thesis satisfies all the requirements as a thesis for the degree of Doctor of Philosophy.

Assoc.Prof.Dr. Yasemin YARDIMCI
Head of the Department

This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Doctor of Philosophy.

Assoc.Prof.Dr. Onur DEMİRÖRS
Supervisor

Examining Committee Members

Prof. Dr. Semih BİLGEN	(METU, EEE)	
Assoc. Prof. Dr. Onur DEMİRÖRS	(METU, IS)	
Assoc. Prof. Dr. Zeynep ONAY	(METU, BA)	
Prof. Dr. Ünal YARIMAĞAN	(ÖSYM)	
Dr. Altan KOÇYİĞİT	(METU, IS)	

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this wok.

Name and Surname: A.Selçuk Güceğlioğlu

Signature:

ABSTRACT

A PRE-ENACTMENT MODEL FOR MEASURING
PROCESS QUALITY

Güceğlioğlu, A.Selçuk
Ph.D., Department of Information Systems
Supervisor: Assoc. Prof. Dr. Onur Demirörs

June 2006, 160 pages

Most of the process measurement studies are related with time and cost based models. Although quality is the other conventional aspect, there are no widely used models for measuring the process quality in the literature. In order to provide complementary information about the quality, a process quality measurement model has been chosen to be developed and the studies about process characteristics have been searched in the scope of the thesis. Moreover, by utilizing the similarities between process and software, the studies in software quality have been investigated. In the light of the researches, a model is built on the basis of ISO/IEC 9126 Software Product Quality Model. Some of the quality attributes are redefined in the model according to the process characteristics. In addition, new attributes unique only to the process are developed. A case study is performed and its results discussed from different perspectives of applicability, understandability and suitability.

Keywords: Process quality, quality attributes, Information Systems (IS) effects, software quality characteristic.

ÖZ

UYGULAMA ÖNCESİ SÜREÇ KALİTESİNİN
ÖLÇÜLMESİ İÇİN BİR MODEL

Güceğlioğlu, A.Selçuk
Doktora, Bilişim Sistemleri Bölümü
Tez Yöneticisi: Doç.Dr. Onur Demirörs

Haziran 2006, 160 sayfa

Süreç ölçüm çalışmalarının çoğu zaman ve maliyet tabanlı modeller ile ilişkilidir. Kalite diğer bir klasik görünüş olmasına rağmen, literatürde yaygın olarak kullanılan süreç kalitesini ölçen modeller bulunmamaktadır. Tez kapsamında, kalite hakkında tamamlayıcı bilgiler sağlamak amacıyla bir süreç kalite ölçüm modelinin geliştirilmesi seçilmiş ve süreç karakteristikleri ile ilgili çalışmalar araştırılmıştır. Buna ek olarak, süreç ile yazılım arasındaki benzerliklerden yararlanarak, yazılım kalite çalışmaları incelenmiştir. Yapılan araştırmalar ışığında, ISO/IEC 9126 Yazılım Ürün Kalite Modeli temelinde bir model geliştirilmiştir. Model içerisinde, bazı kalite öznitelikleri süreç karekteristiklerine göre yeniden tanımlanmıştır. Ayrıca, yalnızca sürece özgü yeni özniteliler geliştirilmiştir. Bir durum çalışması gerçekleştirilmiş ve sonuçları uygulanabilirlik, anlaşılabilirlik ve uygunluk farklı bakış açılarına göre tartışılmıştır.

Anahtar kelimeler: Süreç kalitesi, kalite öznitelikleri, bilgi sistemleri etkisi, yazılım kalite karakteristikleri.

To my son, YAĞIZ

ACKNOWLEDGEMENTS

I would like to express my most sincere appreciation to my supervisor Assoc. Prof. Dr. Onur DEMİRÖRS for his continuous support and intellectual guidance throughout this work and his very valuable friendship.

I would like to thank to Prof. Dr. Semih BİLGEN and Assoc. Prof. Dr. Zeynep ONAY for their critical remarks and valuable guidance during the whole period of my research.

I would like to acknowledge the participants in the case study who spent their time and shared their views and experience with me.

I would like to thank to Yelda KUŞCU for her review and valuable feedback.

I would like to thank to my wife, “Yeşim,” and my son, “Yağız,” my mother, my father for their continuous patience, understanding and emotional support during these years.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

This chapter is divided into four sections. The first section explains the need for a process quality measurement. The second section presents the model developed in the thesis for measuring the process quality. The third section describes the method employed for validating the model. Finally, the last section gives outline of the thesis.

1.1 The Need for a Process Quality Measurement

Process is one of the most valuable assets of the organizations. Its design and implementation have considerable impacts on the success of an organization. For this reason, process-centered studies are emphasized in the literature as a necessity for accomplishing business goals (Davenport, 1993; Hammer 2001).

Information Systems (IS) is an aspect that profoundly affects the process and its design (Mooney, Gurbaxani and Kraemer, 1996). In an IS development project, frequently, processes of an organization are analyzed and a system is designed with new process definitions. Most of the studies in the IS literature employ time and cost based models and attributes such as productivity growth, return on investment and market share for measuring effects of IS projects on the organizations (Brynjolfsson and Hitt, 1994). These models can provide the organizations with crucial information about IS effects, but, naturally, they can only be measured during or after the processes are executed. In order to indicate this measurement time, these kinds of attributes are named as *post-execute* attributes in the thesis. The processes should be modified according to post-execute attribute values and re-executed to measure the effects of new arrangements. This kind of iterations requires much effort and cost.

There are also other problems with using post-execute attributes. The first problem is to have the difficulties in identifying IS effects. Available models do not identify IS effects on the process. What kind of changes in the process affect the measurements is usually not a primary issue. The second problem is related with the difficulties in isolating contributions of IS effects from other contributors. As there are more than one factor affecting the process, it is difficult to isolate and measure only IS effects. And finally economic performance might not be the most critical factor for some organizations such as public organizations. As the economic criteria are not so meaningful for these organizations, only productivity gains can be used to measure IS effects on such organizations (Danziger, 1987). These problems are also stated in one of the most well-known IS Success Model (DeLone and McLean, 1992). In the model, available studies are accepted as in early stages and much work is suggested to be performed for measuring IS effects on the organizations.

In addition to time and cost related attributes, another important aspect for the process is quality. However, there is limited number of attributes defined in the quality aspect. Complexity and dependency are examples of such attributes. Complexity is related to comprehensibility of a process (Hammer and Steven, 1994). Since the comprehensibility of the process, with its inputs, activities and outputs, by each member of the organization is vital for the effectiveness, it makes complexity a precious attribute for the process. Dependency, which is mentioned as the second example, focuses on the interactions with other processes in the organization (Hammer, 1996). Higher number of interactions with other processes increases the possibility of a delay in the process because of higher time consumption while getting responses. In such a case, dependency attribute may help identifying the reasons of the delays by focusing on the interactions in order to minimize these delays. Measuring these attributes by using process definitions can provide early feedback and reveal critical problems before the processes are executed. These kinds of attributes are called as *pre-execute* attributes in the thesis to indicate measurement time. Unfortunately, there are no widely accepted and used models including pre-execute attributes for measuring the process quality in different perspectives such as usability, reliability and maintainability.

Business Process Change (BPC), whether in the form of improvement or reengineering, is another study affecting the process. In a BPC study, organizations analyze their processes, address the barriers that impede their ability and identify new ways to improve them. In this perspective, BPC has close relationships with IS development projects. BPC studies allow IS analysts to capture what a business does by answering some important questions such as “where bottlenecks are,” “where additional resources are needed,” “where commitments are not being satisfied” and “how processes can be optimized.” When implemented in coordination the answers of the questions asked during the BPC initiative form a basis for IS development. Therefore, not only IS projects have close relationship with the BPC studies but also the quality of them will directly affect the quality of the IS employed. Based on BPC, various techniques such as Activity Based Costing (ABC) and Cost Benefit Analysis (CBA) are proposed for measuring the processes. These models use time and cost related post-execute attributes such as cycle time, throughput time, cost reductions and revenue increases for measuring the impacts of the studies on the processes, similar to the models employed for measuring IS effects on the process. In this circumstance, there is a need to measure the impacts of the BPC studies on the process quality with using pre-execute attributes for having early feedback.

1.2 Proposing a Model for Measuring the Process Quality

The literature research has demonstrated the lack of frameworks for defining and measuring process quality. To enable quantitative evaluation of quality attributes, a process quality measurement model is developed in this study. At the beginning of the development, Goal Question Metric (GQM) method (Basili, 1992) was used to investigate quality attributes. Some attributes such as complexity, dependency, consistency, information technology (IT) usage and interoperability were defined. However, these findings remained to be organization specific and it was difficult to generalize these metrics to form a more comprehensive model.

During the literature survey, the analogy between software and process (Osterweil, 1987) has given a useful direction to the study. Process and software have similar logical structures. For instance, structure of the process with its inputs, activities and outputs is similar to that of the software with its input parameters, functions and output parameters. The relation between software and function exists between process and activity. Software and process constitutes a part of the whole and has interactions with other parts as well. In addition, high quality is of prime importance for both of them.

In order to provide a more complete quality attribute set, available software quality models were examined (Boehm, Brown and Lipow, 1976; McCall, Richards and Walters, 1977; ISO/IEC FCD 9126-1.2, 2000). ISO/IEC 9126 Software Product Quality Model, one of the most widely accepted models, was used to extend the study (ISO/IEC FCD 9126-1.2, 2000). The standard describes a software evaluation model for developing or selecting high quality software. The software product is evaluated for every relevant quality characteristics in the model by using validated and widely accepted metrics. Not only process characteristics that are determined during the literature review but also similarities between process and software are used for developing the model. Process quality attributes are redefined according to the process characteristics; and new attributes unique to the process are developed to extend the model.

The model is designed in four-leveled structure that is similar to the ISO/IEC 9126, as depicted in Figure 1.1. The first level is called as category. There is one category as "quality" but in the future, new categories can be added to extend the model. The second level is called as characteristic. The quality category includes Maintainability, Functionality, Reliability and Usability characteristics. The third level is for sub-characteristics and finally, fourth level is for metrics. There are 17 metric definitions in the model to measure the quality attributes. Similar to the development of new categories, new characteristics, sub-characteristics and metrics can be defined in the model as well.

The first objective of the model is to measure the quality attributes by using process definitions with their inputs, activities and outputs; therefore, providing early feedback about the processes before they are put into execution. The quality measurement results can also be used with post-execute attributes as complementary purpose. The second objective is to give information about effects of the studies such as BPC and IS on the process, in terms of quality attributes. The changes in the quality attribute values can indicate effects of the study on the process. In this way, new studies can be organized to increase or decrease specific quality attribute values according to the priorities of the study.

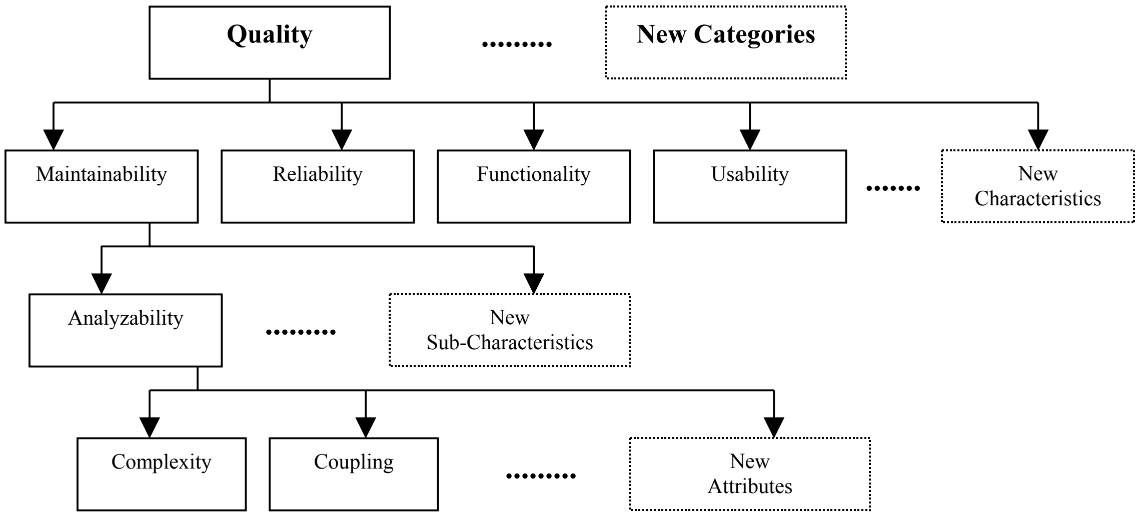

Figure 1.1 Model Structure

1.3 Method Employed for Validation of the Model

Case study research method was used for investigating applicability, usability and suitability of the quality attributes, as well as, validating and evolving the model. Before the case study, a pilot study was performed on a single process (Demirors and Gucegliogu, 2005). In the pilot study, the model was applied to AS-IS and TO-BE forms of the process. TO-BE form of the process was designed according to the specifications of an IS project. The quality attribute values were measured for both forms. This pilot study provided the following valuable feedback to the model development.

- The usage of process definitions to measure process quality was experimented and quality attributes were measured for both forms.
- The changes from AS-IS form to the TO-BE form were measured in terms of quality attributes' values. In addition, IS effects on the process quality were

measured by means of restoration effectiveness, IT usage and IT density attributes.

- Quality attribute definitions were detailed by adding new fields such as "input to measurement," "focus," "assumptions and constraints" and "questions for identifying the attributes in activity definition" to make the measurement clearer.

The results of the pilot study provided motivation to design and conduct a case study. After completing the modifications on the model, a case study was designed for an organization where the pilot study was performed. The case study design was described with research questions, data collection and data analysis methods. Similar to the pilot study, the model was applied to both AS-IS and TO-BE forms of the processes. The quality attribute values of both forms of the processes were measured by using process definitions.

The problems or difficulties encountered in the AS-IS form processes were recorded from the documents prepared in the analysis of processes. These problems and their present situations in the TO-BE form were compared with the changes in the quality attribute values from AS-IS to TO-BE. It is recognized that the improvements in the quality attribute values could indicate the solutions provided to the problems in the TO-BE form processes. The connections among the problems and quality attributes were used to validate the model. The measurement values of the interrelated quality attributes provided consistent results for the validation as well.

The case study results were discussed with the participators at the closure part of the study. The applicability, usability and suitability of the model were evaluated by means of mutual open-ended questions. The answers provided another means for the validation. The comments stated by the participators and measurement values gave meaningful answers to the research questions determined at the beginning of the case study.

1.4 Thesis Outline

The remainder of the thesis is organized as follows. Chapter 2 presents a literature review for IS and BPC effectiveness measurements. Firstly, IS success and its measurement is given. The most well known IS Success Models and their points of view about IS effects on the process are investigated. Secondly, BPC, the other study affecting the process, is evaluated with its objectives, steps and techniques employed for measuring the processes by using time and cost based models and metrics. The tight relationships between BPC and IS studies are emphasized in this circumstance as well. Thirdly, and finally, available sample models and their contributions are examined. With the available time and cost related metrics, the need for a process quality measurement is identified.

Chapter 3 describes development of the model, where model objectives and definitions are given. The structure of the model is detailed with its characteristics sub-characteristics and metrics. The quality attribute definitions categorized under maintainability, reliability, functionality and usability are introduced. The guidelines for the usage of each quality attribute are explained.

Chapter 4 includes case study research conducted to refine and validate the model. It describes a brief justification for the research method and details about case study design with research questions, data collection and analysis methods. The steps performed for forming process definitions of AS-IS and TO-BE forms, modeling them with using a process-modeling tool, identifying and recording problems encountered in the AS-IS form processes and details of the measurements are explained. The results are discussed and other experiences acquired during the case study are given.

Chapter 5 gives a short summary of the study and emphasizes the contributions of the model. It further states limitations of the model such as needs of additional quality attribute definitions and deficiencies of some present quality attributes. The propositions for overcoming the limitations and the development of a tool for making the measurement easier are given as future study.

CHAPTER 2

LITERATURE REVIEW

This chapter provides a review of the related literature and is divided into two sections. The first section investigates the effects of Information System (IS) studies on the process. The most well-known IS Success Models are examined in this context to determine available studies for measuring the effects of IS on the process. The second section is a literature review concerning business process change studies.

2.1 Effects of Information System (IS) Studies on the Process

The studies in IS literature about measuring the IS effects are brought together and classified in the studies named as IS Success Models. The most well known models are DeLone & McLean IS Success Model (DeLone and McLean, 1992), Seddon IS Effectiveness Matrix (Seddon, Staples, Patnayakuni and Bowtell, 1999) and Contingency Theory for IS Assessment (Myers, Kappelman and Prybutok, 1997). These models and their points of view for measuring the effects of IS on the process are investigated below.

2.1.1 DeLone and McLean IS Success Model

One of the most widely known frameworks for measuring the effectiveness of IS is DeLone and McLean IS Success Model (DeLone and McLean, 1992). The purpose of the model is to synthesize previous researches including IS success into a more coherent body of knowledge and to provide guidance to future researchers. In the model, DeLone and McLean (1992) attempted to combine individual measures systematically from the IS success categories to create a comprehensive measurement instrument. This model is based on the Shannon and Weaver communication theory (Shannon and Weaver, 1949) and the studies of Mason (Mason, 1978) on the communication theory.

According to the theory of Shannon and Weaver (1949), information can be measured at three different levels as technical level, semantic level and effectiveness level. These levels are defined as follow: Technical level is the accuracy and efficiency of the system, which produces the information, semantic level is the success of the information in conveying intended meaning and effectiveness level is effect of the information on the receiver. The concept of output levels from communication theory demonstrates the "*serial nature*" of information. The information flows through a series of stages from its production through its use or consumption to its influence on individual and/or organizational performance (depicted in the first row of Table 2.1).

Table 2.1 Three Studies: Shannon and Weaver (1949), Mason (1978) and DeLone and McLean (1992)

Shannon & Weaver (1949)	Technical Level	Semantic Level	Effectiveness or Influence Level		
Mason (1978)	Production	Product	Receipt	Influence on Receipt	Influence on System
DeLone & McLean (1992)	System Quality	Information Quality	Use & User Satisfaction	Individual Impact	Organizational Impact

Mason (1978) extended Shannon and Weaver (1949) model by renaming effectiveness as influence and defined the influence level of information as "*a hierarchy of events which take place at the receiving end of an information system which may be used to identify the various approaches that might be used to measure output at the influence level*" (depicted in the second row of Table 2.1). This series of influence events includes the receipt of the information, the evaluation of the information and the application of the information. Information application leads to a change in recipient behavior and change in system performance. Mason's adaptation of communication theory to the measurement of IS suggests that there may be a need to be separate success measures for each level of information.

Based on the studies of Shannon and Weaver (1949) and Mason (1978), DeLone and McLean (1992) developed IS Success Model. They introduced a comprehensive taxonomy to organize different research studies about defining IS success, as well as to present a more integrated view of IS success concept. This taxonomy has six major dimensions of IS success as System Quality, Information Quality, Information Use, User Satisfaction, Individual Impact and Organizational Impact (see Figure 2.1). In the DeLone and McLean IS Success Model (1992), System Quality measures technical success, Information Quality measures semantic success; and Use, User Satisfaction, Individual impacts and Organizational impacts measure effectiveness success (depicted in the third row of Table 2.1).

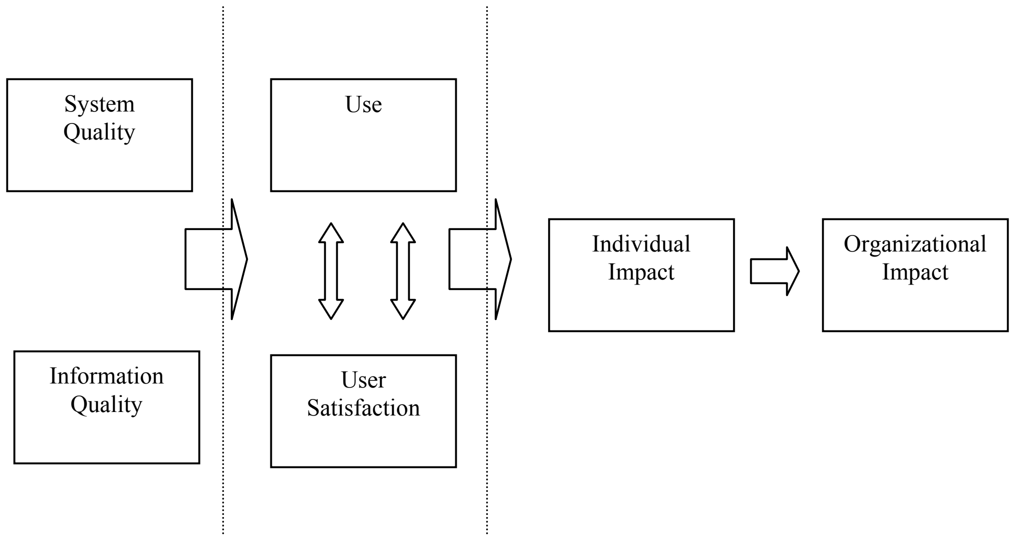

Figure 2.1 DeLone and McLean IS Success Model (1992)

A total of 180 articles published during 1981-1987 were reviewed and then these articles were organized according to the dimensions of the taxonomy. In the Success Model, DeLone and McLean (1992) emphasize the definition of IS dependent variable as necessity. They state that without a well-defined dependent variable, much of IS research is purely speculative.

The first dimension, system quality, measures the information system itself and most of its measures are fairly straightforward, reflecting more engineering-oriented performance characteristics of the system in question. The second dimension, information quality, focuses on the quality of the information system output, in other words the quality of the information that the system produces, primarily in the reports forms. Most measures of the information quality are from the perspective of the user thus fairly subjective in character. Also these measures are often included as a part of the measures of user satisfaction. The third dimension, information use is about recipient consumption of the output of an information system. The usage of information system reports, or of management science/operation research models are placed in this dimension. The fourth dimension, user satisfaction, is defined for the recipient response to the use of the output of an information system. User satisfaction is probably the most widely used single measure of the IS effectiveness for this purpose. The fifth dimension, individual impact, is related about the effect of information on the behavior of the recipient. It is closely related to performance. This impact is an indication such that an information system has given the user a better understanding of the decision context, improved his or her decision making productivity, produced a change in user activity, or changed the decision maker's perception of the importance or usefulness of the information system.

The sixth and the last dimension is organizational impact. This dimension focuses on the effect of IS on organizational performance. When the available studies in this dimension are investigated, it is recognized that most of the studies consider measurement of post-execute economic attributes such as costs, contributions to company profits and return on investment (Emery, 1971). Cost Benefit Analysis (CBA) technique is used to measure IS effects on these metrics. However, as the economic criteria are not so meaningful for government agencies, Danziger (1987) proposed using productivity gains to measure the IS effects on the organization. He explained that productivity gains occur when the functional output of an organization is increased at the same or increased quality with the same or reduced resource inputs. He included five productivity measures; staff reduction, cost reduction, increased work volume, new information, and increased effectiveness in public services.

There are also a few problems for measuring the IS effects on the organizational impact dimension. One of them is limited understanding of IS effects. The focus on the firm level output variables, while important, does not clearly identify IS effects on the organization and its working (Mooney et al, 1996). The other one is the difficulty of isolating the effect of the IS effort from other effects which influence the organizational performance (DeLone and McLean, 1992).

In the light of the available studies in the organizational impact dimension, DeLone and McLean (1992) state that the studies about measuring the IS effects on the organizations and processes are at the initial stage and much work is required to be done in categorizing and measuring the changes in the organizations and work practices, and relating them to the IS.

2.1.2 The Updated DeLone and McLean IS Success Model

Due to the progress in terms of the impacts of IS on business and society as well as progress in IS research during the ten years from the first model, the IS Success Model is updated (DeLone and McLean, 2003). In the updated model (see Figure 2.2), a new dimension, service quality is added. Service quality is an important dimension of IS success, especially in the e-commerce environment where customer service is crucial. It is stated that as commonly used measures of IS effectiveness focus on the products rather than the service of the IS function, there is a danger that IS researchers will mismeasure IS effectiveness if they do not include a measure of IS service quality in their assessment package. The researchers believe that properly measured service quality deserves to be added to system quality and information quality as components of IS success. Although a claim could be made that service quality is merely a subset of the model's system quality, the changes in the role of IS over the last decade argue to define it as a separate variable.

Another change is the decomposition of Use into Use and Intention to Use. In order to overcome the difficulties in interpreting the multidimensional aspects of Use, such as mandatory versus voluntary and informed versus uninformed, DeLone and McLean (2003) suggest that "Intention to Use" may be a worthwhile alternative measure in some contexts. "Intention to use" is an attitude, whereas "use" is a behavior. This substitution may resolve some of the process versus causal concerns. However, attitudes, and their links with behavior, are difficult to measure, and many researchers may choose to stay with use with a more informed understanding of it.

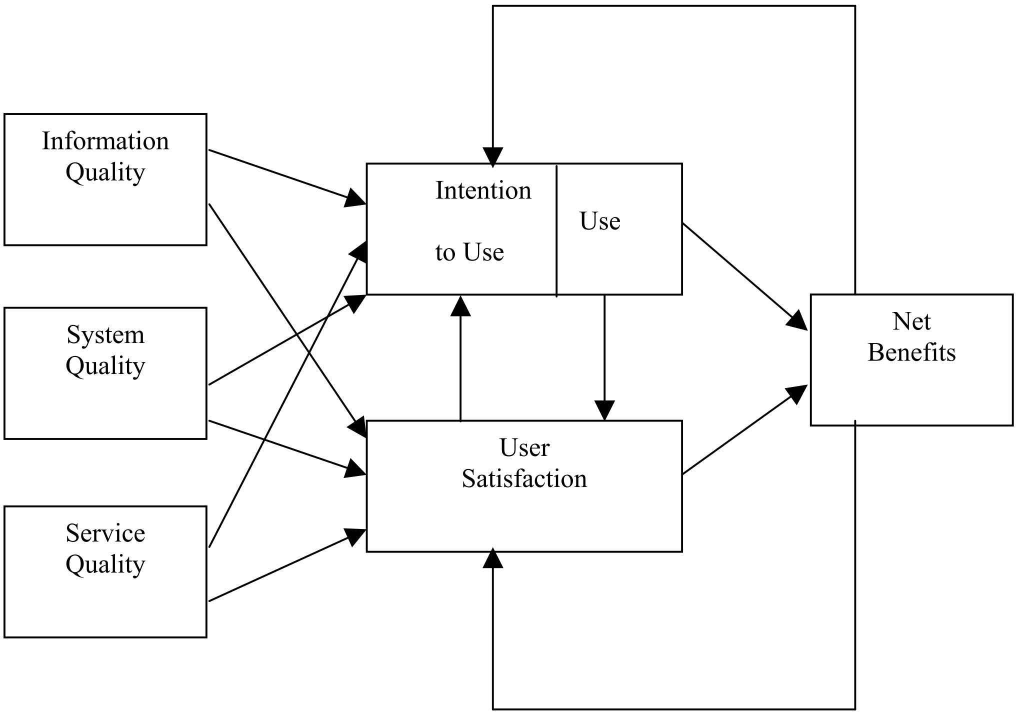

Figure 2.2 Updated DeLone and McLean IS Success Model (2003)

The last change is combination of individual and organizational impacts into a single variable, net benefit. DeLone and McLean (2003) preferred to use net benefits because the impacts of the original term may be positive or negative, thus resulting in a possible confusion as to whether the results are good or bad. Also, no outcome is wholly positive, without any negative consequences. Thus, net benefits are probably the most accurate descriptor of the final success variable.

This new variable, net benefits, raises three issues that must be taken into account: What qualifies as a benefit?, for whom?, and at what level of analysis?. The definition of net benefit will have a broader range than individual and organizational impact. As it is stated in the former model, DeLone and McLean (2003) again emphasize in the new model that more field study is necessary to investigate and incorporate net benefit measures.

2.1.3 Seddon IS Effectiveness Matrix

Seddon IS Effectiveness Matrix, providing a different point of view, is developed for measuring IS Success (Seddon et al, 1999). Seddon proposed a two-dimensional matrix in the model for classifying IS effectiveness measures (depicted in Table 2.2). The first dimension is the type of system studied and includes a range from a single IT application, a type of IT or IT applications, all IT applications used by an organization or sub-organization, an aspect of a system development methodology, and to the IT function of an organization or sub-organization. The second dimension is the stakeholder whose interests the system is being evaluated. There are five types of stakeholder as an independent observer, an individual user, a group of users, the management or owners of the organization and a country or mankind.

The matrix was tested to classify IS effectiveness measures from 186 empirical papers in three major IS journals during the nine years from 1988 to 1996. In the classification, IS effectiveness matrix provided a useful guide for conceptualizing effectiveness measurement in IS research, and for choosing appropriate measures by concerning the system and stakeholder types.

In the Seddon's IS Effectiveness Matrix study, the authors gave some interpretations about DeLone & McLean IS Success Model (1992). They recognize important contributions of DeLone and McLean's Model to the literature on IS success measurement, but emphasizes that different stakeholders in an organization may validly come to different conclusions about the success of the same IS. So, according to their points of view, it is not sensible to systematically combine the measures from their six IS success categories in measuring IS success, instead, because of the range of different systems, stakeholders, and issues involved in different studies, a wide diversity of sharply-focused dependent variables is essential. Seddon claims that different stakeholders and different types of systems require very different measures of IS effectiveness. He concludes that as IS research covers a multitude of topics, the notion of "IS effectiveness" is not an appropriate dependent variable (Seddon et al, 1999).

Table 2.2 IS Effectiveness Measures for Different Combinations of System and Stakeholder

Stakeholder/ interest group	an **aspect** of IT design or use	a **single** IT application in an organization	a **type** of IT or IT application	**all** IT applications used by an organization or sub organization	an aspect of a system development **methodology**	an **IT function** in an organization
Independent observer						
Individual primary focus: Individual better-offness						
Group primary focus: Group better-offness						
Management or Owners primary focus: Organizational better-offness						
A Country primary focus: Society's better-offness						

In the Seddon IS Effectiveness Matrix, similar to the DeLone and McLean IS Success Model (1992), post-execute economic measures such as firm growth, cost savings, return on assets, percentage change in labor, and market share are used for measuring the IS effects on the organizations (corresponds to row 4, management or owners primary focus, in Table 2.2). The other similarity is about the limited number of studies in the literature for measuring the effects of IS on the organizations.

2.1.4 A Contingency Theory for IS Assessment

The studies of Myers focus on the necessity of IS assessment for the effective management and continuous improvement (Myers et al, 1997). Myers suggests a contingency theory for the IS assessment to guide senior IS managers in selecting appropriate dimensions and measures for their organizations. The purpose of the contingency theory stems from the goal of providing guidance for an IS assessment selection strategy.

IS managers often lack the tools they need to decide if they are accomplishing the right activities. In addition, there are abundant resources for selecting measures. In these circumstances, the theory aims to help IS managers by answering the following questions;

- What are the appropriate IS success dimensions that should be assessed within each organizational and external environmental context?,
- Once the appropriate dimensions are selected, what are the appropriate measures to evaluate performance in each dimension, again, given the context of the organizational and external environment?, and
- Finally, how should these IS success dimensions and measures be selected?.

The contingency theories propose that different strategies are appropriate for different competitive business settings. They differ from the universal view by emphasizing "*it all depends*" and they differ from the situation specific view by asserting that there are classes of settings for which strategic generalizations can be made. Corporate level strategy, organization structure, industry, organization size, business strategy, work group interdependence, culture, incentive system, information intensity of products and/ or services, IS management expertise, IS end-user skills, strategic role of IS, size of IS organization, IS budget size, user participation/involvement, history of organization, individual characteristics, task, climate, and location of the responsible executive are presented as potential contingency variables.

The theory is summarized in Figure 2.3. IS Success Dimensions and Selected Measures, adapted from (Saunders and Jones, 1992), is depicted in the left hand side of the figure. Saunders and Jones (1992) developed the "*IS Function Performance Evaluation Model*" which was used to describe how measures should be selected from the multiple dimensions of the IS function relative to specific organizational factors and based on the perspective of the evaluator. This model provides additional knowledge to the developing theory for IS assessment. There are considerable overlaps between the studies of DeLone and McLean (1992) and Saunders and Jones (1992). Several DeLone and McLean IS Success Model's categories of IS success are represented by one or more of the Saunders and Jones Performance Dimensions. For example, the Saunders and Jones dimensions; "IS impact on strategic direction," "IS contribution to organization's financial performance," "integration of IS and corporate planning," and "integration with related technologies across other organizational units" could be all considered as sub-dimensions of "organizational impact." Also, "quality of information outputs" corresponds to "information quality," "user/management attitudes" correspond to "user satisfaction," and "adequacy of system development practices" and "IS operational efficiency" roughly correspond to "system quality." The six dimensions of the DeLone and McLean IS Success Model (1992) are updated with suggested measures from the studies in other disciplines since 1988. Also, the two additional dimensions (service quality and workgroup impact) of IS success are strongly mentioned as worthy to be included in the model and other possible measures are presented. Some of the measures for each IS success dimension are provided and supplemented with the lists collected by DeLone and McLean IS Success Model (1992) as well. For instance, cost savings, improved customer service, improved productivity, return on investment and increased data availability measures are defined for organizational impact dimension.

There is "Selected Contingency Theory Variables" as External Environmental Variables and Organizational Variables in Figure 2.3. External environmental variables include industry, competitive environment, culture, economy, availability of resources and climate arguments. Organizational variables include mission, size, goals, top management support, maturity of IS function, size of IS function, culture and IS budget size arguments. It is aimed to select and prioritize of IS success dimensions and select measures for each dimension according to these arguments.

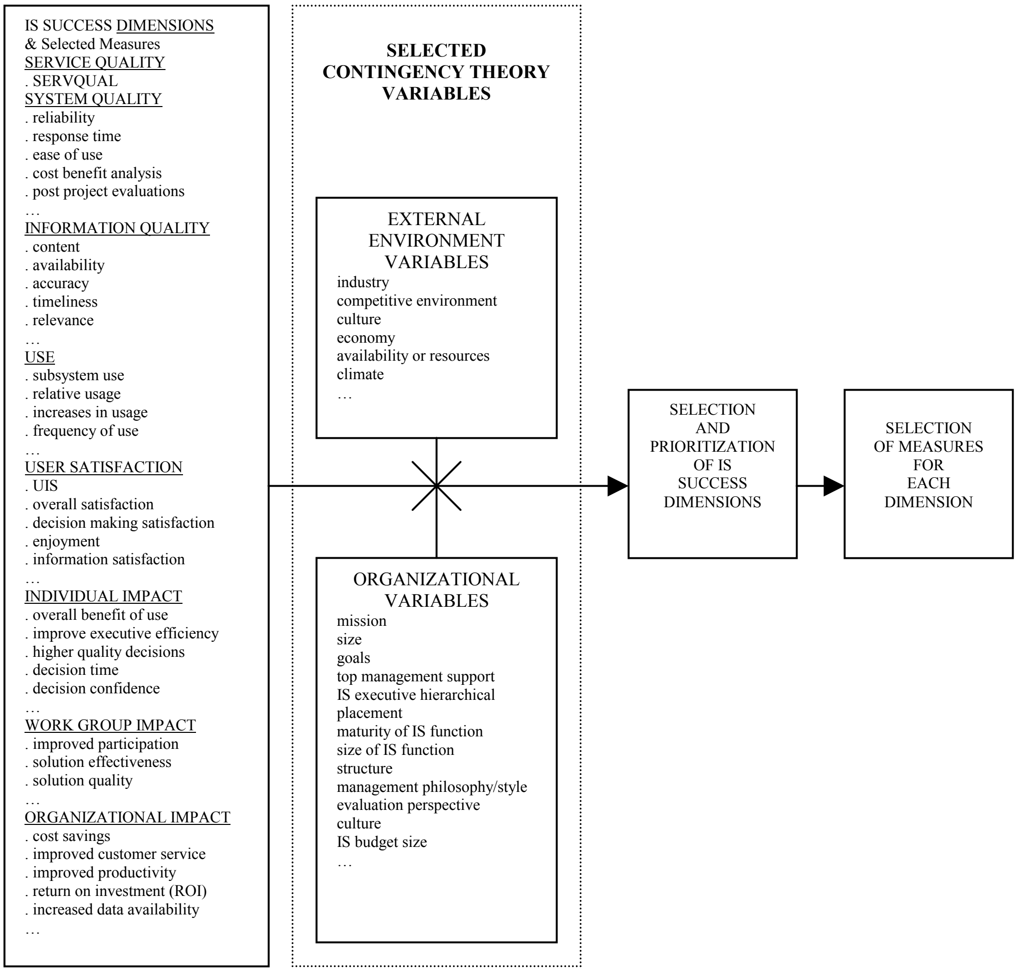

Figure 2.3 IS Assessment Model

Myers (Myers et al, 1997) accepts the progress toward the development of a comprehensive framework for the IS assessment as significant. Such a theory has the potential to contribute to the quality and productivity of the IS function within the larger organization by providing feedbacks to manage and improve the IS function in order to respond the needs of the organization. However, he also emphasizes that there are much remaining work to be done. The position of their study is seen as the initiation of the development of a contingency theory for the IS assessment, because the algorithm for selecting the appropriate dimensions and measures has yet to be developed and will require empirical research. The following questions should be searched and answered in both quantitative and qualitative manner.

- How should the IS manager select the appropriate IS success dimensions and measures for each given their organizational and environmental contexts?,
- How should the dimensions and the measures be combined?, and
- What is working in practice in successful organizations?.

2.1.5 Process-Based Approaches for Measuring IS Effects

When the various studies about IS Success Models are taken into consideration, the researches for measuring the IS effects on the organizational impact dimension can be grouped under two types of approaches as product-based and process-based. King and Xia (2004) state that in order to measure the IS effects on the organizational impact dimension, both approaches should be evaluated together, otherwise, IS effects on the organizational impact dimension is undervalued.

The first approach is based on the organizational performance models such as the study of Brynjolfsson and Hitt (1994). These kinds of models concentrate on the post-execute attributes such as net profit, return on investment and market share. They are primarily goal oriented and attempt to establish a link between IS effects and measures of organizational performance. Most of the studies in the organizational impact dimension are placed in the scope of the first approach.

The second approach is based on the process-based models. There are only a few process-based models focusing on effects of IS on the organizations by investigating the changes in organizational structure and business processes. These studies attempt to establish a link between IS effects and organizational performance through some intermediate processes that are affected by IS. However, available process-based models in the literature are in conceptual level and some of the well-known ones are investigated below.

2.1.5.1 Mooney's Process Oriented Framework

Mooney et al. (1996) argue that organizations derive business value from IS through its impacts on intermediate business processes. The intermediate processes include the operational processes that comprise an organization's value chain and the management processes of information processing, control, coordination and communication. The potential business value of IS increases as IS continues to permeate and penetrate the organization, impacting an increasing number of processes at a deeper level. Mooney's (1996) process-based model traces the path or chain of activities that IS takes on the way for reaching firm-level performance. With this approach, they want to link IS effects to organizational performance through some intermediate processes.

Mooney et al. (1996) state that the modifications on the business process attributes in automational, informational and transformational dimensions create a number of results to the organization. Some of the results are given in the Table 2.3. There are close relationships between process attribute modifications and the results that have been acquired. This interaction is depicted in Figure 2.4.

Table 2.3 Results of the IS Effects on Process Attributes

Business Process Types	**Results of Process Attribute Modifications in Three Dimensions**		
	Automational	Informational	Transformational
Operational	Labor Costs Reliability Throughput Inventory Costs Efficiency	Utilization Wastage Operational Flexibility Responsiveness Quality	Product and Service Innovation Cycle Times Customer Relationships
Managerial	Administrative Expense Control Reporting Routinization	Effectiveness Decision Quality Resource Usage Empowerment Creativity	Competitive Flexibility Competitive Capability Organizational Form

For instance, in automational dimension, IS affects cycle time attribute of the process and modifies it to a shorter duration, resulting in labor cost savings for operational processes and shortening administrative expenses for managerial processes. Another example, for the same dimension, is that IS affects robustness attribute of the process and modifies it to more strengthen value, resulting in an increasing reliability for operational processes and an increasing control for managerial processes. Although IS effects on the processes are explained in the model, there are no methods or techniques developed for measuring these effects quantitatively.

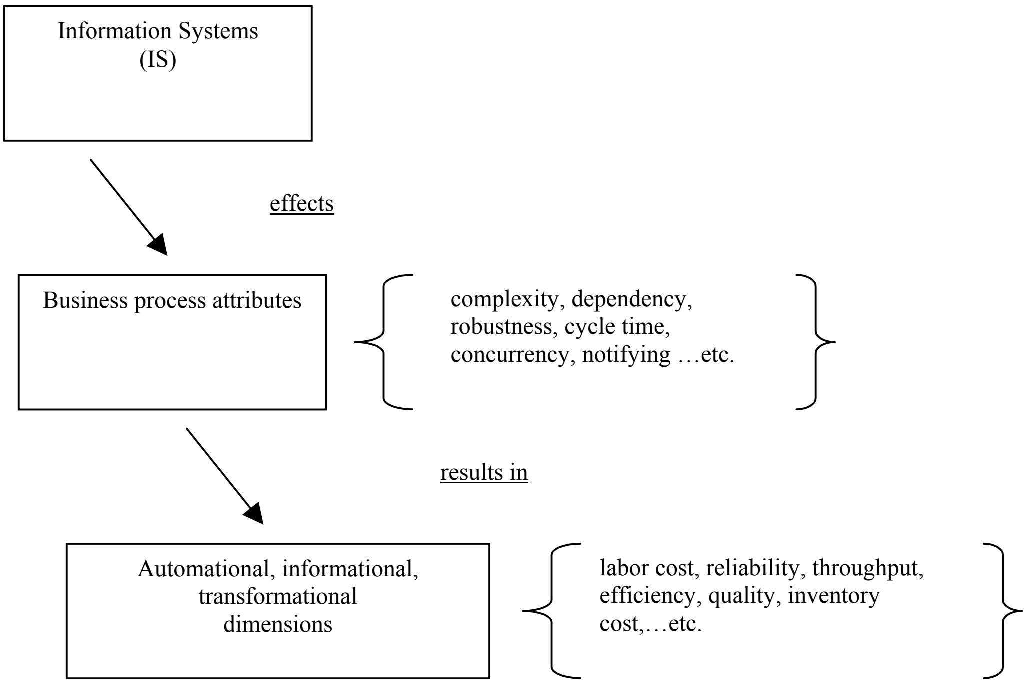

Figure 2.4 IS Effects on Business Process Attributes

2.1.5.2 A Process-Based Model for the Organizational Impact of IS

King and Xia (2004) propose a process-based model for investigating organizational impact of IS. As the model was based on the studies of Soh and Markus (1995), Beath, Goodhue and Ross (1994) and Sambamurthy and Zmud (1994), before giving the details of the study of King and Xia (2004), the core of the former studies are needed to be briefly summarized.

Soh and Markus (1995): They propose a process-based model that includes three processes, depicted Figure 2.5. The first process, "*IS conversion process,*" translates IS expenditures into IS assets. The second process, "*IS use process*," links IS assets with IS impacts on business processes. The third process, "*competitive process,*" links IS impacts with organizational performance.

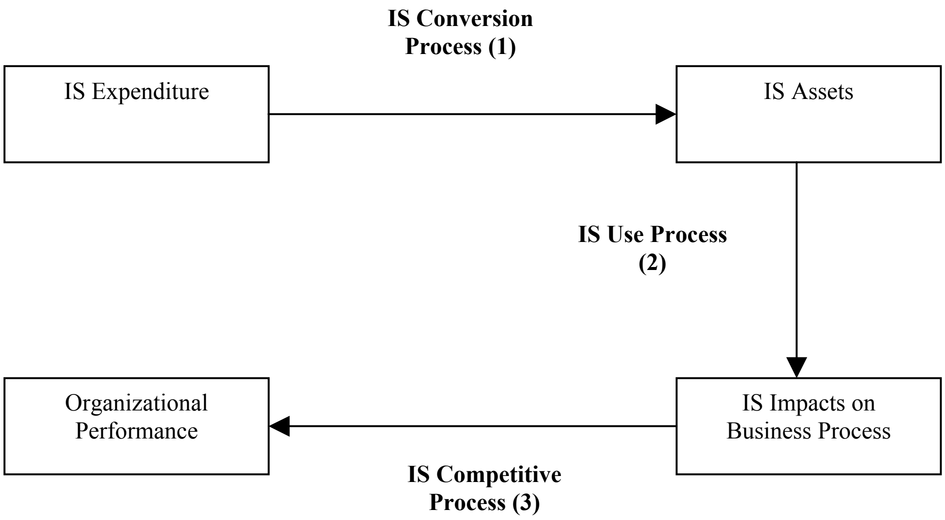

Figure 2.5 Soh and Markus (1995) Model with Three Processes

Beath et al. (1994): They propose a similar model involving two processes: the first one connects IS assets with IS-based business processes and the second connects one IS-based business processes with business value. They propose that IS assets improve organizational performance by affecting three intermediate processes: cycle time of application systems development, productivity of operations, and strategic alignment of planning.

Sambamurthy and Zmud (1994): They propose an "*IS impact*" model that consists of three sub-processes. The first process connects organizational input factors to IS management roles and processes, the second one connects IS management roles and processes to impacts on IS based business processes, and the third one connects impacts on IS-based business processes to business value.

In the light of the process-based models ordered above, King and Xia (2004) also propose a new process-based two-stage model to better understand the process through which the organizational impact of IS can be evaluated. As shown in Figure 2.6, the effects of IS can be captured at two levels through two sub-processes: a leverage process and a conversion process.

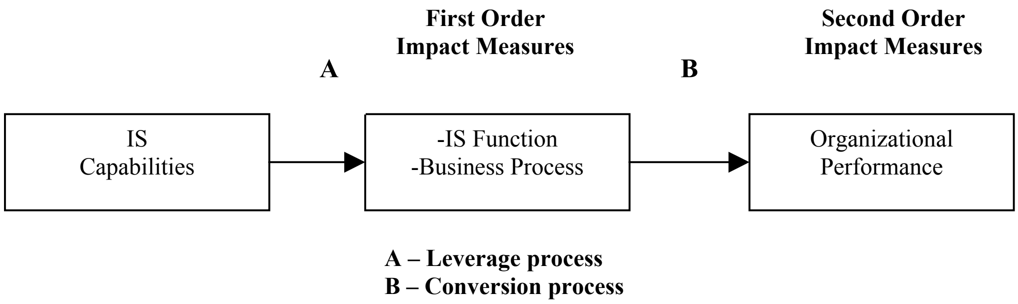

Figure 2.6 A Process-Based Model for the Organizational Impact of IS

Leverage process: The first sub-process captures the impact of IS on the intermediate processes. This sub-process is named as "*leverage process*" because it reflects the organization's effectiveness in leveraging its IS to deliver desired performance at the intermediate level. Two sets of intermediate processes are considered in the conceptual model: the overall IS function and the intermediate business processes.

Conversion process: The relationship between the first-order impact measures of IS on the intermediate processes and the second-order impact measures on organizational performance is referred as "*conversion process*." Since the ultimate goal of IS is to improve the effectiveness and performance of the organization, the conversion process represents the aggregated organization-level business value gained from the investments in IS.

While the leverage process represents the first-order impact of IS, the conversion process represents the second-order impact of IS. The effectiveness of each sub-process is a necessary condition to occur for any positive impact of IS. There must also be a fit or complementarity between the two sub-processes. In addition, the effectiveness of the leverage and conversion processes depends on not only the organization's ability to manage the boxes and linkages shown in Figure 2.6 but also the fit or complementarity between these sub-processes and other organizational factors and processes.

A research model is developed to investigate both impacts of IS on organizational performance and impacts mediated by the IS effects on IS functional effectiveness and business processes (see Figure 2.7).

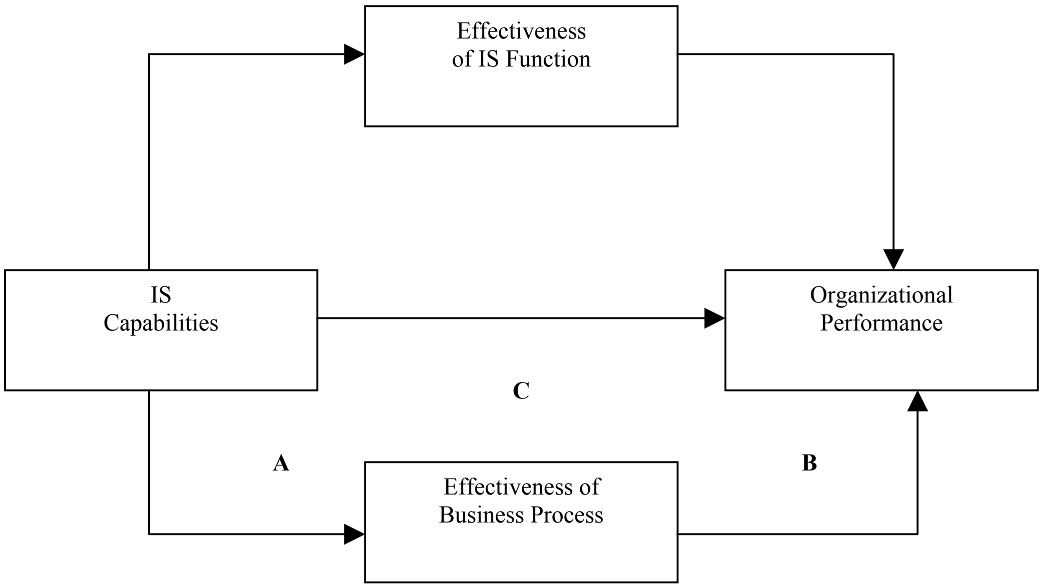

Figure 2.7 Research Model: Investigating the Effects of IS on Organizational Performance

IS Effects on Business Process (A, B, C): IS capabilities is proposed to have a first-order impact (leverage process) on the business processes' effectiveness which in turn produce a second-order impact (conversion process) on organizational performance. IS is unique in that it has implications for both operational and management processes (Mooney et al, 1996). IS can improve the efficiency of operational processes through automation, or enhance their effectiveness and reliability by linking them together. IS may enable the organization to reduce cycle time and production costs, improve quality and customer service, and increase sales. Similarly, management processes may be enhanced by information sharing, timely communications and improved decisions. The capabilities of an organization's IS positively affect the effectiveness of business processes: greater IS capabilities would lead to greater effectiveness of the business processes that they support (corresponds to A in Figure 2.7).

Organizations deliver their products and services and create value through their value chain activities. The effectiveness of the business activities and processes involved in the value chain are key factors that influence the overall performance of the organization. As the use of IS enables an organization to initiate new competitive strategies, to reduce the costs of product design, development, production, marketing, and sales, and to enhance internal and interorganizational efficiency, it would be expected that the organization's performance in terms of productivity, market share and profitability would be improved. The effectiveness of the business processes positively affects organizational performance (corresponds to B in Figure 2.7).

IS, no matter how effective, may be meaningless unless it is used and leveraged to improve the business activities that it supports. In other words, an effective IS is not the end itself, but rather, is a means for reaching the end. The mediating role of intermediate business processes between IS and organizational performance reflects another dimension of "*conversion effectiveness.*" As stated before, several models that advocate the mediating role of the intermediate business processes have been proposed. For example, Sambamurthy and Zmud (1994) propose that IS creates business value by delivering new and improved products and services, transforming business processes, enriching organizational intelligence, and creating more dynamic organizational structure. Markus and Soh (1993) contend that IS will not have any impact on organizational performance unless they are appropriately used to develop and improve products and services, redesign business processes, support better decision making, improve coordination and enhance productivity. Therefore, the impact of IS can manifest at intermediate levels through improvements of the business activities in the value chain. The capabilities of an organization's IS indirectly affect organizational performance through the business processes' effectiveness (corresponds to C in Figure 2.7).

In order to investigate the issues stated in A, B and C, King and Xia (2004) prepared a questionnaire. There were 285 responses from IS executives and 274 responses from business executives. The findings suggest that organizational performance increases when IS capabilities improve the business processes. The business processes can play a stronger role in converting IS capabilities into organization-level gains. This study states that the focus of management should not be on making IS investments or even on the more-sophisticated approach of creating specific IS capabilities. Rather, there is an emphasis that is put on achieving intermediate goals in terms of a manner in which IS capabilities are used to create more effective business processes which should be primary focus of management attention.

2.1.5.3 Özkan's Framework for the Assessment of IS Effectiveness

Özkan (2006) aims in this study to organize diverse research about IS effectiveness in the literature, as well as to present a more integrated view of IS effectiveness. She states that the extensive survey of the relevant literature point in the direction of an integrated approach to the assessment of IS effectiveness. In that regard, individual assessment frameworks considered comply with the needs only partially. Therefore, although they yield convenient solutions in practice, they do not fulfill all of the necessities.

The purpose of this research is to develop a comprehensive IS assessments framework using existing IS assessment theory as a base and incorporating theory from other disciplines. This assessment framework provides five maturity levels (0: Non-existent, 1: Initial/Ad Hoc, 2: Repeatable but Intuitive, 3: Defined Process, 4: Managed and Measurable, 5: Optimized) that define an ordinal scale for measuring the maturity of an information system in regard to its effectiveness. The conceptual model proposed in this study provides a solid basis for the IS processes. In addition, it extends previous studies by focusing on the processes relate with three major components that construct an information system: people, resources, services and benefits.

2.2 Analysis and Improvement of the Processes

This section investigates significance of the processes for the organizations and gives details about Business Process Change (BPC) study with its objectives, steps and techniques employed for measuring the changes in the processes. In this context, the close relationships between BPC and Information System (IS) studies are indicated and effects of IS on the processes are detailed and categorized.

2.2.1 Characteristics of the Process

Davenport (1993) defines process as "*a structured and measured set of activities designed to produce a specified output for a particular customer or market,"* and business process as "*a set of logically related tasks performed to achieve a defined business outcome.*" These definitions imply a strong emphasis on how work is done within an organization. They also emphasize the necessity of the process design according to the customer needs. In addition, Davenport (1993) takes attention to measurability property of the process. By means of this property, organizations can employ various techniques for measuring their processes and design new arrangements for satisfying customer expectations and consequently increase their business outcomes. These arrangements can be performed on the process structure, stated in the process definition, which includes inputs, a set of activities and outputs.

In parallel to the Davenport (1993) study, Hammer and Steven (1994) argues importance of the process oriented thinking for the success of the organizations. According to their points of view, process oriented studies should concentrate on the objectives and final outcomes. The measurements of the outcomes can demonstrate whether predefined targets have been achieved or not.

Another critical issue about the process is the distinction between process and task (Hammer, 1996). A task is "*a unit of work, a business activity normally performed by one person.*" A process, in contrast, "*is a related group of tasks that together create a result of value to customer.*" Based on these brief definitions, the difference between task and process is the difference between part and the whole. Hammer (2001) states that the problems that afflict modern organizations are process-based problems, not task problems. The problems lie not in the performance of individual tasks and activities, or the units of work, but in the process, how the units fit together into a whole. He concludes that, in order to achieve the performance levels that customers now demand, organizations must arrange and manage themselves around axis of the process.

2.2.2 Business Process Change (BPC) Studies

In a BPC study, whether in the form of improvement or reengineering, organizations examine their processes, identify ways to improve these processes, and address barriers that impede their ability to achieve their business goals in the most efficient manner (Harrington, 1991).

There are three steps as description, analysis and optimization in a BPC study. The goals and processes of the organization are determined in the description step. A set of understandable and repeatable structures is used for defining the processes. In the second step, available processes are analyzed and modeled according to the business users' points of view. With the optimization step, unnecessary processes are removed, inappropriate historical features and policy constraints are eliminated and new essential processes are added. At the end of the study, an intuitive and non-technical model representing how the business is conducted is produced. During the study, the interaction and coordination between people throughout the organization to deliver high quality services to their customers is emphasized. The result of the BPC study is a practical action plan for implementing the identified changes in the processes. The plan provides a blueprint for achieving the organization's goals and implementing the changes, while respecting the organization's strategic mission and culture.

BPC studies provide considerable benefits to the organizations. In the first sense, it provides a complete picture of an organization related to a set of processes. This picture helps the organization to understand how they use a system throughout the organization, to determine how it fits within their business, to identify potential pitfalls and to define specific requirements for a new or modified system. This kind of approach facilitates working with the organizations to help them to take the most appropriate decisions. The other benefits of the BPC studies are quickly creating and validating the process modeling with business users, bringing technical and management staff together, who generally do not speak the same language, helping them communicate and understand each other's roles and offering flexibility to the designers to effectively use new technologies or approaches. These benefits reveal the tendency of the BPC study to usage of technological tools and developments.

2.2.3 Techniques Employed in BPC Studies

In order to measure post-execute attributes such as outcomes and generated costs when the processes are executed, various techniques are used in BPC studies. Activity Based Costing (ABC) and Cost-Benefit Analysis (CBA) are the most common ones. ABC is a systematic and cause & effect method of assigning the cost of activities to products, services, customers or any cost object (Tunney and Reeve, 1992). It is based on "*products consume activities*" principle. This approach differs from traditional accounting techniques in such a way that traditional cost systems allocate costs based on direct labor, material cost, revenue or other simplistic methods, and ABC attributes costs based on the "*outputs,*" consumed in one unit production. ABC is generally used to get a better framework of the financial position of a company. Each unit of product or service is associated with a given cost and defined as "*value-added*" or "*non-value-added.*" It gives the designers the ability to identify high-cost activities. ABC also traces back previous indirect costs to their true sources and allocates them to each activity as direct costs, thereby showing a more accurate picture of the activity in terms of costs and benefits. ABC systems trace costs using multiple allocation methods in a Bill of Activity format. Many organizations use ABC for product costing, target costing, service pricing, customer profitability analysis and product line profitability analysis.

CBA is another technique used for the product-based measurement (Griffin, 1998). It is a systematic comparison of all the costs and benefits of proposed alternative schemes with a view of determining which scheme or combination of schemes will contribute most to the achievement of predetermined objectives at a fixed cost; or the magnitude of the benefit that can result from schemes requiring the minimum cost. In this sense, CBA is the analysis of an opportunity to demonstrate the benefits in cost saving in order to receive management commitment and support for the implementation. The most important part of that approach is the management commitment. The types of CBA opportunities can include adding staff, introducing new technologies, purchasing equipment, upgrading existing software and/or hardware, outsourcing or bringing service(s) in-house, changing vendors, modifying workflow, implementing (new) procedures, remodeling facilities, and relocating offices or a function.

Most of the techniques employed in BPC studies focus on post-execute metrics such as time and cost as exemplified in the ABC and CBA. These techniques provide the organizations with valuable information about whether the business outcomes have been achieved with reasonable costs or not. They can identify improvement issues such as considering activities having the highest costs or the longest cycle time. However, these measurements can be performed during or after the processes are executed. New arrangements such as changing vendors, modifying workflow or purchasing equipments are decided according to the measurement results. The impacts of the arrangements can only be measured, similarly, when the processes are re-executed.

In opposition to the various techniques adopted for measuring the processes in time and cost aspects, there are no widely used frameworks for quantitatively measuring the process quality. However, quality is the other critical aspect for the processes and provides considerable insights about the process internals. Moreover, process quality can be measured before the processes are executed therefore can give early feedbacks. As a complementary purpose, process quality studies can also be evaluated with the time and cost related models.

2.2.4 The Relations between BPC Studies and IS Development

There are mutual relationships between BPC studies and IS development. Typically, a BPC study allows the analysts to capture the broad outline and procedures that manage what a business does. This study answers some important questions such as "*where bottlenecks are*," *"where additional resources are needed*," "*where commitments are not being satisfied*," and "*how processes can be optimized*." These questions and their answers also form a basis for IS development. The IS development studies are arranged around answering these kinds of questions. In addition, as the BPC study has a broader range than just the IS considered, the BPC study provides an overview of where the proposed IS will fit into the organizational structure. This allows the analysts to clearly map what is in the scope of the proposed IS and what will be implemented in other ways such as using manual processes.

The other connection is that IS development recognizes the value of high quality BPC study as IS development is not just about building the system right, it's about building the right system.

2.2.5 Categorization of IS Effects on the Process

Organizations form and implement the processes to realize their missions. The processes of an organization can be categorized as operational and managerial processes (Mooney et al, 1996). Operational processes are those that embody the execution of tasks comprising the activities of an organization's value chain. In effect, operational processes constitute the "*doing of business.*" Managerial processes, on the other hand, are those activities associated with the administration, allocation, and control of resources within the organizations. These definitions distinguish between processes associated with primary business operations, and the others associated with information handling, coordination, and control that are required to ensure the efficiency and effectiveness of the primary operations. When the scopes of the operational and managerial processes are considered, the sub-processes of them can easily be detailed. In this sense, operational processes include production processes, design and development processes, maintenance and test processes, product/service delivery processes and acquisition and logistics processes. Managerial processes include information handling processes, coordination processes, communication processes and knowledge processes.

IS has considerable effects on both kinds of the processes. But, when the available studies are investigated, it is clearly noticed that few studies have focused on searching the relations between IS effects and the processes (Mooney et al, 1996). IS development affects operational processes in such a way of automating them by providing technologies of work flow systems, flexible manufacturing, data capture devices, imaging and computer aided design tools (CAD). IS can improve the efficiency of the operational processes through automation or enhance their effectiveness and reliability by establishing linkage among them. Similarly, IS study affects the managerial processes by providing electronic mail, database and decision support tools. These tools improve the efficiency and effectiveness of communications and decisions. These examples reveal the effects of IS study on the processes especially in process improvement studies. However, the effects of IS are not limited with only supports coming from automation in process improvement. IS is also recognized as having a critical role in Business Process Reengineering efforts (BPR), primarily as an enabler of new operational and managerial processes (Davenport, 1993). Organizations continuously keep in mind what IS provides to them and put their process designs that are better suited to the applications of IS.

There are studies for categorizing the IS effects on the processes. One of them is Davenport's study (Davenport, 1993). He concentrates on the effects of IS in the BPR perspective and identifies nine opportunities as automational, informational, sequential, tracking, analytical, geographical, integrative, intellectual, and disintermediating for the process innovation through IS effects. These opportunities cause redesigning current processes or innovating new ones.

There is also another categorization of IS effects on the processes (Mooney et al, 1996). In this classification, IS can have three separate but complementary effects on the processes. First, automational effects refer to the efficiency perspective in the process changes with the role of IS effects as a capital asset being substituted for labor. Within this dimension, effects are derived primarily from impacts such as productivity improvements, labor savings, and cost reductions. Second, informational effects emerge primarily from the IS's capacity to collect, store, process, and disseminate information. Following these operations, effects are accrued from improved decision quality, employee empowerment, decreased use of resources, enhanced organizational effectiveness, and better quality. Third, transformational effects refer to the process changes with the IS's ability to facilitate and support process innovation and transformation. The process changes associated with these effects will be manifested as reduced cycle times, improved responsiveness, downsizing, and service and product enhancement as a result of reengineered processes and redesigned organizational structures.

CHAPTER 3

A NEW MODEL FOR MEASURING PROCESS QUALITY

This chapter presents a new model that has been developed for measuring process quality attributes. The details of the model are given in five sections as objectives, foundations, scope, usage and categories.

3.1 Model Objectives

The objectives of the development of a model for measuring the process quality are briefly ordered below.

- *Providing complementary information about the process quality to the available time and cost related models.* Most of the available studies focus on time and on cost related metrics. However, there are no defined and widely used models for measuring quantitatively the other important aspect, quality. With the development of the model, processes can be measured by using quality metrics.
- *Providing the usage of process definitions for measuring the process quality.* Available models can only be performed after the processes are executed. By means of the model, process definitions can be used for measuring process quality. Therefore, process quality measurement provides early feedback about the process internals before they are executed.
- *Providing a model for measuring the effects of IS on the organizational impact dimension.* Most of the available studies classified in the organizational impact dimension consider measurement of economic issues such as costs, contributions to company profits and return on investment (Emery, 1971; DeLone and McLean, 1992; Seddon et al, 1999).

However, as the economic criteria are not so meaningful for public organizations, productivity gains can only be used to measure the IS effects on the organization. With the development of the model, these organizations will measure the IS effects on process quality. The model will provide a different point of view to the available studies, which are at the initial stage stated by DeLone and McLean (1992).

- *Investigating IS effects on organizational impact dimension in terms of process quality attributes.* Available models have limitations for understanding the IS effects. They do not clearly identify IS effects on the organization and its working (Mooney et al, 1996). However, with the development of the model, a quantitative measurement can be performed for measuring IS effects on the process quality attributes.

3.2 Model Foundations

The properties or characteristics of a process quality that may be affected by IS development or BPC studies constitute the core point of the model. Each influenced entity is named as "*attribute.*" In order to identify quality attributes for measuring process quality, the studies (Davenport, 1993; Hammer and Steven, 1994; Hammer, 1996; Hammer, 2001) about the characteristics of the processes have been evaluated. By utilizing the research studies about the process in the literature, some of the process quality attributes have been defined. For this purpose, Goal Question Metric (GQM) method (Basili, 1992) was used as an initiative. Some of the attributes such as dependency, complexity and accuracy were defined. However, these attribute definitions were remain to be exemplifying not explaining the quality attributes.

During the investigation of the quality attributes, the close relationships between process and software product directed the study to the software domain. Osterweil (1987) states some of the close relations between process and software. For instance, process and software product have similar logical structures. While a process is defined with inputs, a set of activities and outputs, a software product is defined with input parameters, a set of functions and output parameters. In this analogy, activity and functions, including tasks or operations to be performed, also matches logically to each other. Similar relation between software product and function exists between process and activity such that "*activity is one of the subunits of the process and represents a logical completeness in its context*." In addition, process and software constitutes a part of the whole and have interactions with the other parts.

In order to provide a more complete and acceptable quality attribute set, available software quality models were examined in the study (Boehm et al, 1976; McCall et al, 1977; ISO/IEC FCD 9126-1.2, 2000). It is widely accepted that the evaluation of software products in order to achieve software product quality is one of the processes in the software development life-cycle (ISO/IEC FCD 9126-1.2, 2000). Software quality can be evaluated by measuring internal attributes (typically static measures of intermediate products), or by measuring external attributes (typically by measuring the behavior of code when executed). The objective for the software product is to have the required effect in a particular context of use.

ISO/IEC 9126 Software Product Quality Model (ISO/IEC FCD 9126-1.2, 2000), one of the most widely used models, was used to extend the study. ISO/IEC 9126 describes a software product evaluation model for developing or selecting high quality software products. It presents a comprehensive specification and evaluation framework for ensuring software product quality. The software product is evaluated for every relevant quality characteristics in the model, by using validated and widely accepted metrics. ISO/IEC 9126 categorizes software quality attributes into six characteristics as functionality, reliability, usability, efficiency, maintainability and portability, which are further sub-divided into sub-characteristics. The sub-characteristics can be measured by internal or external metrics.

The structure of the new model is based on the ISO/IEC 9126. After the evaluation of the software quality model, software quality characteristics in ISO/IEC 9126 are redefined according to the process specific attributes and new characteristics unique to the processes are identified to extend the model. Based on these definitions process metrics are specified.

3.3 Model Scope and Details

The model is designed as having a four-level structure. The first level is called as "*category.*" There is one category as quality in the model. The second level is called as "*characteristic.*" Each category has its own characteristics. In the model, the quality category includes four main characteristics as maintainability, reliability, functionality and usability. As the efficiency characteristic is frequently employed in the time and cost related models, it is left out of the scope. The other characteristic, portability is also not included in this phase to focus on the basic process characteristics. The third level is for "*sub-characteristic*" and finally, fourth level is for "*metrics*" for measuring the process quality "*attributes.* " The model can be extended in future studies by adding new categories, characteristics, sub-characteristics and attributes based on organizational needs.

The attributes defined in the model are not intended to be an exhaustive set. Users of this model can select or modify and apply metrics from this model or may define application specific metrics for their individual application domain. Intended users of this model include evaluator (an individual or organization that performs an evaluation), developer (an individual or organization that performs a development activities), maintainer (an individual or organization that performs maintenance activities), user (an individual or organization that uses the process to perform a specific function) and quality manager (an individual or organization that performs a systematic examination of the process) when evaluating the process quality as part of quality assurance and quality control. When using a modified or a new non-identified metric in the model, the user should specify how the metric relates to the model and give detailed information about its measurement (as given in Table 3.1).

3.4 Model Usage

The process quality metrics can be applied to process definitions. These definitions are detailed in the process activity level with activity name, activity definition, actors, and forms, reports, archival records, applications or other tools used in the activity.

The metrics provide the users with the ability to measure the quality of the activities and thereby predict the quality of the process. This allows the users to detect quality issues and take corrective actions during the early stages of the development. The user can measure the extent to which the process satisfies his or her quality expectations.

There are two basic inputs for the measurement. The first one is the process definitions of candidate processes, "*AS-IS in practice.*" The process modeling with a suitable graphical notation will be helpful for depicting the interactions among processes and also their activities. The second one is available as regulatory or guideline documents, "*process in theory*" about the processes in the organization where the processes are operated currently. These documents indicate process flows or list of rules, and also constraints that the processes should stay within. The process quality attributes are measured by comparing the AS-IS modeling of processes with processes defined in the documents. The results will make out the conformance of "*AS-IS forms of the processes*" to the "*processes in theory.*"

Instead of using the AS-IS modeling, TO-BE modeling of the processes can be used in the measurement. For this case, TO-BE model of the processes is compared to the "*process in theory*" (after updating necessary changes on the regulatory or guideline documents in the organization according to the new arrangements) and quality attributes are calculated.

When the model is applied to both AS-IS and TO-BE forms of the same processes, the impacts of the new arrangements on the processes are measured in terms of the quality attributes. In this way, users can measure the effects of IS studies on their processes by using the process definitions.

The metric definitions in the model is detailed by using the fields listed in Table 3.1. The reason for the usage is given in the "*purpose of the metric.*" The information about how the measurement is performed is explained in the "*method of application.*" The formula and its usage are indicated in the "*measurement formula and data element computations.*" The type of the result is identified in the "*measurement type.*" Preferred result value and its range are given in the "*interpretation of measured value.*" The information about whether the metric is developed by making some adaptations from ISO/IEC 9126 or is newly defined in the model is explained in the "*reference.*" The inputs used in the measurement are defined in the "*input to the measurement.*" The fields "*focus*" and "*guidance for identifying the attribute*" include guiding issues about the attribute.

Table 3.1 Metric Details

Metric name	Provides name of the metric
Purpose of the metric	Defines reason for the usage
Method of application	Provides an outline of the application
Measurement formula and data element computations	Provides measurement formula and explains the meanings of the used data elements
Measurement type	Gives information about the type used, for instance "count type" for number of decisions or number of fault avoidance mechanisms
Interpretation of measured value	Provides range and preferred values
Reference	Provides reference to ISO/IEC 9126 Software Product Quality Model for adapted or redefined metrics or states the new development
Input to measurement	Provides names of the documents such as process modeling document with graphical representation, regulatory documents or guidelines about processes in the organizations that are taken into consideration during the measurement
Focus	Defined focus during the measurement (e.g. focus may be on tasks within activity itself, on its outputs, on the decisions taken, or on the interactions with other processes, etc.)
Guidance for identifying the attribute	Provides questions for investigating the attribute in the activities
Assumptions and constraints	States assumptions about attribute such as using "number of activity" for representing size of the process and constraints such as necessity of some documents for measuring the attribute

3.5 Quality Category

17 attributes are defined under the defined characteristics (see Figure 3.1). Each metric is specified in detail as specified in Table 3.1. In metrics specifications, "number of activities" is used to normalize the result. However both such usage and requirements for the granularity of activities requires further clarification.

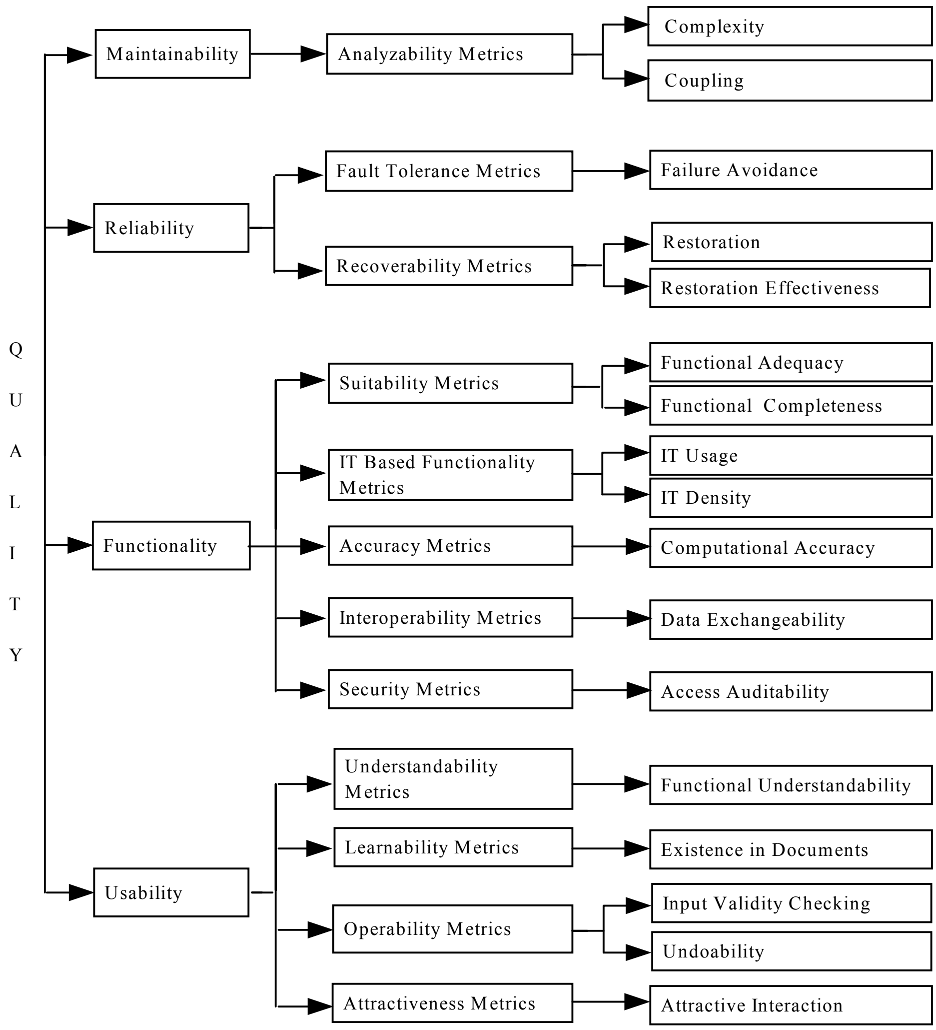

Figure 3.1 Specified Attributes

3.5.1 Maintainability Metrics

Maintainability metrics are used for examining the level of effort required for maintaining the process activities. This effort is investigated in the model in Analyzability perspective.

3.5.1.1 Analyzability Metrics

Analyzability metrics are used for examining the staffs' or maintainers' spent efforts or spent resources in trying to diagnose the deficiencies or causes of failures, or identification of parts to be modified in the process activities.

Two metrics are defined in the model as "*complexity*" and "*coupling*" for measuring the analyzability of the process activities.

A. Complexity:

Complexity is one of the factors affecting traceability and therefore analyzability of the process. Number of process activities, number of decisions (with their types as structured, unstructured and semi-structured) and number of staff employed in a process are examples of such factors. For instance, the analyzability of a process is directly affected in harder way when number of decision points and associated branches in that process increase. In that case, finding and fixing an error in the process flow requires much more time and attention. New arrangements can repair the current error, but may cause different troubles.

Similar to the process concept, complexity is also a critical issue in the software. Cyclomatic complexity is one of the techniques used in the software for measuring the complexity (McCabe, 1976), and defined as "*one larger number of decision points in software flow.*" It is assumed that high number of decision points makes analyzability of the software difficult. The increase in the number of decision points adds new branches to the software flow, which results in higher complexity and consequently more difficult analyzability.

In the model, the cyclomatic complexity technique was adapted to the process concept for measuring the complexity of a process. It is defined as "*number of decision points in process activities.*" This measurement gives insight about the complexity of the process from a perspective based on the number of decision points (see details in Table 3.2).

In order to provide more sensitive complexity measurement, classification of the structural decisions, as structured, unstructured and semi structured, are added to this development. Each decision type is counted separately in the model by implementing the following brief definitions.

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

B. Coupling:

Coupling is another factor affecting traceability and therefore analyzability of the process. This metric examines interactions in the process flow with other processes in an organization. The analyzability of a process becomes harder when number of interactions (it may also be called as "*dependencies*") increases. Investigation of a problem involves tracing dependent processes as well. In that case, finding and fixing an error in the process flow requires much more time and effort.

Similar to the process concept, coupling is also a critical issue in the software. Coupling is defined as "*number of communications with other software modules*" for a software module. The increase in the number of dependent software modules results in higher difficulty in the analyzability of the software module.

In the model, software coupling technique was adapted to the process concept for measuring coupling of the process. It is defined as "*number of interactions with other processes.*" The interactions are accomplished for transferring data, forms or documents among the processes.

Table 3.2 Complexity Metric

Metric name	Complexity
Purpose of metric	Calculate complexity of the process from the perspective based on the number of decision points
Method of application	Count decisions which necessitate different branches in the process flow and compare its number with the number of activities
Measurement formula and data element computations	X = 1- A / B, for overall evaluation A = Number of decisions B = Number of activities In detail, each decision type is counted separately. X (1) = 1- A / B, for structured decisions A = Number of structured decisions B = Number of activities X (2) = 1- A / B, for unstructured decisions A = Number of unstructured decisions B = Number of activities X (3) = 1- A / B, for semi-structured decisions A = Number of the semi-structured decisions B = Number of activities
Measurement type	X = 1- count / count (A = count, B = count)
Interpretation of measured value	0 < = X < = 1 The higher value of X (1), X (2), X (3), the better analyzability
Reference	Adapted from "complexity" metric of ISO/IEC 9126 Software Product Quality Model
Input to measurement	Process definitions in the activity level, process modeling diagrams
Focus on	Decision points in process activities
Guidance for identifying decisions in the process	Condition sentences in the process activity definitions show possible decisions in the process. Complexity is the count of *If <condition, ……> then <tasks to be done> else <other tasks to be done>* sentences and categorization according to the decision types. This notation represents branching to a different flow in the process. The following questions help for finding the decisions in the process. • Are there decisions taken by staff or managers in the process that require different tasks? • Are there different branches in the process depending on the different conditions?
Assumptions and constraints	Assumption 1: "number of activity" is assumed as size of the process and used to normalize the result. Assumption 2: All activities are assumed to be prepared in the same granularity.

This measurement gives insight about dependencies of the process to other processes in an organization from a perspective based on the number of interactions (see details in Table 3.3). Simple connections among processes results in easier tracing and understanding and therefore easier analyzability of the process.

Table 3.3 Coupling Metric

Metric name	Coupling
Purpose of metric	Calculate coupling of the process from a perspective based on the number of interactions
Method of application	Count interactions with other processes and compare with number of activities
Measurement formula and data element computations	X = 1- A / B A = Number of interactions B = Number of activities
Measurement type	X = 1- count / count (A = count, B = count)
Interpretation of measured value	0 < = X < = 1 The higher value of X, the better analyzability
Reference	Defined in the model
Input to measurement	Process definitions in the activity level, process modeling diagrams
Focus on	Data transfers among processes
Guidance for identifying interactions in the process with other processes	Names of processes in the activity definitions represent possible interactions. The following questions help for identifying the interactions with other processes. • Are there data, forms or documents received from or send to other processes? • Are there situations, which wait responses from other processes or send results to them?
Assumptions and constraints	Assumption 1: “number of activity” is assumed as size of the process and used to normalize the result. Assumption 2: All activities are assumed to be prepared in the same granularity.

3.5.2 Reliability Metrics

Reliability metrics are used for examining capabilities of the process activities for designing more reliable process. For this purpose, process activities are investigated in the perspectives of Fault Tolerance and Recoverability.

3.5.2.1 Fault Tolerance Metrics

Finding possible faults that may occur in the process activities by using various techniques and applying arrangements for avoiding them is one of the issues about process reliability. When the reliability requirements described by the organization are achieved, the process will be as it is projected and far from the faults as much as possible

In order to measure fault tolerance in a point of view, a quality attribute, named as *"failure avoidance"* is defined in the model.

A. Failure Avoidance:

The term "*failure*" is used in the model for user-based mistakes such as mistakes in selecting, filling or updating forms, documents, records… etc., made by the staff or managers in the process activities.

The reviews, inspections, checkpoints or similar techniques in the process flow are accepted as "*failure avoidance*" in the model. These kinds of techniques help the staff to recognize their mistakes. The increase in the number of failure avoidance techniques will affect the reliability of the process positively. During the measurement of this quality attribute, number of failure avoidance techniques applied in the process activities is identified and where they are used is examined (see details in Table 3.4).

3.5.2.2 Recoverability Metrics

Recoverability metrics are used for assessing process activities' capability to re-establish an adequate level of performance and recover the data directly affected in case of a failure.

Two metrics are given for the measurement as "*restorability*" and "*restoration effectiveness*." The first metric, "*restorability,*" is defined for examining whether the activities are recorded or not. The second metric, *"restoration effectiveness,"* is defined for investigating whether the activities can be restored from the records when an abnormal event occurs.

Table 3.4 Failure Avoidance Metric

Metric name	Failure Avoidance
Purpose of metric	Identify failure avoidance techniques employed in the process activities to avoid from user-based mistakes
Method of application	Count activities in which review, inspection, checkpoint or similar techniques are applied and compare it 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
Measurement type	X = count / count (A = count, B = count)
Interpretation of measured value	0 < = X < = 1 The higher value of X, the better failure avoidance
Reference	Adapted from "failure avoidance" metric of ISO/IEC 9126 Software Product Quality Model
Input to measurement	Process definitions in the activity level, process modeling diagrams, documents (e.g. regulation, guideline, rules) about process in organization
Focus on	Reviews, inspections, checkpoints or similar techniques applied in the process
Guidance for identifying failure avoidance mechanisms in the process	Questions for identifying failure avoidance techniques. • Are there reviews or checkpoints for controlling activities whether they are going on correctly? • Are there guiding documents or forms used by the staff while performing the activities? • Are there techniques applied for better and consistent data entry?
Assumptions and constraints	Assumption 1: "number of activity" is assumed as size of the process and used to normalize the result. Assumption 2: All activities are assumed to be prepared in the same granularity.

A. Restorability:

Restorability metric is used for examining the activities and deciding whether they are recorded or not. It is assumed that restoration of an activity can't be realized if this activity is not recorded (e.g. recoding of requests, results or duties to forms or documents). In other words, only recorded activities may be restored when an abnormal event such as damaged or missed forms or documents in manual processes and crash in computer systems in IS supported processes occurs (see details in Table 3.5).

Table 3.5 Restorability Metric

Metric name	Restorability
Purpose of metric	Identify restorability of the process activities (How completely are the activities recorded?)
Method of application	Count the number of activities which are recorded and compare it with the number of activities
Measurement formula and data element computations	X = A / B A = Number of activities which are recorded on paper or computerized environment B = Number of activities
Measurement type	X = count / count (A = count, B = count)
Interpretation of measured value	0 < = X < = 1 The higher value of X, the better restorability
Reference	Adapted from "restorability" metric of ISO/IEC 9126 Software Product Quality Model
Input to measurement	Process definitions in the activity level, process modeling diagrams, documents (e.g. regulation, guideline, rules) about process in organization
Focus on	Recording of activities
Guidance for identifying restorability of forms, documents and other media used in the process	Questions for identifying restorability of activities. • Are results, requests or duties that take place in the activity recorded? • Are there rules that oblige recording the activities by means of forms, documents or archival records?
Assumptions and constraints	Assumption 1: "number of activity" is assumed as size of the process and used to normalize the result. Assumption 2: All activities are assumed to be prepared in the same granularity.

B. Restoration Effectiveness:

This metric investigates effectiveness of restoring recorded activities. This attribute includes methods used in preparing, deleting or updating forms, reports, archival records or similar other documents in both manual and IS supported processes (see details in Table 3.6). Recording forms, documents and archival records to different documents or preparing more than one copy are some examples, which provide restoration effectiveness for manual processes. When a form is missed or damaged, its data recorded in other documents or its second copy can be used for reducing lost data as much as possible.

The backups prepared in computerized environment are the examples given for restoration effectiveness in IS supported processes. The backup files are restored and the necessary data can be accessed in a data lost situation.

Table 3.6 Restoration Effectiveness Metric

Metric name	Restoration Effectiveness
Purpose of metric	Identify restoration effectiveness of the activities (How much effective is the restoration capability?)
Method of application	Count the number of activities which can be restored by using the records in paper-based or computerized 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 total 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 The former formula measures the restoration effectiveness by considering all activities whether recorded or not, while the latter formula measures the restoration effectiveness by considering only recorded activities.
Measurement type	X = count / count (A = count, B = count)
Interpretation of measured value	0 < = X < = 1 The higher value of X, the better restorability effectiveness
Reference	Adapted from "restoration effectiveness" metric of ISO/IEC 9126 Software Product Quality Model
Input to measurement	Process definitions in the activity level, process modeling diagrams, documents (e.g. regulation, guideline, rules) about process in organization
Focus on	Restoring activities from recorded sources (e.g. in paper or computerized environment)
Guidance for identifying restoration effectiveness of forms, documents and other media used in the process	Questions for the restoration effectiveness of activities: • What can be done when a hard copy is missed or damaged? • Are there any backups for the soft copy of the records or files?
Assumptions and constraints	Assumption 1: "number of activity" is assumed as size of the process and used to normalize the result. Assumption 2: All activities are assumed to be prepared in the same granularity.

3.5.3 Functionality

Functionality metrics are defined for investigating process activities in the perspectives based on Suitability, Functionality in terms of Information Technology (IT), Accuracy, Interoperability and Security separately.

Each sub-characteristic and its metrics are defined below.

3.5.3.1 Suitability Metrics

In an organization, each process is defined by activities and goals. With suitability metrics, activities of a process are examined in functionality perspective to decide whether they are suitable or not to the organizational rules and regulations. For this purpose, regulatory documents are used in the measurement.

Two metrics are given in the model as "*functional adequacy*" and "*functional completeness.*"

A. Functional Adequacy:

Activities in a process are defined by activity names, tasks, actors and all documents used in carrying out the tasks. These definitions bring some expectations along with the activities. With functional adequacy attribute, there is an evaluation in the model for each process by comparing its performed activities in practice, "*activities in practice,*" and defined activities in the regulatory documents, "*activities in theory.*"

The aim is to be able to measure how close the practice to the theory (see details in Table 3.7).

The deficiencies in accomplishing tasks and the discrepancies in expected outputs are the main criteria in deciding on the adequacy of the activity.

B. Functional Completeness:

This metric investigates activities that are defined within regulation, but missing in practice (see details in Table 3.8).

Table 3.7 Functional Adequacy Metric

Metric name	Functional Adequacy (How much adequate are the activities in practice?)
Purpose of metric	Identify adequacies or inadequacies of the process activities in practice
Method of application	Count the number of activities that are adequate for performing the tasks as prescribed in the regulatory documents and compare it 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
Measurement type	X = count / count (A = count, B = count)
Interpretation of measured value	0 < = X < = 1 The higher value of X, the better functional adequacy
Reference	Adapted from "functional adequacy" metric of ISO/IEC 9126 Software Product Quality Model
Input to measurement	Process definitions in the activity level, process modeling diagrams, documents (e.g. regulation, guideline, rules) about process in organization
Focus on	Differences between activities in practice and activities defined in the regulatory documents
Guidance for identifying functional adequacy of an activity	Questions for identifying functional adequacy of activities. • Are there discrepancies that impede the activity from satisfying the expectations? • Are there inconsistencies between the activity in practice and the activity in theory?
Assumptions and constraints	Assumption 1: "number of activity" is assumed as size of the process and used to normalize the result. Assumption 2: All activities are assumed to be prepared in the same granularity. Assumption 3: Regulatory document is available in the organization.

3.5.3.2 IT Based Functionality Metrics

As software products run on hardware as a matter of fact, there are no metrics about IT based functionality in the ISO/IEC 9126 Software Product Quality Model.

The usage of IT in the process activities is not compulsory, however, it provides some important advantages such as automating activities by connecting them to each other, minimizing the number of user based mistakes and taking backups in computerized environments. For this reason, two new metrics are defined for the processes in this model, as "*IT usage*" and *"IT density."*

Table 3.8 Functional Completeness Metric

Metric name	Functional Completeness (How much complete is the functional implementation?)
Purpose of metric	Identify missing activities in practice
Method of application	Count the number of missing activities detected in practice and compare it 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
Measurement type	X = count / count A = count B = count
Interpretation of measured value	0 < = X < = 1 The higher value of X, the better functional completeness
Reference	Adapted from "functional implementation completeness" metric of ISO/IEC 9126 Software Product Quality Model
Input to measurement	Process definitions in the activity level, process modeling diagrams, documents (e.g. regulation, guideline, rules) about process in organization
Focus on	Missing activities in practice
Guidance for identifying missing activities in the process	Questions for identifying missing activities in practice. • Are there any unsatisfied goals although all activities are well performed? • Are there requirements as a practice for existence of a new activity? • Are there activities that are defined in regulatory document, but not implemented in practice?
Assumptions and constraints	Assumption 1: "number of activity" is assumed as size of the process and used to normalize the result. Assumption 2: All activities are assumed to be prepared in the same granularity. Assumption 3: Regulatory document is available in the organization.

A. IT Usage:

IT usage metric investigates the use of IT applications in the process activities. Each activity is examined to determine whether IT usage is present or not (see details in Table 3.9).

Table 3.9 IT Usage Metric

Metric name	IT Usage (What is the proportion of IT usage in the process?)
Purpose of metric	Identify IT usage in the process activities
Method of application	Count the number of activities in which IT applications are used and compare it 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
Measurement type	X = count / count A = count B = count
Interpretation of measured value	0 < = X < = 1 The higher value of X, the more IT usage
Reference	Defined in this model
Input to measurement	Process definitions in the activity level, process modeling diagrams
Focus on	IT applications in activities
Guidance for identifying IT usages in the process	Questions for identifying IT usage in activities. • Is there any use of hardware or software tools for data storage, arrangement, control or query purposes? • Are there any automatic data arrangements or controlling mechanisms in the activities?
Assumptions and constraints	Assumption 1: "number of activity" is assumed as size of the process and used to normalize the result. Assumption 2: All activities are assumed to be prepared in the same granularity.

B. IT Density:

IT density metric examines the use of IT applications in preparation, deletion, updating or searching forms, reports, archival records or other similar documents in the process activities (see details in Table 3.10).

3.5.3.3 Accuracy Metrics

Accuracy metrics investigate process activities whether they achieve acceptable or agreeable results.

One metric is defined in this model as "*computational accuracy*."

Table 3.10 IT Density Metric

Metric name	IT Density (How much IT density is there in the process?)
Purpose of metric	Identify the use of IT applications in preparation, deletion, updating or searching purposes
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 it 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
Measurement type	X = count / count (A = count, B = count)
Interpretation of measured value	0 < = X < = 1 The higher value of X, the more IT density
Reference	Defined in the model
Input to measurement	Process definitions in the activity level, process modeling diagrams
Focus on	IT usages in preparation, deletion, updating or searching forms, reports, archival records or similar other documents
Guidance for identifying IT usages for preparation of forms, documents and archival records	Questions for identifying IT density in activities. • Are there any forms or documents prepared in paper-based environment? • Are there documents or forms prepared in computerized environment?
Assumptions and constraints	Assumption 1: "number of activity" is assumed as size of the process and used to normalize the result. Assumption 2: All activities are assumed to be prepared in the same granularity.

A. Computational Accuracy:

This metric examines the implementation of the accuracy requirements that are specifically defined in the regulatory documents of the organization (see details in Table 3.11).

It indicates the amount of implemented requirements that are specifically defined in the regulatory documents of the organization.

Table 3.11 Computational Accuracy Metric

Metric name	Computational Accuracy (How completely the implementation of accuracy requirements is achieved?)
Purpose of metric	Identify implementation of the accuracy requirements in practice
Method of application	Count the number of activities in which accuracy requirements have been implemented as defined in the regulatory document and compare it 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
Measurement type	X = count / count A = count B = count
Interpretation of measured value	0 < = X < = 1. The closer to 1, the more accurate
Reference	Adapted from "computational accuracy" metric of ISO/IEC 9126 Software Product Quality Model
Input to measurement	Process definitions in the activity level, process modeling diagrams, documents (e.g. regulation, guideline, rules) about process in organization
Focus on	Accuracy requirement definitions in process activities
Guidance for identifying accuracy requirements in practice	Questions for identifying implementation of accuracy requirements in practice. • Are there specifically defined accuracy requirements in the regulatory documents? • Do the staff implement specific accuracy requirements as defined in regulatory documents?
Assumptions and constraints	Assumption 1: "number of activity" is assumed as size of the process and used to normalize the result. Assumption 2: All activities are assumed to be prepared in the same granularity. Assumption 3: Regulatory document is available in the organization.

3.5.3.4 Interoperability Metrics

Interoperability metrics investigate process activities that have interactions with other processes in the organization.

One metric is defined for the measurement as "*data exchangeability*."

A. Data Exchangeability:

Data exchangeability metric takes the data, which is received from the interacted processes into account and investigates the ability of the data usage without any additional operations (see details in Table 3.12).

Table 3.12 Data Exchangeability Metric

Metric name	Data Exchangeability
Purpose of metric	Identify operations applied to the data received from another process
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 it with the number of activities which have interactions with other processes
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.
Measurement type	X = count / count A = count B = count
Interpretation of measured value	0 <= X <= 1. The closer to 1, the more data exchangeability
Reference	Adapted from "data exchangeability" metric of ISO/IEC 9126 Software Product Quality Model
Input to measurement	Process definitions in the activity level, process modeling diagrams, documents (e.g. regulation, guideline, rules) about process in organization
Focus on	Use of the transferred data in process activities
Guidance for identifying operations performed on the received data	Questions for identifying use of data in received process. • Are there any operations applied to the transferred data in the activity before using it? • Can the data be used in the activity as it is transferred?
Assumptions and constraints	Assumption 1: "number of activity" is assumed as size of the process and used to normalize the result. Assumption 2: All activities are assumed to be prepared in the same granularity.

3.5.3.5 Security Metrics

Security metrics investigate accesses to the data for reading, deleting or updating purposes (e.g. in forms, documents, or archival records) in the process activities. One metric is given for the measurement as "*access auditability*."

A. Access Auditability:

This metric investigates auditability of the accesses to data sources in the process activities. The identity of the person who has accessed to data sources is examined by means of this attribute (see details in Table 3.13).

Table 3.13 Access Auditability Metric

Metric name	Access Auditability (How auditable is access to the data?)
Purpose of metric	Identify auditability of the accesses in the process activities
Method of application	Count the number of the activities in which there is access to data and the access can be audited and compare it 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
Measurement type	X = count / count (A = count, B = count)
Interpretation of measured value	0 < = X < = 1. The closer to 1, the more auditable
Reference	Adapted from "access auditability" metric of ISO/IEC 9126 Software Product Quality Model
Input to measurement	Process definitions in the activity level, process modeling diagrams, documents (e.g. regulation, guideline, rules) about process in organization
Focus on	Auditability of accesses in process activities
Guidance for identifying accesses to forms, documents and archival records	Questions for identifying access auditability in process. • Can accesses to forms, documents, or archival records be audited in activity? • Is it possible to identify the actors who performed the operations? • Are there requirements for new access auditability methods in the activity?
Assumptions and constraints	Assumption 1: "number of activity" is assumed as size of the process and used to normalize the result. Assumption 2: All activities are assumed to be prepared in the same granularity.

3.5.4 Usability

Usability metrics are used for examining the extent to which process activities in question can be understandable, learnable, operable and attractive.

These metrics are investigated in perspectives based on Understandability, Learnability, Operability and Attractiveness.

3.5.4.1 Understandability Metrics

Understandability metrics examine easiness or difficultness encountered by the staff in understanding process activities.

These metrics assess whether the staff can understand the usability of the process for particular tasks.

One metric is defined for the measurement as *"functional understandability."*

A. Functional Understandability:

This metric assesses understandability of the process activities by the staff (see details in Table 3.14).

3.5.4.2 Learnability Metrics

Learnability metrics examine how long it takes to the staff to learn the usage of a particular activity from documents.

Learnability is strongly related to understandability, so understandability measurements can be indicators of the learnability potential of the process.

One metric is defined for the measurement as *"existence in documents."*

A. Existence in Documents:

This metric examines available documents about the process and measures what proportion of activities are described in them. This metric does not measure the completeness, adequacies or correctness of the descriptions in the documents (see details in Table 3.15).

Table 3.14 Functional Understandability Metric

Metric name	Functional Understandability (What proportion of the process activities can the staff understand?)
Purpose of metric	Identify difficulties in understanding process activities
Method of application	Count the number of activities of which purposes and tasks are understood by the staff and compare it 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
Measurement type	X = count / count A = count B = count
Interpretation of measured value	0 <= X <= 1 The closer to 1, the better understandability
Reference	Adapted from “function understandability” metric of ISO/IEC 9126 Software Product Quality Model
Input to measurement	Process definitions in the activity level, process modeling diagrams, documents (e.g. regulation, guideline, rules) about process in organization
Focus on	Misunderstandings or difficulties in understanding process activities
Guidance for identifying understandability of the activity	Questions for identifying functional understandability of activities. • Are there issues that should be explained for accomplishing the activity correctly? • Do the staff experience difficulties in comprehending the activities?
Assumptions and constraints	Assumption 1: “number of activity” is assumed as size of the process and used to normalize the result. Assumption 2: All activities are assumed to be prepared in the same granularity.

3.5.4.3 Operability Metrics

Operability metrics examine easiness provided to the staff for operating and controlling the process while performing the activities.

Two metrics are defined for the measurement as *“input validity checking”* and “*undoability*.”

Table 3.15 Existence in Documents Metric

Metric name	Existence in Documents (What proportion of the process activities is described in the documents?)
Purpose of metric	Identify the descriptions about the process activities in documents (e.g. in the regulatory or help documents)
Method of application	Count the number of activities described in the available documents and compare it 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
Measurement type	X = count / count A = count B = count
Interpretation of measured value	0 <= X <= 1 The closer to 1, the more complete documentation
Reference	Adapted from "completeness of user documentation and/or help facility" metric of ISO/IEC 9126 Software Product Quality Model
Input to measurement	Process definitions in the activity level, process modeling diagrams, documents (e.g. regulation, guideline, rules) about process in organization
Focus on	Documentations about process activities in the organization
Guidance for identifying existence in documents	Questions for identifying descriptions of the activities in the available documents. • Can staff obtain needed information from documents to learn the activities? • Can staff take information about an activity when they experience difficulties in practice?
Assumptions and constraints	Assumption 1: "number of activity" is assumed as size of the process and used to normalize the result. Assumption 2: All activities are assumed to be prepared in the same granularity. Assumption 3: Regulatory document is available in the organization.

A. Input Validity Checking:

Input validity checking metric examines the process activities in terms of checking implementation for their input parameters (see details in Table 3.16). This metric indicates the amount of activities for which input parameters can be checked.

Table 3.16 Input Validity Checking Metric

Metric name	Input Validity Checking (What proportion of the process activities provide check for valid data for their input parameters)
Purpose of metric	Identify the validity checking possibilities for input parameters in the process activities
Method of application	Count the number of activities in which checking for valid data is provided for input parameters and compare it 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
Measurement type	X = count / count A = count B = count
Interpretation of measured value	0 <= X <= 1 The closer to 1, the better input validity checking in the activities
Reference	Adapted from "input validity checking" metric of ISO/IEC 9126 Software Product Quality Model
Input to measurement	Process definitions in the activity level, process modeling diagrams, documents (e.g. regulation, guideline, rules) about process in organization
Focus on	Possibilities for input parameter validity checking in the process activities
Guidance for identifying input validity checking operation	Questions for identifying input validity checking in the process. • Can the staff realize the validity of input parameters while performing the activity? • Are there situations where mistakes may be done due to the input parameter invalidity?
Assumptions and constraints	Assumption 1: "number of activity" is assumed as size of the process and used to normalize the result. Assumption 2: All activities are assumed to be prepared in the same granularity.

B. Undoability:

This metric examines undoability of the recorded process activities after they are completed (see details in Table 3.17).

This metric indicates the amount of recorded activities which can be undo after they are completed.

Table 3.17 Undoability Metric

Metric name	Undoability (What proportion of the process activities can be undo?)
Purpose of metric	Identify the undoability of the process activities
Method of application	Count the number of the recorded activities which can be undone after they are completed and compare it 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 total activities Another formula measuring undoability can be given as below: X = A / B A = Number of activities which can be undone B = Number of recorded activities The former formula measures the undoability by considering all activities whether recorded or not, while the latter formula measures the undoability by considering only recorded activities.
Measurement type	X = count / count (A = count, B = count)
Interpretation of measured value	0 <= X <= 1 The closer to 1, the better undoability
Reference	Adapted from "user operation undoability" metric of ISO/IEC 9126 Software Product Quality Model
Input to measurement	Process definitions in the activity level, process modeling diagrams, documents (e.g. regulation, guideline, rules) about process in organization
Focus on	Undoing the process activities after they are completed
Guidance for identifying undo operation	Questions for identifying undoability in the process. • Are there situations requiring undo operation and return back to former data? • Can operations performed on forms, documents, and archival records be undone when the staff member does mistakes?
Assumptions and constraints	Assumption 1: "number of activity" is assumed as size of the process and used to normalize the result. Assumption 2: All activities are assumed to be prepared in the same granularity.

3.5.4.4 Attractiveness Metrics

Attractiveness metrics examine appearance of the process activities. These metrics are influenced by factors such as design of forms and documents.

One metric is given for the measurement as *"attractive interaction."*

A. Attractive Interaction:

Attractive interaction metric examines design and use of forms, reports and archival records or similar other documents in the process activities (see details in Table 3.18).

Table 3.18 Attractive Interaction Metric

Metric name	Attractive Interaction (How attractive is the interface of the process to the staff?)
Purpose of metric	Identify difficulties or easiness in preparation, deletion or updating forms, reports, archival record or similar other documents used in the process activities
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 it 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 total 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.
Measurement type	X = count / count (A = count, B = count)
Interpretation of measured value	0 <= X <= 1 The closer to 1, the more attractive interaction
Reference	Adapted from "attractive interaction" metric of ISO/IEC 9126 Software Product Quality Model
Input to measurement	Process definitions in the activity level, process modeling diagrams, documents (e.g. regulation, guideline, rules) about process in organization
Focus on	Attractive interaction of forms, documents and archival records used in the process activities
Guidance for identifying attractive interaction	Questions for identifying the attractive interaction in the process activities. • Are there difficulties in filling or updating forms in the activities? • Is it easy enough to update archival records in the activities for the staff?
Assumptions and constraints	Assumption 1: "number of activity" is assumed as size of the process and used to normalize the result. Assumption 2: All activities are assumed to be prepared in the same granularity.

CHAPTER 4

A CASE STUDY FOR MEASURING PROCESS QUALITY

This chapter includes five sections. In the first section, the importance of case study research method in information systems is given briefly. The second section presents purpose of the case study. The research questions, case definition and methods employed for interpreting the findings are ordered in the third section. The fourth section orders the steps followed in the case study such as collecting the data, arranging the data into documents and applying the model to the processes. The measurement results are analyzed in the last section. The quality attribute values are discussed and relationships between them are identified.

4.1 Case Study Research in Information Systems

Case study research method is the most common qualitative method adopted in information systems (Myers, 1997). Although there are various definitions, Yin (1984) defines case study as "*an empirical inquiry that investigates a contemporary phenomenon within its real life context, especially when the boundaries between phenomenon and context are not clearly evident.*"

There are three reasons why case study research is a viable information systems research strategy (Benbasat, Goldstein and Mead, 1987). First, the researcher can study information systems in a natural setting, learn about state of the art, and generate theories from practice. Second, case method allows the researcher to answer "how" and "why" questions, that is, to understand the nature and complexity the processes taking place in. Third, a case approach is an appropriate way to research an area in which few previous studies have been carried out.

With the rapid pace of change in the IS field, many new topics, for which valuable insights can be gained through the use of case research, emerge each year. Benbasat et al. (1987) state that case study research method is particularly well-suited to IS research because the technology is relatively new and interest has been shifting to organizational rather than technical issues.

The application of case study research method for measuring process quality attributes is given below with detailed information. It starts by defining purposes of designing and implementing the case study and finishes by evaluating its results.

4.2 Purpose of the Case Study

Case study research method is used to observe understandability, suitability and applicability of the quality attributes. For these purposes, in the scope of the case study, the following issues are considered.

- Applying the model to a set of processes and measuring their quality attribute values,
- Examining detailed description of each attribute during the case study,
- Checking adequacies of the definitions and forming complete attribute definitions at the end,
- Identifying relations among quality attributes and evaluating changes in their values, and
- Utilizing feedbacks acquired from the case study to refine and therefore improve the model.

Before designing the case study, a pilot study was performed on a single process (Demirors and Guceglioglu, 2005). Two forms of process definitions were used for the chosen process. One of them was manual form of the process and named as "*AS-IS form,*" while the other form was IS project-supported form of the process and named as "*TO-BE form.*" Quality attributes were measured for both AS-IS and TO-BE forms. The pilot study provided the following valuable feedbacks to the model.

- The usage of the process definition to measure process quality was experimented.

- Some of the contradictions in the quality attribute definitions were removed.
- Quality attribute definitions were detailed by adding new fields such as "*measurement type,*" "*interpretation of measured value*" and "*questions for identifying the attributes in the process definitions*" to make the measurement simpler.
- The changes from AS-IS form to the TO-BE form were examined in terms of quality attributes' values. In addition, IS effects on the process quality was measured.

4.3 Case Study Design

The case study is planned for an organization where the pilot study was accomplished. In order to respect privacy, the identity of the organization and participators in the case study are not given explicitly. Supply Chain Department, one of departments in the organization, is selected as the subject of the case. Detailed process definitions within activity level, process modeling diagrams and regulations and rules employed in the Supply Chain Department for the processes' applications constitute the relevant data.

This case study satisfies the conditions of both explanatory and exploratory case studies (Yin, 1984). It is an explanatory one as it focuses on providing detailed information about the present quality attributes. It is also exploratory one as it emphasizes on finding new ways for increasing understandability and applicability of the quality attributes.

4.3.1 Components of the Case Study Design

Research design has three components as research questions, case definition and interpretation of results.

4.3.1.1 Research Questions

Research questions are determined in the planning phase of the case study. Quality attributes are investigated in the scope of the research questions. These questions and methods carried out for answering them are ordered below with brief explanations.

Research Question 1: Can software quality characteristics of maintainability and reliability and software techniques of complexity and coupling be adapted to the measurement of the process quality?

Method Used for Answering Question 1: This research question is related to suitability and adaptability of the software quality characteristics and software techniques to measure the process quality. For answering the question, the definitions of complexity and coupling quality attributes will be used. After the measurement, processes are compared with each other to evaluate their complexity and coupling attribute values.

Research Question 2: Is it possible to measure process quality by means of the proposed characteristics and metrics?

Method Used for Answering Question 2: This research question is interested in the validation of the measurement. Similar to the pilot study, AS-IS and TO-BE forms processes are used to measure their process quality attributes. The problems encountered during AS-IS form processes will be used to indicate the relations between the problems and quality attributes. Due to this usage, this research question is a key to investigate the suitability of the quality attribute usage for measuring process quality as well.

Research Question 3: How can the quality attributes be applied to measure the process quality?

Method Used for Answering Question 3: This research question is about the applicability of the quality attributes. Detailed definitions of quality attributes and process definitions are used for measuring process quality and therefore answering the question. This research question also investigates the usability of process definitions for the process quality measurement.

In the scope of this research question, during the case study, adequacies of the present quality attributes are examined and deficiencies or contradictions are identified. These feedbacks will be used at the end of the case study to increase understandability of the quality attributes.

Research Question 4: How can the model be refined and therefore improved?

Method Used for Answering Question 4: The experiences acquired in answering preceding research questions will be used to improve the model. In addition, there is a closure part at the end of the case study for evaluating the model and its application with the participators. A list of questions will be asked to the participators and their points of view about the measurement will be gathered. With those questions, different methods that could be employed for increasing understandability and applicability of the quality attributes will be inquired.

4.3.1.2 Case Definition

The processes of the Supply Chain Department are selected as the case. In addition to the Supply Chain Department, the organization has four departments named as A, B, C and D. Each department is managed by a department manager and their administrative work is followed by a department secretary separately. The departments accomplish their material operations such as purchasing, delivering and repairing by means of the Supply Chain Department.

The Supply Chain Department has five sections as Storing, Purchasing, Reception, Transportation and Maintenance (see in Figure 4.1).

The purpose of the case study was expressed to the Supply Chain Department manager. The need of working with one or two staff was explained to him. The manager assigned two staff, one from the storing section and the other from purchasing section. These staff have been working in the department approximately for five years. They have experiences about storing and purchasing operations. They also have information about the duties of the other sections. Their participation to this case study is dependent to their availability, i.e. their appropriate times they can dedicate to the study (mostly, after completing their working hours). Data collection and application of the model were performed by the participation of two staff.

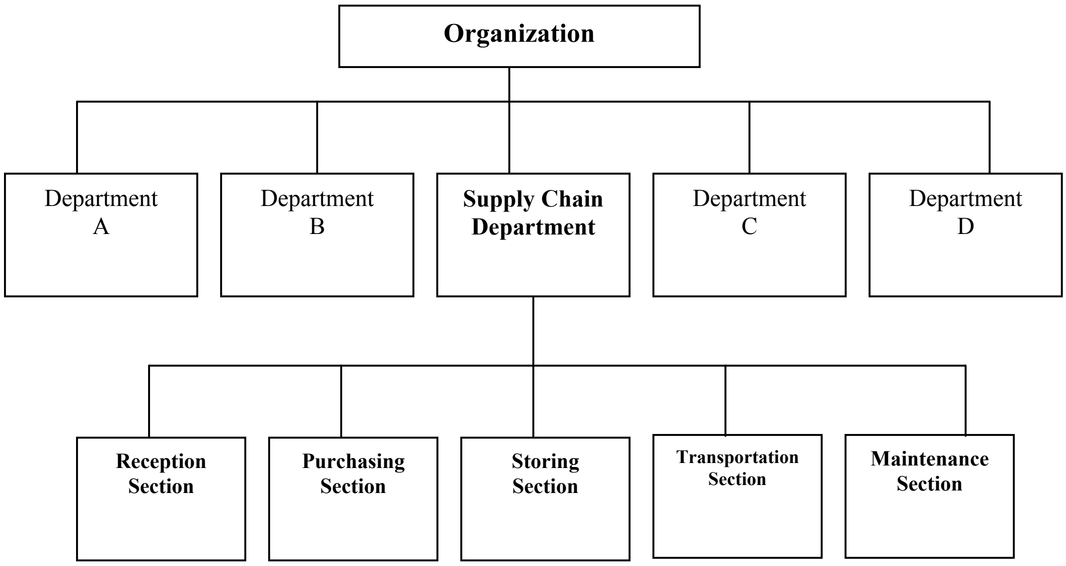

Figure 4.1 Supply Chain Department and its Sections

This case study is an example of a single case study. When the process concept is investigated thoroughly in Chapter 2, its standard structure is mentioned by inputs, activities and outputs. As the proposed model is established on this standard structure, the process quality measurement becomes a systematic way with the quality attribute definitions. The application of the model on the Supply Chain Department processes provides insights about the applicability, suitability and understandability of the quality attributes. In addition to all these, the Supply Chain Department presents additional opportunities for conducting the case study such as:

- The processes of the department are about material operations and can be found in many other organizations.
- The staff of the department modeled and documented information about their AS-IS form processes.
- The staff identified problems encountered during those AS-IS form processes.
- TO-BE form processes are developed and supported by an IS project.
- The availability of AS-IS and TO-BE forms provide good opportunities to implement the model for both of them. The comparison of AS-IS and TO-BE forms' measurements gives an idea about IS effects on the process quality.

- The problems identified by the staff in the AS-IS form are used for the validation of the case study results.

There are eight processes in the department as Material Request, Meeting Material Request, Material Purchasing, Material Registration, Material Counting, Material Returning, Material Record Deletion and Material Repair and Maintenance. AS-IS and TO-BE form processes were used in the case study.

4.3.1.3 Interpreting the Findings

Case study results are interpreted after completing quality attribute measurement. The findings are ordered below in the Conducting Case Study division.

4.4 Conducting Case Study

The conduction of the case study includes collecting the data, arranging collected data into documents, applying quality attributes, recording the results and observations and analyzing quality attributes' measurements. This work is explained below step by step as mentioned.

4.4.1 Collecting the Data

Multiple data collection method was employed in the study. The data was collected by the participation of two staff for the following items.

- Examining the documents about the analysis of the AS-IS form processes and the design of the TO-BE form processes,
- Examining available forms, tools and archival records associated with the processes,
- Examining the problems identified by the staff formerly in the AS-IS form processes,
- Measuring the quality attributes of AS-IS and TO-BE form processes,
- Observing the execution of process flows when it is necessary and
- Evaluating the results with the participated staff.

The documents about AS-IS form processes were used for defining the activities. The documents, "*Analysis of the Processes*" and "*Data Flow Diagrams*" prepared by the staff during the analysis of the AS-IS processes were examined. There was also another document named as "*Material Management Document*" for stating the rules and regulations that should be conformed during the material operations in the organization. This document was used for determining the rules and requirements for the processes.

Analysis of the Processes, Data Flow Diagrams and *Material Management Document* were used for forming activity definitions of the AS-IS form processes. Each process was defined with the following subheadings; *Process Name*, *Process No*, *Short Description*, *Sections Participating in the Process* and *Activities*. Activity definitions were prepared in the following format (see Table 4.1). Total number of activity for each AS-IS form process is given in Table 4.2.

Table 4.1 Detailed Process Definitions within Activity Level

No	Activity Name	Activity Definition	Staff	Forms/ Documents/ Archival Records/ Tools/ Applications/ Other Media
1				
2				
3				
.				
.				
n				

Table 4.2 Total Number of Activity for each AS-IS Form Process

No	Process Name	Total Number of Activity
1	Material Request	16
2	Meeting Material Request	18
3	Material Purchasing Process	12
4	Material Registration Process	4
5	Material Counting Process	20
6	Material Returning Process	13
7	Material Record Deletion Process	13
8	Material Repair and Maintenance Process	6

The forms, reports, archival records and tools employed in the processes were determined (see Table 4.3). Their contents and meanings were recorded and, during the case study, sample forms were examined.

AS-IS form processes were modeled by using ARIS (**Ar**chitecture of integrated **I**nformation **S**ystems) Process Modeling Tool (Scheer, 2003) to examine interactions between activities and also between other processes in the department. ARIS is a business process modeling tool and a methodology for business process redesign. It is used extensively to link and tailor SAP applications.

Table 4.3 Forms, Tools, Documents Employed in the AS-IS Form Processes

No	Name of the Forms, Documents, Archival Records or Tools
1	Department Stock Card
2	Material Request Form
3	Formal Petition
4	Document Record Book
5	Request Follow List
6	Material Exit Form
7	Organization Stock Card
8	Store Stock Card
9	Request Follow List
10	Material Purchasing Form
11	Firm File
12	Firm List
13	Payment Details
14	Material Refusal Form
15	Material Admission Form
16	Material Counting Form
17	Supply Chain Counting Form
18	Official Report
19	Material Returning Form
20	Material Record Deletion Form
21	Material Record Deletion List
22	Material Repair Form

After completing the activity definitions and process modeling diagrams, they were reviewed with two staff. The necessary corrections were done on the documents.

The problems that were experienced by the staff during the execution of the AS-IS form processes were recorded by using the stated documents.

Similar to the AS-IS form processes, detailed process definitions within activity level are formed for the TO-BE form processes. There were documents about TO-BE form processes. These documents are "*Design of the Processes*", "*Data Flow Diagrams*" and "*Help Facility.*" There was also another document named as "*Material Management Document*" for stating rules and regulations that should be conformed during the material operations in the organization. This document is the updated version of the same document for the AS-IS form processes. This document is used in determining the rules and requirements for the TO-BE form processes.

The activity definitions of the TO-BE form processes were prepared in the same format with the AS-IS form. Total number of activity is given for the TO-BE form processes as below.

Table 4.4 Total Number of Activity for each TO-BE Form Process

No	**Process Name**	**Total Number of Activity**
1	Material Request	6
2	Meeting Material Request	6
3	Material Purchasing Process	11
4	Material Registration Process	4
5	Material Counting Process	12
6	Material Returning Process	7
7	Material Record Deletion Process	8
8	Material Repair and Maintenance Process	5

The forms, reports, archival records and tools employed in the TO-BE form processes were determined (see Table 4.5). The contents and meanings were recorded.

TO-BE form processes were modeled by using ARIS Process Modeling Notation. After completing activity definitions and process modeling diagrams, they were reviewed with two staff and necessary corrections were done on the documents.

4.4.2 Arranging the Data into Documents

Before starting to measure the quality attributes, collected data was arranged into documents. These documents provide easily to understand the processes during the quality attribute measurement.

Process Definition Document: This document includes explicit detailed process definitions within the activity level, their modeling diagrams and related regulations and rules.

The contents and meanings of forms, archival records, tools and documents about the processes were recorded into this document as well.

Table 4.5 Forms, Tools, Documents Employed in the TO-BE Form Processes

No	Name of the Forms, Documents, Archival Records or Tools
1	Material Request Form
2	Stock Card
3	Material Exit Form
4	Material Purchasing Form
5	Firm File
6	Firm List
7	Payment Details
8	Material Refusal Form
9	Material Admission Form
10	Material Counting Form
11	Supply Chain Counting Form
12	Official Report for Material Counting Form
13	Material Returning Form
14	Material Record Deletion Form
15	Material Record Deletion List
16	Material Repair Form

Problems in the Processes Document: The problems and difficulties encountered by staff in the AS-IS form processes were arranged into this document. This data was used at the end of the study to interpret the results.

Quality Attribute Definition Document: The quality attribute and metric definitions with detailed information about their usages and the questions to be directed to the appliers were arranged into this document. The model was presented to the staff with this document.

Quality Measurement Document: The application of the *Quality Attribute Definition Document* to *Process Definition Document* was performed with the participation of the staff. The measurements, contradictions or inadequacies in the metric definitions were recorded to this document.

4.4.3 Applying the Model to the Processes

The model was introduced to the staff by using Quality Attribute Definition Document. The measurement was performed for the 17 quality attributes.

Empty forms were prepared for the measurement of each quality characteristic (see Table 4.6, 4.7, 4.8 and 4.9).

4 of 8 processes were measured with the participation of the staff and the rest was measured by the staff directly.

Table 4.6 Maintainability Attributes Measurement

Activity Number	Complexity	Coupling
1		
2		
3		
N		

Table 4.7 Reliability Attributes Measurement

Activity Number	Failure Avoidance	Restorability	Restoration Effectiveness
1			
2			
3			
n			

Table 4.8 Functionality Attributes Measurement

Activity Number	Functional Adequacy	Functional Comp.	IT Usage	IT Density	Comput. Accuracy	Data Exchang.	Access Audit.
1							
2							
3							
n							

Table 4.9 Usability Attributes Measurement

Activity Number	Functional Understandability	Existence in Documents	Input Validity Checking	Undoability	Attractive Interaction
1					
2					
3					
n					

During the measurement, Process Definition Document, Problems in the Processes Document, Quality Attribute Definition Document and Quality Measurement Document were used actively.

The details of the quality attribute measurements are presented in the Technical Report (Guceglioglu and Demirors, 2006).

4.4.3.1 Sample Process, Material Request (AS-IS Form)

The first process, Material Request, is used to demonstrate how the quality attributes were measured. The measurement detail is given firstly for the AS-IS form and then for the TO-BE form.

The other processes were measured with their AS-IS and TO-BE forms as in the Material Request Process and can be found in the Technical Report (Guceglioglu and Demirors, 2006).

4.4.3.1.1 Details in the Process Definition Document

Process Definition Document includes the following descriptions for the Material Request Process (AS-IS).

Process Name: Material Request

Process No: Process number is 1.

Short Description: The departments in the organization inform their material needs to the Supply Chain Department to be fulfilled. Material Request process includes a range activities starting from the birth of the need to the receiving the needed materials from the supply chain department.

Sections Participating in the Process: Section, which requests new materials, and storing section participate in the process. The department secretary and department manager also take roles in this process.

Activities: The activities employed in the Material Request process are given in the following table.

Table 4.10 Material Request Activities (AS-IS)

No	Activity Name	Activity Definition	Staff	Forms/ Documents/ Archival Records/ Tools/ Applications/ Other Media
1	Informing material needs to department secretary	Department secretary is assigned to interest and coordinate material requests of the sections. Each department has only one department secretary in the organization. Section manager informs his material needs to department secretary orally. He explains features and numbers of requested materials to the secretary. He also states reasons for the request. At the end of the activity, it is expected that department secretary and section manager understand each other about the materials which will be requested from the Supply Chain department.	Section Manager Department Secretary	By Telephone Conversation Interview
2	Finding current numbers of the requested materials in department	Department secretary follows material names and their available numbers in the department with Department Stock Card. Department Stock Card is kept in Microsoft Excel file. She examines the stock cards by using material name and features. When she finds the stock card of the requested material, she attains its available number in the department. If the material name is not found in the stock card, she decides that a new material is requested and a new stock card is created in the file.	Department Secretary	Department Stock Card
3	Preparing Formal Petition for the request	Department secretary uses Microsoft Word Template file for preparation of Formal Petition including the material names, available numbers written in the stock card, requested numbers and reasons stated by the section manager.	Department Secretary	Formal Petition
4	Preparing Material Request Form	Department secretary prepares two copies of Material Request Form. A Microsoft Word Template file is used for the preparation. The requested material names, features and numbers are written to the form. One of the copies is kept in the department itself, and the other copy will be sent and kept in the Supply Chain department.	Department Secretary	Material Request Form
5	Taking a rendezvous for presenting the Formal Petition and Material Request Form to department manager	Before sending to the Supply Chain department, department secretary takes a rendezvous for presenting the Formal Petition and Material Request Forms to the department manager and explaining the situation.	Department Secretary Department Manager	By Telephone Conversation Interview
6	Approving or refusing the request by department manager with stating reasons	Department secretary presents Material Request Forms and Formal Petition to department manager. Department manager reviews the Material Request Forms and Formal Petition. If he finds mistakes in the forms, department secretary corrects them. He may approve and sign the Material Request Forms or refuses it. If he refuses the request, then the process is terminated. If he approves the request, the other activities are performed in the process. Department manager gives a decision by using information of numbers of requested materials in the department, features of the materials and reasons stated by the section manager.	Department Manager Department Secretary	Material Request Form Formal Petition Signature
7	Informing section manager about the rejection	When department manager refuses the request, department secretary informs the section manager and gives detail information about the reasons stated by the department manager.	Department Secretary Section Manager	Material Request Form Formal Petition
8	Recording the Material Request Form to Document Record Book	Department secretary records Material Request Form to the Document Record Book. The line in the Document Record Book corresponds to formal number of the Material Request Form and department secretary writes the number to the Material Request Form and Formal Petition. Formal Petition is preserved in the department.	Department Secretary	Document Record Book Material Request Form Formal Petition
9	Sending the Material Request Forms to the Supply Chain Department	Department secretary calls a staff member for sending the Material Request Forms to the Supply Chain department secretary. Supply Chain department secretary receives the Material Request Forms and signs them for indicating the receipt. Meeting Material Request process is started for this request.	Department Secretary Staff Supply Chain Department Secretary	Material Request Forms Signature

Table 4.10 (continued)

No	Activity Name	Activity Definition	Staff	Forms/ Documents/ Archival Records/ Tools/ Applications/ Other Media
10	Receiving one of the signed Material Request Form	Department secretary receives one of the signed copy of the Material Request Form after the Supply Chain department secretary has signed the forms.	Department Secretary Staff	Material Request Form
11	Adding the request to Request Follow List	Department secretary follows material requests that are sent to the Supply Chain Department by a list. This list is kept in a Microsoft Word File. When she sends a Material Request Form to the Supply Chain department, she writes the information about the form to Request Follow List. The request is omitted from the list when the materials are received. She can find the numbers of their requests in the Supply Chain department from the list.	Department Secretary	Request Follow List
12	Receiving the materials and Material Exit Forms by the department secretary	Staff bring the materials and Material Exit Forms to the department and gives them to the department secretary. Department secretary signs the Material Exit Forms for indicating the receipt and staff return with one of the Material Exit Forms to the Supply Chain department secretary.	Staff Department Secretary	Materials Material Exit Forms
13	Recording Material Exit Form to Document Record Book in the department	Department secretary writes information about the Material Exit Form to the Document Record Book.	Department Secretary	Material Exit Form Document Record Book
14	Updating the request in Request Follow List	Department secretary updates the Request Follow List for indicating the received materials.	Department Secretary	Request Follow List Material Exit Form
15	Arranging Department Stock Card with received materials	Department secretary updates the stock card of the department with the numbers of received new materials.	Department Secretary	Department Stock Card
16	Giving received materials to the section manager who has requested	Department secretary gives the materials to the section manager.	Department Secretary Section Manager	Materials

Forms/ Documents/ Archival Records / Tools / Applications/ Other Media Used in the Material Request Process are given below.

Department Stock Card: A Microsoft Excel file is used for keeping material names and their numbers in the department. Department secretary takes monthly backup of this file. The file includes following data items for each material.

- Material Name,
- Material Features,
- Number in the Department.

When department secretary updates the file, she inserts a line to the file including formal number of the form and its date. This information relates the changes in the file to the Document Record Book.

Formal Petition: A Microsoft Word Template file is used for preparation of this form. The form includes following data items.

- Material Names,
- Available Numbers in the Department,
- Reasons for Request,
- Requested Numbers.

Material Request Form: A Microsoft Word Template file is used for preparation of this form. The form includes following data items.

- Department Name,
- Date,
- Formal Number,
- Material Names,
- Requested Numbers,
- Initials for Receipt,
- Signature of the Department Manager,
- Initials of the Supply Chain Department Manager.

Document Record Book: Document Record Book is used for recording forms in the departments. It is kept in paper-based environment. The document includes the following data items.

- Formal Number (counter),
- Date,
- Name of the Form,
- Descriptions about the form (name of the section, reasons for the request, short information about the requested materials).

Department secretaries also use Document Record Book for getting formal number to forms.

Request Follow List: The requests that are sent to the Supply Chain Department are followed by means of this list. This list is kept in a Microsoft Windows file and includes following data items:

- Date of the sending,
- Material Request Form Number,
- Current Status,
- Descriptions about the form.

When department secretary receives materials from the supply chain department, she omits the request by updating the "current status" field of the list.

Department secretary and supply chain department secretary keep similar but separate lists to follow the requests in their departments.

Material Exit Forms: A Microsoft Word Template file is used for the preparation of this form. The form includes following data items.

- Date,
- Formal Number,
- Material Names,
- Numbers of Materials to be Given,
- Initials for Reception,
- Signature of the Supply Chain Department Manager.

The process modeling of the Material Request Process (AS-IS) is given in Figure 4.2, 4.3 and 4.4.

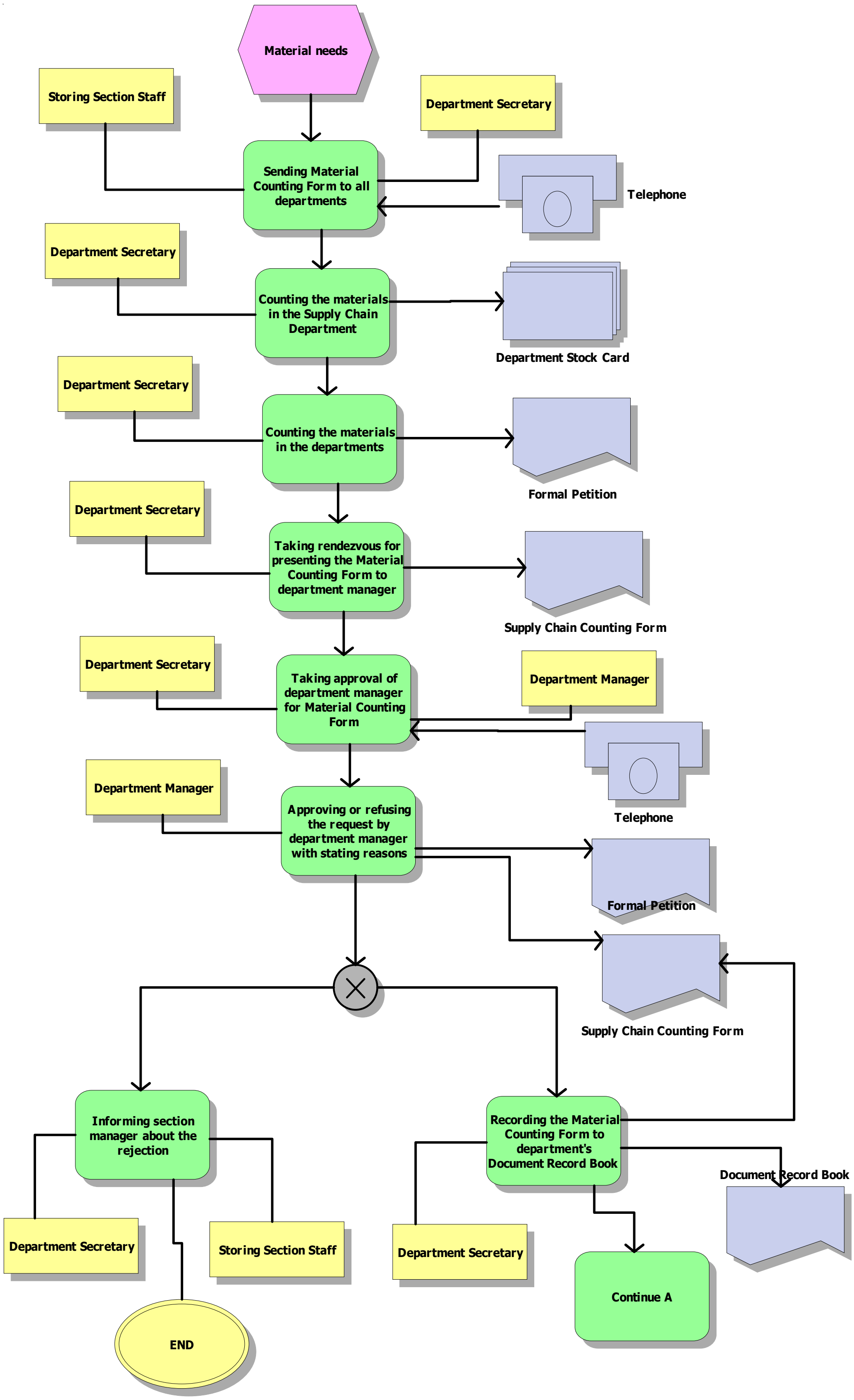

Figure 4.2 Material Request Activities-I (AS-IS)

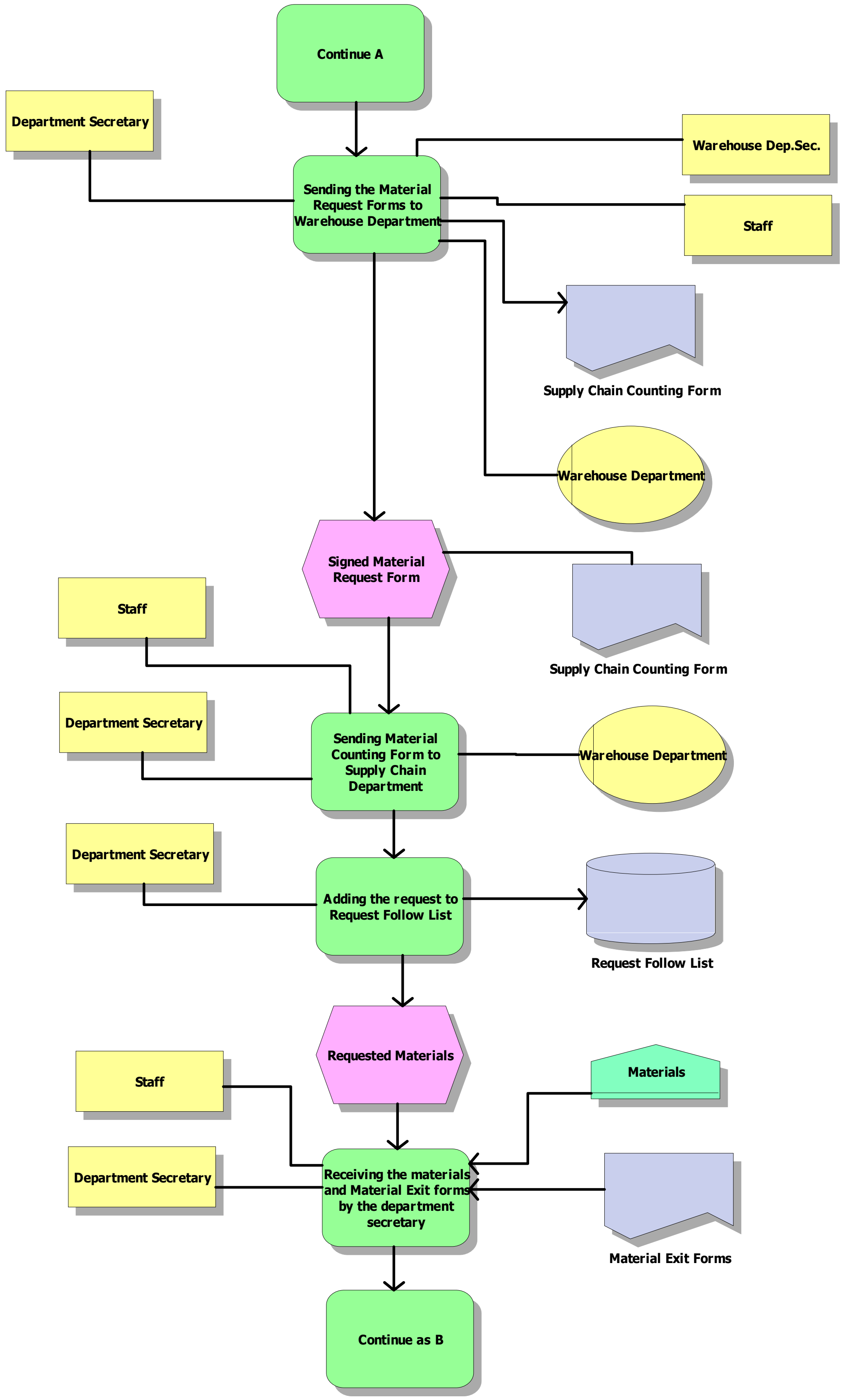

Figure 4.3 Material Request Activities-II (AS-IS)

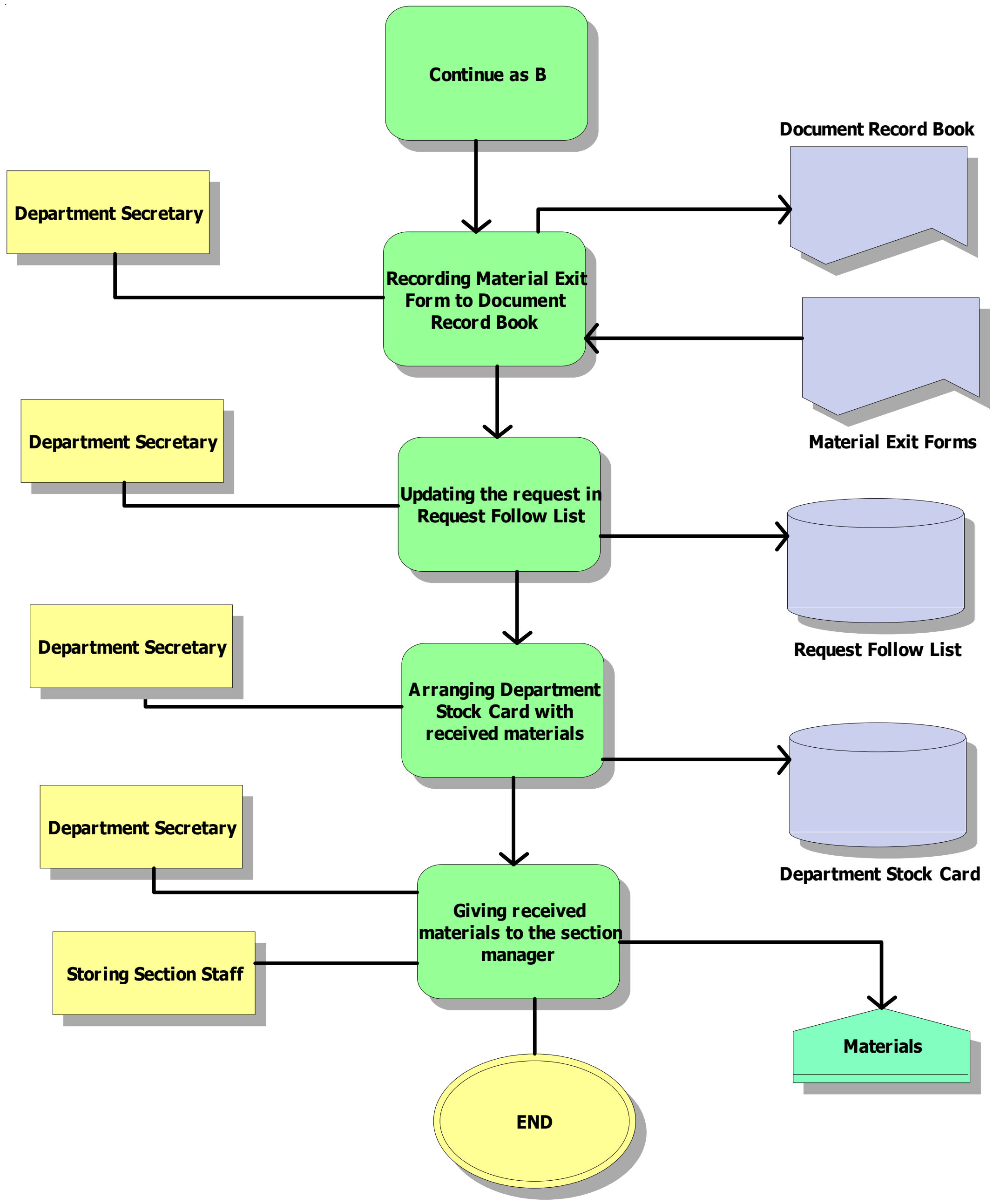

Figure 4.4 Material Request Activities-III (AS-IS)

4.4.3.1.2 Details of the Problems in the Processes Document

The participator staff state the following problems and difficulties for the Material Request Process. ("P" is used as an abbreviation of problem.)

P1: Section managers experience difficulties while describing needed materials with their features to department secretary. Sometimes, department secretary misunderstands material descriptions made by section managers. There are no standard material name and feature descriptions such as material code.

P2: Department secretary may request more or less materials than the need that section manager has expressed. Some of the materials may be forgotten and not be requested. In this case, department secretary has to make a new request for the missing materials from supply chain department, which results in a second order.

P3: Department secretary records Material Request Forms and Material Exit Forms to Document Record Book manually and follows their detailed information. The information of "*when the form is received or sent,*" "*who has made the request*" and request reasons stated by section managers are written manually to Document Record Book.

Department secretary searches old Document Record Books for accessing detailed information when a problem occurs. However, department secretary may not find old Document Record Books or their related pages.

P4: Department secretary experiences difficulties while recording Material Request Form and Material Exit Form. First of all, she must write detailed information about the forms, which requires much more time.

In addition, since the line reserved for each record is narrow, it creates some other difficulties in recording. Department secretary encounters difficulties in searching forms and in reading information within the narrow line.

4.4.3.1.3 Details in the Quality Measurement Document

Quality Measurement Document includes the following measurements for the Material Request Process (AS-IS), maintainability in Table 4.11, reliability in Table 4.12, functionality in Table 4.13 and Table 4.14 and usability in Table 4.15 respectively.

Table 4.11 Maintainability Measurement of Material Request Process (AS-IS)

Activity Number	Complexity	Coupling
1	No decision	No interaction
2	No decision	No interaction
3	No decision	No interaction
4	No decision	No interaction
5	No decision	No interaction
6	Semi-structured decision for approving or refusing the Material Request Form. Department manager uses information written in the forms and his judgment while taking a decision. There is no rule which determines "when a request is approved" or "under which conditions a request is refused." It is not a complex decision, but it requires human opinion.	No interaction
7	No decision	No interaction
8	No decision	No interaction
9	No decision	Interaction with Meeting Material Request process (sending the request with Material Request Form)
10	No decision	Interaction with Meeting Material Request process (receiving the signed Material Request Form)
11	No decision	No interaction
12	No decision	Interaction with Meeting Material Request process (receiving the requested materials with Material Exit Form)
13	No decision	No interaction
14	No decision	No interaction
15	No decision	No interaction
16	No decision	No interaction

Table 4.12 Reliability Measurement of Material Request Process (AS-IS)

Activity Number	Failure Avoidance	Restorability	Restoration Effectiveness
1	No review, inspection, checkpoint or similar techniques	Not recorded	No restoration
2	No review, inspection, checkpoint or similar techniques	Not recorded	No restoration
3	No review, inspection, checkpoint or similar techniques	Recorded in Formal Petition	Restoration from Formal Petition backup
4	No review, inspection, checkpoint or similar techniques	Recorded in Material Request Form	Restoration from Material Request Form backup
5	No review, inspection, checkpoint or similar techniques	Not recorded	No restoration
6	Department manager reviews Material Request Form and Formal Petition prepared by department secretary. When he finds mistakes in the forms, department secretary corrects them.	Recorded in Material Request Form and Formal Petition	Restoration from second copy of Material Request Form
7	No review, inspection, checkpoint or similar techniques	Not recorded	No restoration
8	No review, inspection, checkpoint or similar techniques	Recorded in Document Record Book	No restoration Document Record Book is kept in one copy in paper-based environment.
9	No review, inspection, checkpoint or similar techniques	Not recorded	No restoration
10	No review, inspection, checkpoint or similar techniques	Not recorded	No restoration
11	No review, inspection, checkpoint or similar techniques	Recorded in Request Follow List	Restoration from Request Follow backup
12	Department secretary reviews Material Exit Form, Material Request Form and received materials. When she finds inconsistencies between the requested and received materials, she interviews with Supply Chain department secretary.	Not Recorded	No restoration
13	No review, inspection, checkpoint or similar techniques	Recorded in Document Record Book	No restoration Document Record Book is kept in one copy in paper-based environment.
14	No review, inspection, checkpoint or similar techniques	Recorded in Request Follow List	Restoration from Request Follow backup
15	No review, inspection, checkpoint or similar techniques	Recorded in Department Stock Card	Restoration from Department Stock Card backup
16	Section manger reviews materials that are brought by department secretary. He checks them whether they are requested by him or not.	Not Recorded	No restoration

Table 4.13 Functionality Measurement of Material Request Process-I (AS-IS)

Activity Number	Functional Adequacy	Functional Completeness	IT Usage	IT Density
1	Inadequate As material code is not used during the description of materials, department secretary and section manager may not understand the same material. This activity is inadequate for informing the department secretary about the needed new materials.	-	No IT usage	No forms, documents, archival records or other similar documents that are prepared, updated, deleted or searched
2	Adequate	-	IT usage in searching Department Stock Card	Department Stock Card is searched in Microsoft Excel file.
3	Adequate	-	IT usage in preparation of Formal Petition	Formal Petition is prepared in Microsoft Word file.
4	Adequate	-	IT usage in preparation of Material Request Form	Material Request Form is prepared in Microsoft Word file.
5	Adequate	-	No IT usage	No forms, documents, archival records or other similar documents that are prepared, updated, deleted or searched
6	Adequate	-	No IT usage	Material Request Form is manually signed by department manager.
7	Adequate	-	No IT usage	No forms, documents, archival records or other similar documents that are prepared, updated, deleted or searched
8	Adequate	-	No IT usage	Material Request Form is recorded to Document Record Book which is kept in paper-based environment.
9	Adequate	-	No IT usage	No forms, documents, archival records or other similar documents that are prepared, updated, deleted or searched
10	Adequate	-	No IT usage	No forms, documents, archival records or other similar documents that are prepared, updated, deleted or searched
11	Adequate	-	IT usage in recording to Request Follow List	New request is recorded to Request Follow List which is kept in Microsoft Word file.
12	Adequate	-	No IT usage	Material Exit Form is manually signed by department secretary for indicating the receipt.
13	Adequate	-	No IT usage	Material Exit Form is recorded to Document Record Book which is kept in paper-based environment.
14	Adequate	--	IT usage in updating Request Follow List	Request Follow List is updated in Microsoft Word file.
15	Adequate	-	IT usage in recording to Department Stock Card	Department Stock Card is updated in Microsoft Excel file.
16	Adequate	-	No IT usage	No forms, documents, archival records or other similar documents that are prepared, updated, deleted or searched

Table 4.14 Functionality Measurement of Material Request Process-II (AS-IS)

Activity Number	Computational Accuracy	Data Exchangeability	Access Auditability
1	Accuracy requirement: Department secretary and section manager should be sure about descriptions of the requested materials. This requirement is not implemented in the activity. Department secretary does not verify materials that are described by the section manager.	No interaction	No access There is no access to data.
2	No specific accuracy requirement	No interaction	Access auditability Only department secretary can search Department Stock Card.
3	No specific accuracy requirement	No interaction	Access auditability Only department secretary can prepare Formal Petition.
4	No specific accuracy requirement	No interaction	Access auditability Only department secretary can prepare Material Request Form.
5	No specific accuracy requirement	No interaction	No access There is no access to data.
6	Accuracy requirement: Department manager should check Material Request Form before it is sent to Supply Chain Department. This requirement is implemented in the activity. Department manager reads Material Request Form and Formal Petition to find mistakes and correct them.	No interaction	Access auditability Only department manager can approve or refuse Material Request Form.
7	No specific accuracy requirement	No interaction	Access auditability Only department secretary can read notes on Material Request Form.
8	Accuracy Requirement: Every Material Request Form should have unique Formal Number. This requirement is implemented in the activity. Department secretary writes unique line number from Document Record Book to Material Request Form as formal number.	No interaction	Access auditability Only department secretary can record Material Request Form to Document Record Book.
9	No specific accuracy requirement	Material Request Form is sent from Material Request Process to Meeting Material Request Process. There is an interaction, but the use of data will be evaluated in the Meeting Material Request process.	No access auditability Material Request Form is sent to Supply Chain Department by a staff. There is no information about the staff.
10	No specific accuracy requirement	The one of the signed Material Request Form is received from Meeting Material Request Process. The data in the Material Request Form is used without applying any changes in Material Request Process.	No access auditability Material Request Form is received from Supply Chain Department by a staff. There is no information about the staff.
11	Accuracy requirement: Department secretary should follow and count requests that are sent to Supply Chain Department. This requirement is implemented in the activity. Department secretary follows requests by using Request Follow List. She writes a new record when she sends a request to Supply Chain department and she omits the line when a respond is received from Supply Chain department.	No interaction	Access auditability Only department secretary can record Material Request Form to Request Follow List.
12	No specific accuracy requirement	Material Exit Form is received from Meeting Material Request Process. The data in the Material Exit Form is used without applying any changes in Material Request Process.	No access auditability Material Exit Form is received from Supply Chain Department by a staff. There is no information about the staff.
13	No specific accuracy requirement	No interaction	Access auditability Only department secretary can record Material Exit Form to Document Record Book.

Table 4.14 (continued)

Activity Number	Computational Accuracy	Data Exchangeability	Access Auditability
14	Accuracy requirement: Department secretary should follow and count requests that are sent to Supply Chain Department. This requirement is implemented in the activity. Department secretary follows requests by using Request Follow List. She writes a new record when she sends a request to Supply Chain department and she omits the line when a respond is received from Supply Chain department.	No interaction	Access auditability Only department secretary can update Material Request Form in the Request Follow List.
15	Accuracy requirement: Department secretary should follow Department Stock Card up-to-date. This requirement is implemented in the activity. Department secretary updates Department Stock cards according to the Material Exit Form.	No interaction	Access auditability Only department secretary can update Department Stock Card.
16	No specific accuracy requirement	No interaction	No access auditability There is no information about person to whom the received materials are given.

Table 4.15 Usability Measurement of Material Request Process (AS-IS)

Activity Number	Functional Understandability	Completeness of Documentation	Input Validity Checking	Undoability	Attractive Interaction
1	Difficulties or misunderstandings in material features descriptions	Not described	No input validity checking for descriptions of requested materials stated by section manager	Not recorded	No interaction with forms, reports, archival records or similar other documents, only telephone conversation or interview
2	No difficulties or misunderstandings	Not described	No input validity checking for descriptions of requested materials understood by department secretary	Not recorded	Attractive interaction in searching available stock cards in Department Stock Card
3	No difficulties or misunderstandings	Described	Input validity checking about materials defined in Department Stock Card	Recorded, undoability of preparing Formal Petition Form	Attractive interaction in preparation of Formal Petition
4	No difficulties or misunderstandings	Described	Input validity checking about materials defined in Department Stock Card	Recorded, undoability of preparing Material Request Form	Attractive interaction in preparation of Material Request Form
5	No difficulties or misunderstandings	Not described	Input validity checking for Material Request Form and Formal Petition prepared by department secretary	Not recorded	No interaction with forms, reports, archival records or similar other documents, only telephone conversation or interview
6	No difficulties or misunderstandings	Described	Input validity checking for Material Request Form and Formal Petition prepared by department secretary	Recorded, no undoability of signatures and notes on Material Request Form written by department manager	Attractive interaction in approving or refusing Material Request Form
7	No difficulties or misunderstandings	Described	Input validity checking about results of the material request written by department manager	Not recorded	Not attractive interaction in reading notes on Material Request Form
8	No difficulties or misunderstandings	Described	Input validity checking about data in Material Request Form approved by department manager	Recorded, no undoability, as Document Record Book is prepared in paper-based environment	Not attractive interaction, department secretary experiences difficulties in filling Document Record Book

Table 4.15 (continued)

Activity Number	Functional Understandability	Completeness of Documentation	Input Validity Checking	Undoability	Attractive Interaction
9	No difficulties or misunderstandings	Described	Input validity checking about Material Request Form approved by department manager	Not recorded	Attractive interaction in reading Material Request Form
10	No difficulties or misunderstandings	Described	Input validity checking about Material Request Form signed by Supply Chain department secretary	Not recorded	Attractive interaction in reading Material Request Form
11	No difficulties or misunderstandings	Described	Input validity checking about Material Request Form sent to Supply Chain department	Recorded, undoability of adding new record to Request Follow List	Attractive interaction in recording new request to Request Follow List
12	No difficulties or misunderstandings	Described	Input validity checking about Material Exit Form approved by Supply Chain department manager.	Not recorded	Attractive interaction in reading and signing Material Exit Form
13	No difficulties or misunderstandings	Described	Input validity checking about Material Exit Form approved by Supply Chain department manager.	Recorded, no undoability, as Document Record Book is prepared in paper-based environment	Not attractive interaction, department secretary experiences difficulties in filling Document Record Book
14	No difficulties or misunderstandings	Described	Input validity checking about Material Exit Form approved by Supply Chain department manager.	Recorded, undoability of updating the available record in Request Follow List	Attractive interaction in updating request in the Request Follow List
15	No difficulties or misunderstandings	Described	Input validity checking about Material Exit Form approved by Supply Chain department manager.	Recorded, undoability of updating Department Stock Card	Attractive interaction in updating Department Stock Card
16	No difficulties or misunderstandings	Described	Input validity checking about Material Exit Form approved by Supply Chain department manager.	Not recorded	No interaction with forms, reports, archival records or similar other documents, only telephone conversation or interview

The measurement results of the Material Request Process (AS-IS) are summarized in Table 4.16. The results are depicted by using radar chart (see Figure 4.5).

4.4.3.2 Sample Process, Material Request (TO-BE Form)

The measurement details are given for the TO-BE form of the Material Request process.

4.4.3.2.1 Details of the Process Definition Document

Process Definition Document includes the following descriptions for the Material Request Process (TO-BE).

Process Name: Material Request

Process No: Process number is 1.

Table 4.16 Measurement Summary for Material Request Process (AS-IS)

No	Quality Attribute	Material Request (AS-IS Form)
1	Complexity	0.9375
2	Coupling	0.8125
3	Failure Avoidance	0.1875
4	Restorability	0.5
5	Restoration Effectiveness	0.375
6	Functional Adequacy	0.9375
7	Functional Completeness	1
8	IT Usage	0.375
9	IT Density	0.6
10	Computational Accuracy	0.83
11	Data Exchangeability	1
12	Access Auditability	0.7142
13	Functional Understandability	0.9375
14	Existence in Documents	0.8125
15	Input Validity Checking	0.875
16	Undoability	0.625
17	Attractive Interaction	0.7692

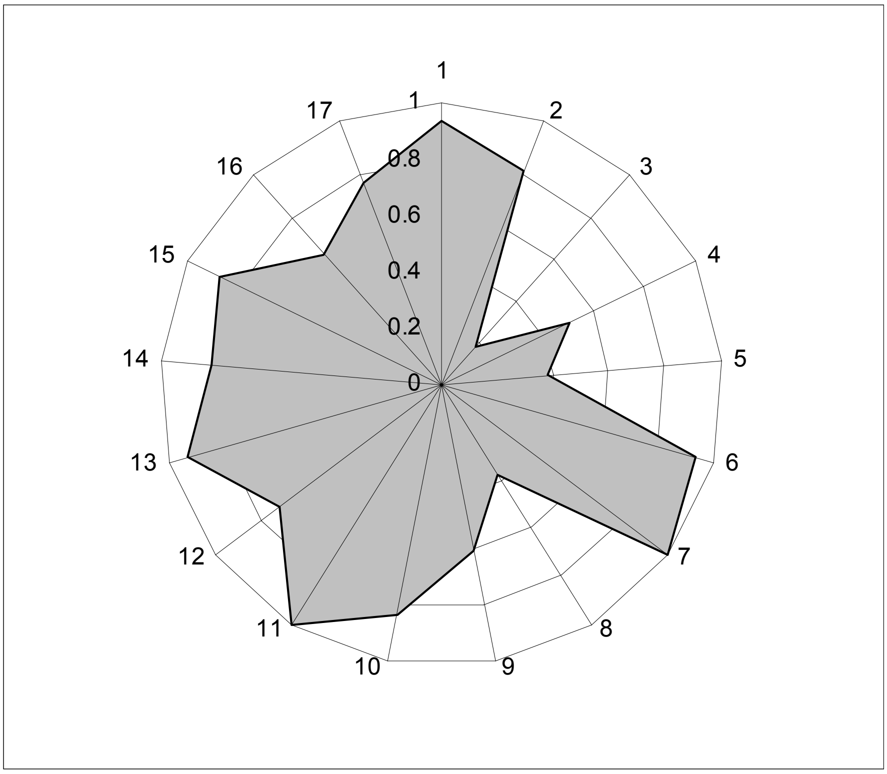

Figure 4.5 Measurement of Material Request Process (AS-IS Form)

Short Description: The departments inform their material needs to the supply chain department to be fulfilled. Material Request process includes the activities starting from the birth of the need to the receiving the needed materials from the supply chain department.

Sections Participating in the Process: Section which requests new materials and storing section participate in the process. The department secretary and department manager also take roles in this process.

Activities: The department secretary and department manager login into the Supply Chain Information System by writing their usernames and passwords. The system assigns necessary responsibilities according to the users' roles.

The activities that are employed particularly in the Material Request process are given in the following table.

Table 4.17 Material Request Activities (TO-BE)

No	Activity Name	Activity Definition	Staff	Forms/ Documents/ Archival Records/ Tools/ Applications/ Other Media
1	Informing material needs to department secretary	Section manager informs his material needs to department secretary. He uses Material Catalogue and finds material codes in the catalogue. He enters the material codes, numbers, and reasons of needs to Material Form and gives its printout to the department secretary.	Section Manager Department Secretary	Material Form
2	Preparing and sending Material Request Form	Department secretary selects new Material Request Form in the system and a new form is opened. She fills the form by selecting the material codes from the Material Catalogue, writing the requested numbers and the reasons stated in the Material Form. During the preparation of the form, she checks the material codes that are informed by the section manager. The system displays available numbers of the materials in the department automatically for giving additional information. When she completes the form, she sends it to department manager for his approval.	Department Secretary	Material Form Material Request Form
3	Approving or refusing the Material Request Form by department manager with stating the reasons	Department manager follows requests which waits approval in Approval List of the system. When he clicks one of the requests, the associated Material Request Form is opened. He reviews the Material Request Form prepared by the department secretary. If he finds mistakes in the form, department secretary or department manager corrects them. He may approve or refuses the request. If he refuses the request, then the process is terminated and its status is set to "refused by department manager." He writes the reasons for the rejection to the system. If he approves the request, the system fills department name, date and formal number of the form automatically and its status as "approved by department manager". It is sent to the Supply Chain department. Supply Chain department secretary receives Material Request Form and begins Meeting Material Request process for this request. The request is removed from the Approval List when the request is approved or refused by the department manager.	Department Manager	Material Request Form Approval List

Table 4.17 (continued)

No	Activity Name	Activity Definition	Staff	Forms/ Documents/ Archival Records/ Tools/ Applications/ Other Media
4	Informing the Section Manager about the rejection	Department secretary can follow status of the Material Request Form in the system. When department manger refuses the request, department secretary informs the section manager about the rejection with the reasons entered by the department manager to the system.	Department Secretary Section Manager	Approval List By Telephone Conversation Interview
5	Receiving the requested materials and the Material Exit Form by the department secretary	Department secretary receives the Material Exit Form in the system when Supply Chain department manager approves Material Exit Form. A staff member brings the materials and gives them to the department secretary.	Staff Department Secretary	Materials Material Exit Form
6	Giving received materials to the section that has requested	Department secretary gives the materials to the section manager that has requested the materials. Department secretary attaches the name of the section manager to the Material Exit Form for indicating the delivery.	Department Secretary Section Manager	Materials Material Exit Form

Forms/ Documents/ Archival Records / Tools / Applications/ Other Media Used in the Material Request Process are given below.

Material Request Form: The form includes the following data items.

- Department Code,
- Department Name,
- Date,
- Formal Number,
- Material Codes,
- Material Names and Features,
- Requested Numbers,
- Status, (indicates its last state, e.g. “approved”, “refused”, “purchased”),
- Last Location (e.g. in department secretary, in the Storing Section).

Material Code, Material Name and Features and Requested Number are written into a separate line. Each Material Request Form is kept in the Material Request Table in the database. Formal number is used as a primary key.

Material Form: The form includes the following data items.

- Date,
- Name and Surname,
- Section Name,
- Material Codes,
- Numbers,
- Reasons.

The staff in the organization can prepare Material Form in computerized environment by using Material Catalogue. After filling the fields in the form, a printout is given to the department secretary for starting the Material Request Process.

Material Exit Form: The form includes the following data items.

- Date,
- Formal Number,
- Formal Number of Material Request Form (to provide connection between Material Request Form and Material Exit Form),
- Material Codes,
- Material Names and Features,
- Numbers of Material to be Given,
- Status, (indicates its last state, e.g. “approved”, “refused”),
- Last Location (e.g. in the department secretary, in the storing section),
- Name of the staff to whom materials are delivered.

Material Code, Material Name and Features and Given Number are written into a separate line. Each Material Exit Form is kept in the Material Exit Table in the database. Formal Number is used as a primary key.

The process modeling of the Material Request Process (TO-BE) is given in Figure 4.6.

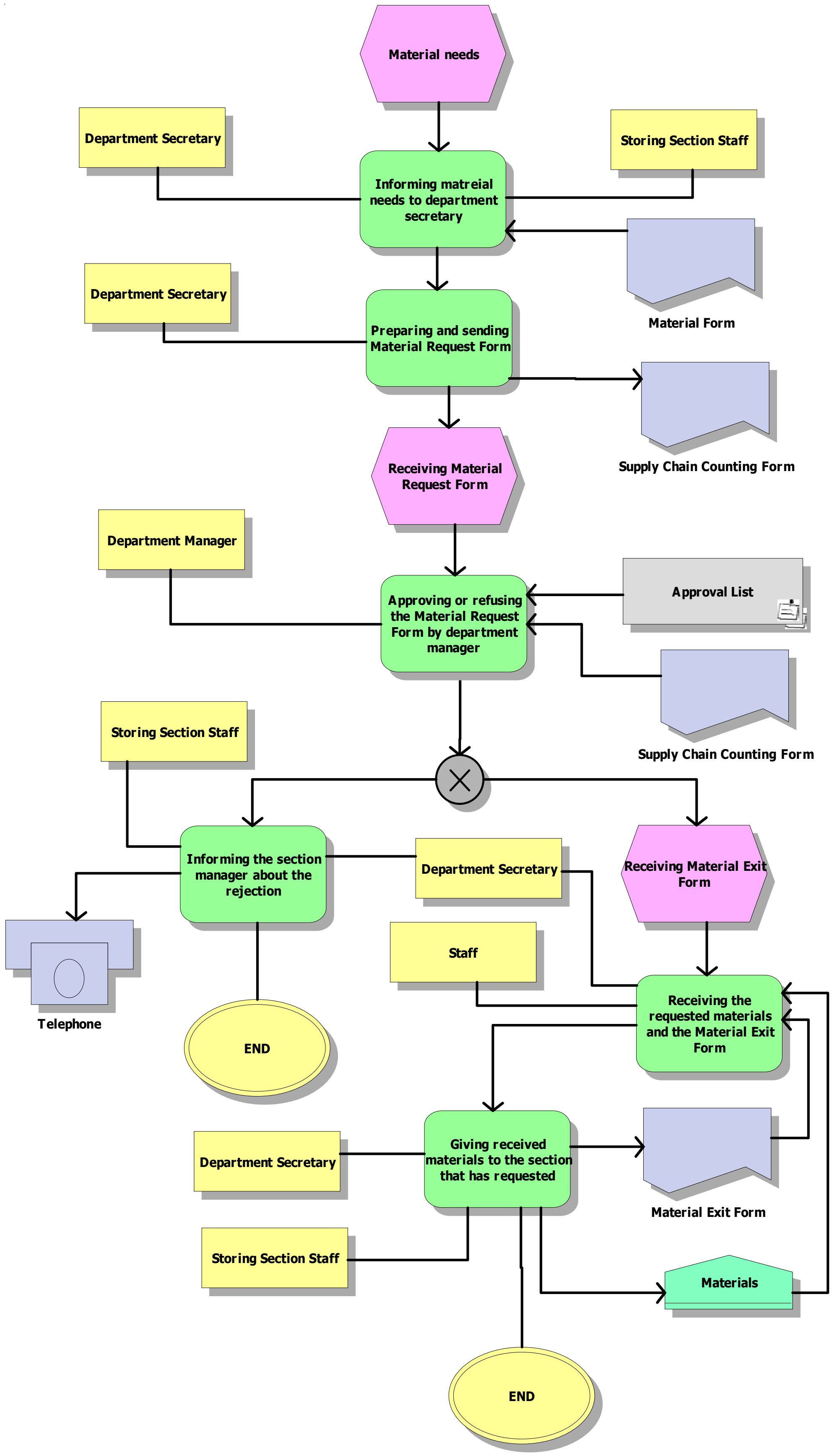

Figure 4.6 Material Request Activities (TO-BE)

4.4.3.2.2 Details of the Problems in the Processes Document

The staff state the following solutions provided in the TO-BE form for the problems identified in the AS-IS form. ("S" is used as an abbreviation of solution.)

S1: The usage of material code solves material description problem. When a material is needed, section manager and department secretary agree on material codes. Material Catalogue is prepared by the supply chain department by listing materials and by coding each of them that is already defined with its features.

S2: Section manager writes his needs to Material Form by using material codes and the needed quantity. Then, he gives the Material Form to department secretary. Department secretary prepares Material Request Form according to the details, not only materials but also their quantities, indicated in the Material Form. Therefore, the needs of the section manager can reach supply chain department as requested in terms of both features and quantities.

S3: Material Request Form, Material Exit Form and their movements in departments are recorded automatically. Department secretary or section manager can search logs for finding detailed information about past events. When a problem occurs in log files, they are restored from backup files.

S4: The usage of the Document Record Book is given up in the TO-BE form. Material Request Form and Material Exit Form are automatically recorded to the log files. Department secretary can search logs by using the fields in the forms. The valid forms are listed to the secretary.

4.4.3.2.3 Details in the Quality Measurement Document

Quality Measurement Document includes the following measurements for the Material Request Process (TO-BE), maintainability in Table 4.18, reliability in Table 4.19, functionality in Table 4.20 and Table 4.21 and usability in Table 4.22 respectively.

Table 4.18 Maintainability Measurement of Material Request Process (TO-BE)

Activity Number	Complexity	Coupling
1	No decision	No interaction
2	No decision	No interaction
3	Semi-structured decision for approving or refusing the request Department manager uses information written in the forms and his judgment while taking a decision. There is no rule which determines “when a request is approved” or “under which conditions a request is refused.” It is not a complex decision, but it requires human opinion.	Interaction with Meeting Material Request process (sending Material Request Form)
4	No decision	No interaction
5	No decision	Interaction with Meeting Material Request Process (receiving Material Exit Form)
6	No decision	No interaction

Table 4.19 Reliability Measurement of Material Request Process (TO-BE)

Activity Number	Failure Avoidance	Restorability	Restoration Effectiveness
1	Department secretary reviews Material Form prepared by section manager.	Recorded in Material Form	Restoration from Material Form file
2	Department secretary checks material codes given by section manager by using Material Catalogue.	Recorded in Material Request Form	Restoration from Material Request Table backup
3	Department manager reviews Material Request Form prepared by department secretary. When he finds mistakes in the form, he or department secretary corrects them.	Recorded in Material Request Form	Restoration from Material Request Table backup
4	No review, inspection, checkpoint or similar techniques	Not recorded	No restoration
5	Department secretary reviews Material Exit Form and compares with the received materials.	Recorded in Material Exit Form	Restoration from Material Exit Table backup
6	Section manger examines the received materials.	Recorded in Material Exit Form for indicating the delivery	Restoration from Material Exit Table backup

Table 4.20 Functionality Measurement of Material Request Process-I (TO-BE)

Activity Number	Functional Adequacy	Functional Completeness	IT Usage	IT Density
1	Adequate	-	IT usage in preparation of Material Form	Material Form is prepared by using Material Catalogue in computerized environment.
2	Adequate	-	IT usage in preparation of Material Request Form	Material Request Form is prepared in Supply Chain Information System.
3	Adequate	-	IT usage in approving or refusing Material Request Form	Material Request Form is approved or refused in Supply Chain Information System.
4	Adequate	-	No IT usage	No forms, documents, archival records or other similar documents that are prepared, updated, deleted or searched
5	Adequate	-	IT usage in receiving Material Exit Form	The status of Material Request Form is updated by the system.
6	Adequate	-	IT usage in entering name of the staff to whom the materials are delivered	The delivery field of the Material Exit Form is updated with name of the staff.

Table 4.21 Functionality Measurement of Material Request Process-II (TO-BE)

Activity Number	Computational Accuracy	Data Exchangeability	Access Auditability
1	Accuracy requirement: Department secretary and section manager should be sure about the requested materials. This requirement is implemented in the activity. Department secretary use material codes for verifying the materials that are given by the section manager.	No interaction	Access auditability The field in the Material Form indicates information about staff who request materials.
2	No specific accuracy requirement.	No interaction	Access Auditability Supply Chain Information System records information about user who prepares Material Request Form.
3	Accuracy requirement: Department manager should check Material Request Form before it is sent to Supply Chain Department. This requirement is implemented in the activity. Department manager reads new requests from Approve List and clicks one of them for reading associated Material Request Form to find mistakes and correct them.	Material Request Form is sent from Material Request Process to Meeting Material Request Process. The use of data will be evaluated in Meeting Material Request process.	Access Auditability Supply Chain Information System records information about user who approves or refuses Material Request Form.
4	No specific accuracy requirement	No interaction	Access Auditability Supply Chain Information System records information about user who access notes on Material Request Form.
5	No specific accuracy requirement	Material Exit Form is received from Meeting Material Request Process. The data in the Material Exit Form is used without applying any changes in Material Request process.	Access Auditability Supply Chain Information System records information about user who receives Material Exit Form.
6	No specific accuracy requirement	No interaction	Access Auditability Supply Chain Information System records information about staff to whom the materials are delivered.

Table 4.22 Usability Measurement of Material Request Process (TO-BE)

Activity Number	Functional Understandability	Completeness of Documentation	Input Validity Checking	Undoability	Attractive Interaction
1	No difficulties or misunderstandings	Described	Input validity checking for requested materials defined by section manager with using Material Form	Recorded, undoability of preparing Material Form	Attractive interaction in preparing and reading Material Form
2	No difficulties or misunderstandings	Described	Input validity checking for requested materials selected from Material Catalogue	Recorded, undoability of preparing and sending Material Request Form	Attractive interaction in preparation of Material Request Form in Supply Chain Information System
3	No difficulties or misunderstandings	Described	Input validity checking for Material Request Form prepared by department secretary	Recorded, not undoability of approving or refusing Material Request Form	Attractive interaction in approving or refusing of Material Request Form in Supply Chain Information System
4	No difficulties or misunderstandings	Described	Input validity checking for status of Material Request Form assigned by department manager	Not recorded	Attractive interaction in reading reasons entered by department manager
5	No difficulties or misunderstandings	Described	Input validity checking for status of Material Exit Form approved by Supply Chain department manager	Recorded, not undoability of approving or refusing Material Exit Form	Attractive interaction in reading Material Exit Form in Supply Chain Information System
6	No difficulties or misunderstandings	Described	Input validity checking for status of Material Exit Form approved by Supply Chain department manager	Recorded, undoability of entering name of the staff to whom the materials are delivered	Attractive interaction in updating the delivery field of the Material Exit Form

The measurement results of the Material Request Process (TO-BE) are summarized in table below. The results are depicted by using radar chart (see Figure 4.7). In the figure, AS-IS (inner black area) and TO-BE measurements are given together.

Table 4.23 Measurement Summary for Material Request Process (TO-BE)

No	Quality Attribute	Material Request (TO-BE Form)
1	Complexity	0.834
2	Coupling	0.667
3	Failure Avoidance	0.833
4	Restorability	0.833
5	Restoration Effectiveness	0.833
6	Functional Adequacy	1
7	Functional Completeness	1
8	IT Usage	0.833
9	IT Density	1
10	Computational Accuracy	1
11	Data Exchangeability	1
12	Access Auditability	1
13	Functional Understandability	1
14	Existence in Documents	1
15	Input Validity Checking	1
16	Undoability	0.6
17	Attractive Interaction	1

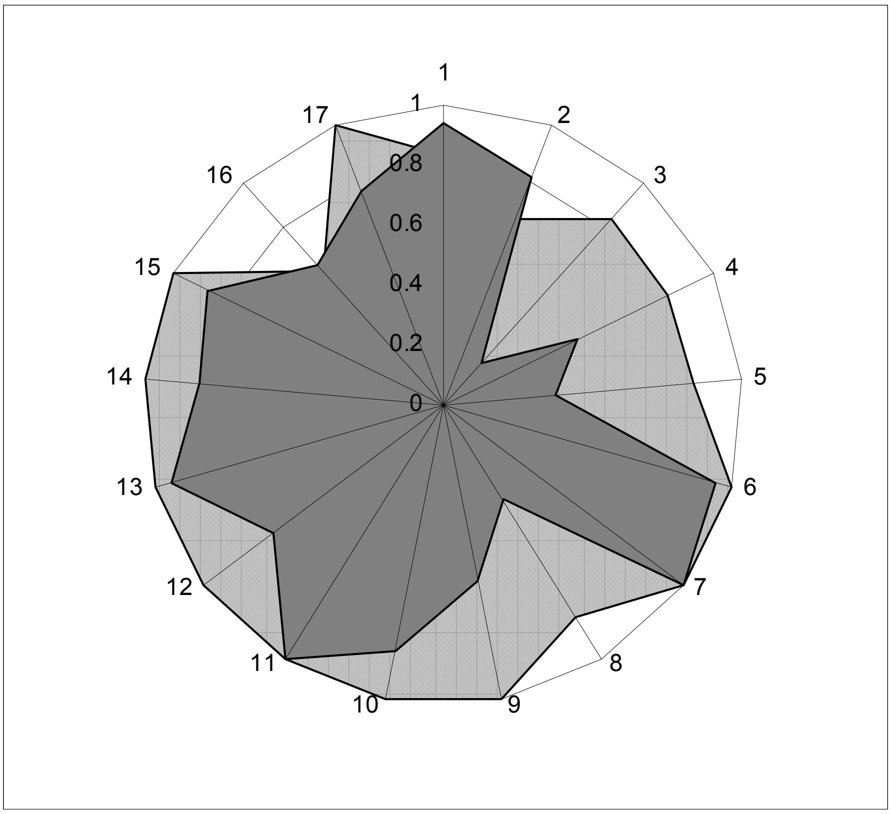

Figure 4.7 Measurement of Material Request Process with AS-IS and TO-BE Values

4.4.4 Effort Spent in the Case Study

The efforts spent for the case study is calculated by considering the steps ordered below.

Table 4.24 Efforts Spent in the Case Study

No	Effort Name	Number of staff	Effort (per man-minute)
1	Preparation of the case study plan	1	360
2	Reviewing and updating the plan	1	120
3	Talking with the supply chain department manager and explaining the purposes of the case study	2	60
4	Talking with two staff and explaining the purposes of the case study	3	180
5	Reviewing relevant documents (Process Analysis Document, Data Flow Diagrams and Material Management Documents) about the AS-IS form processes	1	120
6	Preparation of process definitions in activity level details for the AS-IS form processes	1	1200
7	Drawing process modeling diagrams for the AS-IS form processes by using ARIS tool	1	480
8	Determining rules and regulations from Material Management Document about the AS-IS form processes	3	540
9	Reviewing the process definitions and their modeling diagrams of the AS-IS form processes with two staff	3	900
10	Recording the problems encountered during the execution of the AS-IS form processes	3	450
11	Reviewing relevant documents (Process Design, Help Facility and Material Management Documents) about the TO-BE form processes	1	120
12	Preparation of process definitions in activity level details for the TO-BE form processes	1	600
13	Drawing process modeling diagrams for the TO-BE form processes by using ARIS tool	1	300
14	Determining rules and regulations from Material Management Document about the TO-BE form processes	3	450

Table 4.24 (continued)

No	Effort Name	Number of staff	Effort (per man-minute)
15	Reviewing the process definitions and their modeling diagrams of the TO-BE form processes with two staff	3	540
16	Discussing the solutions provided in the TO-BE form processes for the problems stated in the AS-IS form processes	3	270
17	Introducing the model with explaining the process quality attributes to two staff	3	270
18	Measuring the process quality attributes for four pairs with the participation of two staff	3	720
19	Measuring the process quality attributes of the other four pairs by two staff members themselves	2	400
20	Reviewing the results measured by two staff	1	90
21	Asking a list of questions about the case study to two staff (closure part of the case study)	3	180
22	Collecting all measurement results and preparing a summary documents	1	90
23	Evaluating measurement results for 17 quality attributes	1	350
24	Examining problems and their solutions in the TO-BE form processes and finding relationships with quality attributes	1	300
25	Finding relationships between quality attributes	1	180
26	Refining the model and adding new fields for increasing understandability and applicability of the quality attributes	1	90
27	Interpreting the findings and writing the case study report	1	180
		Total	9540 per man-minute

4.5 Analyzing the Case Study Measurements

The case study results are evaluated from different points of view. One of them is examining the quality attribute values and evaluating them for all processes. The second view is about investigating relations between the problems identified by staff in the AS-IS form processes and quality attribute values. The third one is about answering the research questions determined in the case study planning phase. The fourth is finding out relations among quality attributes and comparing their values.

Finally, the fifth one is the evaluation of the case study and its results with the participators. Each view is detailed below.

4.5.1 Examining Quality Attribute Values

The case study results are given for each characteristic with AS-IS and TO-BE measurement values.

4.5.1.1 Maintainability Measurements

There are two attributes in this category as complexity and coupling.

Complexity Attribute: During the measurement, decisions that initiate different flows were counted. It was accepted that "*structured decision*" has well-defined and standard solution and depends on rule, "*unstructured decision*" has not clear solution and requires creative decision, and "*semi-structured decision*" has repetitive and routine solution, but necessitates human intuition, therefore not depends on a well-defined formula.

When the results given in Table 4.25 and Figure 4.8 are taken into consideration, the following interpretations can be made for the complexity attribute.

- The number of decision was not changed for all processes, from AS-IS to TO-BE form except for Material Purchasing Process. This result is related to the internalization of the AS-IS form processes. These processes have been used for approximately ten years within the department. In the course of the time, there have been some improvements in the processes for stabling the number of decisions.
- There were improvements about decision type in the TO-BE form processes. Some of the decision types changed from "*semi-structured*" to "*structured decision*" as the managers could apply rules with using material codes. The operations related to the materials can be arranged according to their codes therefore, managers do not need to use their intuitions.
- Although there were improvements in the decision type, complexity values decreased from AS-IS to TO-BE form processes when the formula, 1- A / B (A = number of decision, B = number of activity), was applied. This interesting result

stems from the decrease in the number of activity in the TO-BE form while the number of decision is stays the same.

Table 4.25 Measurement Values of Complexity Attribute

Process Name	**Complexity For AS-IS Form**	**Complexity For TO-BE Form**
(1) Material Request	X = 1- 1 / 16 = 0.9375 for overall 1 semi-structured decision X(1) = 1- 0 = 1 X(2) = 1- 0 = 1 X(3) = 1- 1 / 16 = 0.9375	X = 1- 1 / 6 = 0.834 for overall 1 semi-structured decision X(1) = 1- 0 = 1 X(2) = 1- 0 = 1 X(3) = 1- 1 / 6 = 0.834
(2) Meeting Material Request	X = 1- 2 / 18 = 0.889 for overall 1 structured decision 1 semi-structured decision X(1) = 1- 1 / 18 = 0.945 X(2) = 1- 0 = 1 X(3) = 1- 1 / 18 = 0.945	X = 1- 2 / 6 = 0.667 for overall 1 structured decision 1 semi-structured decision X(1) = 1- 1 / 6 = 0.834 X(2) = 1- 0 = 1 X(3) = 1- 1 / 6 = 0.834
(3) Material Purchasing	X = 1- 1 / 12 = 0.9167 for overall 1 structured decision X(1) = 1- 1 / 12 = 0.9167 X(2) = 1- 0 = 1 X(3) = 1- 0 = 1	X = 1- 2 / 11 = 0.819 for overall 1 structured decision 1 semi-structured decision X(1) = 1- 1 / 11 = 0.9091 X(2) = 1- 0 = 1 X(3) = 1- 1 / 11 = 0.9091
(4) Material Registration	X = 1- 1 / 4 = 0.75 for overall 1 semi-structured decision X(1) = 1- 0 = 1 X(2) = 1- 0 = 1 X(3) = 1- 1 / 4 = 0.75	X = 1- 1 / 4 = 0.75 for overall 1 structured decision X(1) = 1- 1 / 4 = 0.75 X(2) = 1- 0 = 1 X(3) = 1- 0 = 1
(5) Material Counting	X = 1- 3 / 20 = 0.85 for overall 3 semi-structured decisions X(1) = 1- 0 = 1 X(2) = 1- 0 = 1 X(3) = 1- 3 / 20 = 0.85	X = 1- 3 / 12 = 0.75 for overall 3 structured decisions X(1) = 1- 3 / 12 = 0.75 X(2) = 1- 0 = 1 X(3) = 1- 0 = 1
(6) Material Returning	X = 1- 2 / 13 = 0.8462 2 semi-structured decisions X(1) = 1- 0 = 1 X(2) = 1- 0 = 1 X(3) = 1- 2 / 13 = 0.8462	X = 1- 2 / 7 = 0.715 1 structured decision 1 semi-structured decision X(1) = 1- 1 / 7 = 0.8572 X(2) = 1- 0 =1 X(3) = 1- 1 / 7 = 0.715
(7) Material Record Deletion	X = 1- 2 / 13 = 0.8462 for overall 1 structured decision 1 semi-structured decision X(1) = 1- 1 / 13 = 0.9231 X(2) = 0 X(3) = 1- 1 / 13 = 0.9231	X = 1- 2 / 8 = 0.75 for overall 2 structured decisions X(1) = 1- 2 / 8 = 0.75 X(2) = 1- 0 = 1 X(3) = 1- 0 = 1
(8) Material Repair and Maintenance	X = 1- 1 / 6 = 0.833 for overall 1 semi-structured decision X(1) = 1- 0 = 1 X(2) = 1- 0 = 1 X(3) = 1- 1 / 6 = 0.833	X = 1- 1/5 = 0.8 for overall 1 semi-structured decision X(1) = 1- 0 = 1 X(2) = 1- 0 = 1 X(3) = 1- 1 / 5 = 0.8

The complexity attribute provided some useful feedbacks about the processes. It determined locations and types of decisions. The processes can be compared with each other according to their complexity values. New improvement studies can be planned for changing decision types or decreasing their numbers.

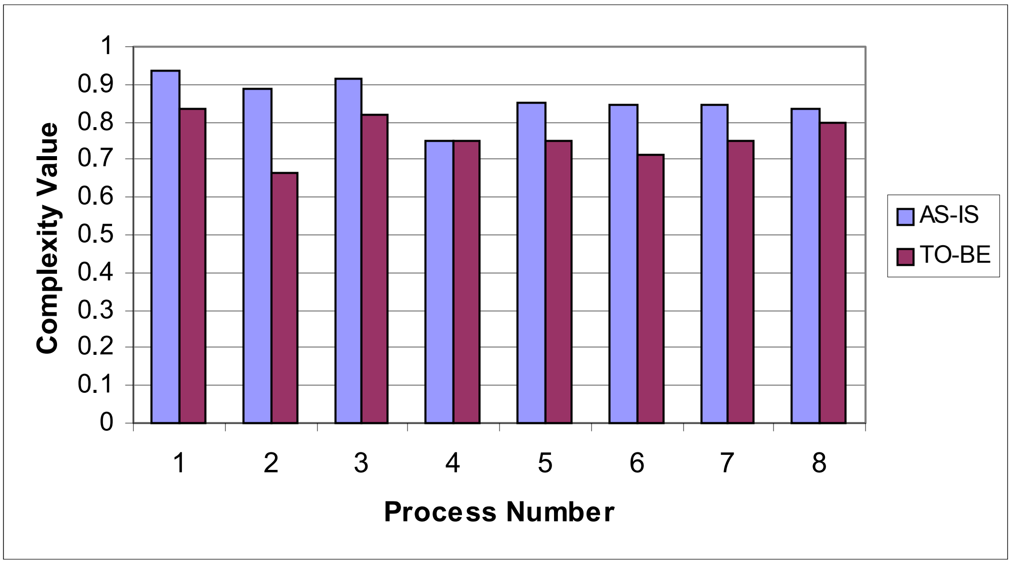

Figure 4.8 Complexity Values of AS-IS and TO-BE Processes

In the case study, it was recognized that "*number of activity*" could be defined as an attribute in the scope of the maintainability. For a process, increase in the number of activities makes traceability and control and therefore maintainability of the process difficult.

Coupling Attribute: This attribute was measured by counting the number of interactions among processes in the department (Table 4.26) and depicted in the Figure 4.9.

Table 4.26 Measurement Values of Coupling Attribute

Process Name	Coupling For AS-IS Form	Coupling For TO-BE Form
(1) Material Request	1- 3 / 16 = 0.8125	1- 2 / 6 = 0.667
(2) Meeting Material Request	1- 5 / 18 = 0.723	1- 5 / 6 = 0.167
(3) Material Purchasing	1- 4 / 12 = 0.667	1- 4 / 11 = 0.6364
(4) Material Registration	1- 2 / 4 = 0.5	1- 2 / 4 = 0.5
(5) Material Counting	1- 0 / 20 = 1	1- 0 / 12 = 1
(6) Material Returning	1- 0 / 13 = 1	1- 0 / 7 = 1
(7) Material Record Deletion	1- 0 / 13 = 1	1- 0 / 8 = 1
(8) Material Repair and Maintenance	1- 0 / 6 = 1	1- 0 / 5 = 1

The following inferences can be made for the coupling attribute.

- The number of interaction was not changed from AS-IS to TO-BE form processes except for Material Request Process. As stated in the complexity attribute, this result is related to the internalization of the AS-IS processes.
- The coupling values decreased from AS-IS to TO-BE form processes when the formula, 1- A / B (A = number of interaction, B = number of activity), was applied. This interesting result stems from the decrease in the number of activities in the TO-BE form while the number of interaction stays the same.

With the coupling attribute, the number of interaction and moreover, activities in which interactions are performed were determined.

New improvement studies can be planned for decreasing the number of interaction or changing their locations.

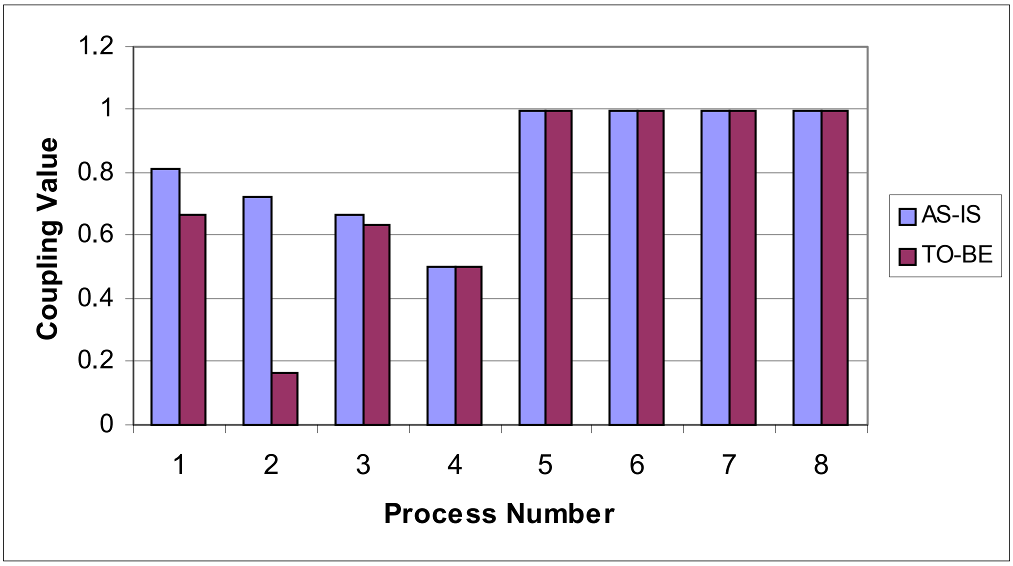

Figure 4.9 Coupling Values of AS-IS and TO-BE Processes

4.5.1.2 Reliability Measurements

There are three attributes in this category as failure avoidance, restorability and restoration effectiveness.

Failure Avoidance Attribute: During the measurement of this quality attribute, the number of failure avoidance techniques such as reviews, inspections, checkpoints or similar methods applied in the process flow was identified.

The following issues were observed for the failure avoidance attribute (see Table 4.27 and Figure 4.10).

- Failure avoidance values increased from AS-IS to TO-BE form processes. In the first sense, this result can be associated with the increase in the number of activities in which failure avoidance techniques applied. When the formula (A / B, A = number of activities in which review, inspection, checkpoint or similar techniques are applied B = number of activities) is considered, it is recognized that there are more than one reason. For Material Request and Material Purchasing processes, the number of failure avoidance techniques applied in them increased. On the other hand, for Meeting Material Request and Material Record Deletion processes, the number of failure avoidance techniques applied in them decreased, but failure avoidance ended up with a higher value in their TO-BE forms as the number of activity decreased. For the last case in Material Counting and Material Returning processes, number of failure avoidance techniques did not change, but due to the decrease in the number of activity, failure avoidance was measured higher than it is in the TO-BE forms. The common property of these three cases is the increase in the number of activity in which failure avoidance techniques applied over the number of all activities.

Table 4.27 Measurement Values of Failure Avoidance Attribute

Process Name	**Failure Avoidance For AS-IS Form**	**Failure Avoidance For TO-BE Form**
(1) Material Request	3 / 16 = 0.1875	5 / 6 = 0.8333
(2) Meeting Material Request	6 / 18 = 0.333	4 / 6 = 0.666
(3) Material Purchasing	3 / 12 = 0.25	4 / 11 = 0.3636
(4) Material Registration	1/ 4 = 0.25	2 / 4 = 0.5
(5) Material Counting	4 / 20 = 0.2	4 / 12 = 0.333
(6) Material Returning	3 / 13 = 0.2307	3 / 7 = 0.4285
(7) Material Record Deletion	5 / 13 = 0.3846	4 / 8 = 0.5
(8) Material Repair and Maintenance	2 / 6 = 0.333	3 / 5 = 0.6

- In the TO-BE form processes, staff such as storing section manager reviews more documents and corrects the mistakes on them. He can apply rules with using material codes from Material Catalogue during examination of the documents. Material code determines the validity of operations, which can be performed on the materials.

With the failure avoidance attribute, number of reviews and their locations are identified.

New improvement studies can be planned for increasing the number of failure avoidance techniques or changing their locations.

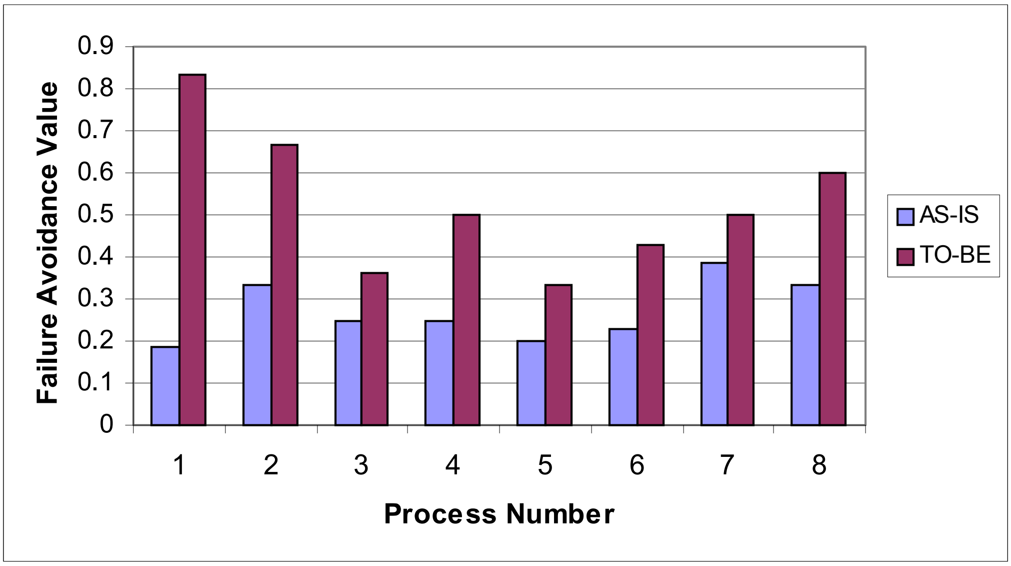

Figure 4.10 Failure Avoidance Values of AS-IS and TO-BE Processes

Restorability Attribute: Recorded activities were counted for measuring the restorability attribute. During the measurement, the idea was "*an activity can not be restored if it is not recorded.*"

The following results were gathered for the restorability attribute (see Table 4.28 and Figure 4.11).

Table 4.28 Measurement Values of Restorability Attribute

Process Name	Restorability For AS-IS Form	Restorability For TO-BE Form
(1) Material Request	8 / 16 = 0.5	5 / 6 = 0.8333
(2) Meeting Material Request	9 / 18 = 0.5	5 / 6 = 0.833
(3) Material Purchasing	7 / 12 = 0.583	11 / 11 = 1
(4) Material Registration	2 / 4 = 0.5	4 / 4 = 1
(5) Material Counting	12 / 20 = 0.6	12 / 12 = 1
(6) Material Returning	8 / 13 = 0.6153	5 / 7 = 0.7142
(7) Material Record Deletion	7 / 13 = 0.5384	7 / 8 = 0.875
(8) Material Repair and Maintenance	2 / 6 = 0.333	4 / 5 = 0.8

- The restorability values increased from AS-IS to TO-BE form. This result stems from recording mechanism that is automatically employed in the TO-BE form processes. For instance, when a staff sends or receives a document, this activity is automatically recorded with the information placed in the document.
- There are no automatic record mechanisms in the AS-IS form processes. For instance, department secretaries use Document Record Book for recording sent or received documents manually. The other staff in the Supply Chain Department do not record their document transfers among them.

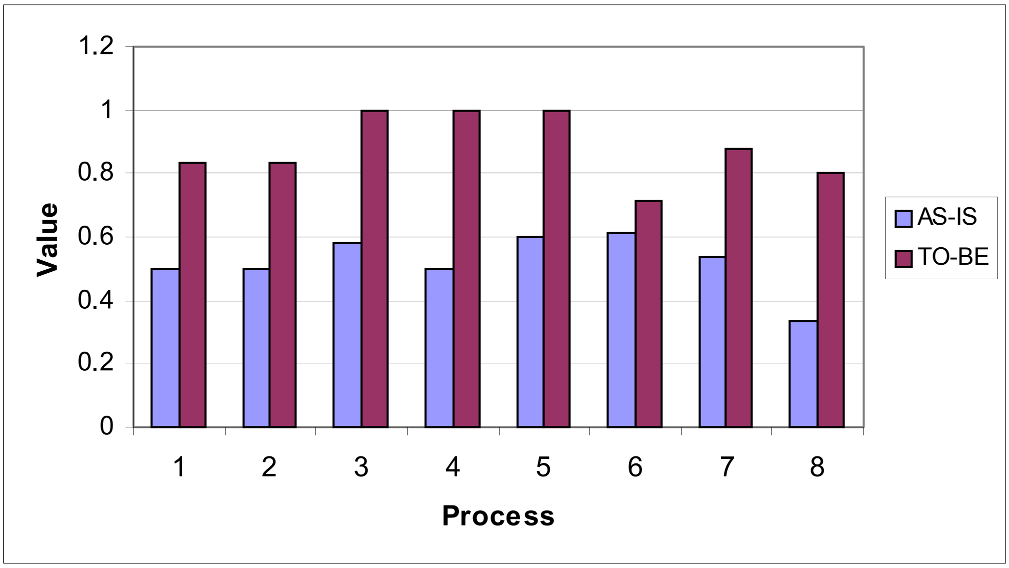

Figure 4.11 Restorability Values of AS-IS and TO-BE Processes

Restoration Effectiveness Attribute: The restorability of recorded activities was measured with this attribute. Restoration was considered for both manual and IS supported activities. Documents recording in more than one paper was accepted as restorable for manual activities. On the other hand, backup files in computerized environment was accepted as restorable for the IS supported activities.

The following evaluations were made for the restoration effectiveness attribute (see Table 4.29 and Figure 4.12).

- There are two formulas for measuring restoration effectiveness. The first one divides restorable activities by the number of activities. On the other hand, the second one uses number of recorded activities as denominator. In order to provide an overall measurement value, the first formula was applied in the case study.

Table 4.29 Measurement Values of Restoration Effectiveness Attribute

Process Name	Restoration Effectiveness For AS-IS Form	Restoration Effectiveness For TO-BE Form
(1) Material Request	6 / 16 = 0.375	5 / 6 = 0.8333
(2) Meeting Material Request	7 / 18 = 0.388	5 / 6 = 0.833
(3) Material Purchasing	5 / 12 = 0.416	11 / 11 = 1
(4) Material Registration	1 / 4 = 0.25	4 / 4 = 1
(5) Material Counting	8 / 20 = 0.4	12 / 12 = 1
(6) Material Returning	5 / 13 = 0.3846	5 / 7 = 0.7142
(7) Material Record Deletion	4 / 13 = 0.3076	7 / 7 = 1
(8) Material Repair and Maintenance	1 / 6 = 0.166	4 / 5 = 0.8

- Since the TO-BE form processes benefit more from IS support in their activities than AS-IS form processes, restoration effectiveness values increased from AS-IS to TO-BE form processes. As stated in the restorability attribute, activities are automatically recorded in the TO-BE form process. The backup files in computerized environment can be used for restoring activities when an abnormal event occurs. On the contrary, in AS-IS form processes, the number of IS supported activities is limited and furthermore, most of the documents are prepared in one copy.

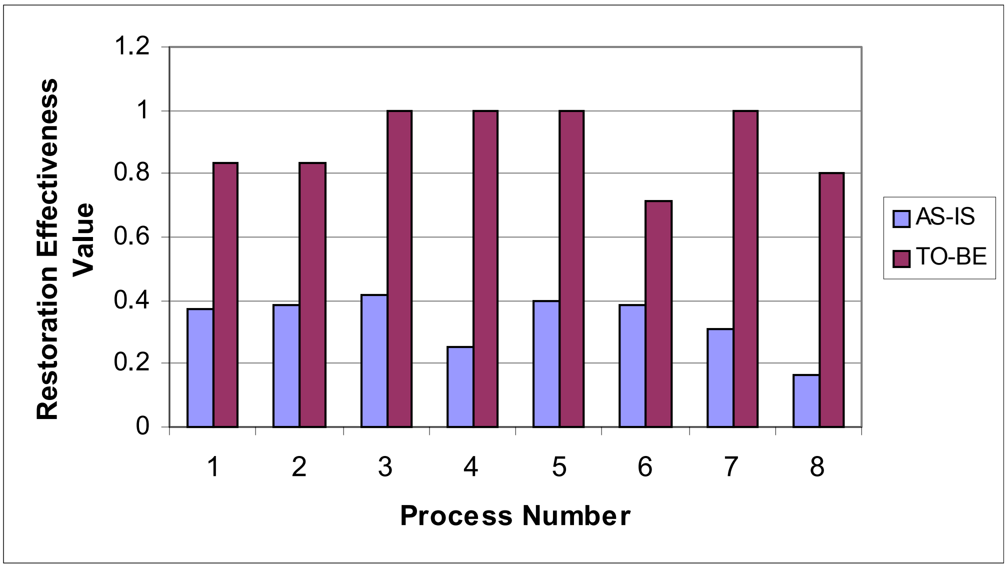

Figure 4.12 Restoration Effectiveness Values of AS-IS and TO-BE Processes

4.5.1.3 Functionality Measurements

There are seven attributes in this category as functional adequacy, functional completeness, IT usage, IT density, computational accuracy, data exchangeability and access auditability.

Functional Adequacy Attribute: During the measurement of the functional adequacy, there was an evaluation for each process by comparing its performed activities in practice with defined activities in the Material Management Document. The activities that are not defined in the Material Management Document were evaluated according to the participator staff's points of view (see Table 4.30 and Figure 4.13).

The following issues were observed for the functional adequacy attribute.

- The functional adequacy values of both AS-IS and TO-BE form processes are high.
- As the activities that are not defined in the Material Management Document were evaluated according to the participator staff's points of view, the functional

adequacy measurements of AS-IS form were affected by internalized use of the processes. Since the turnover rate is low within this organization, higher values for functional adequacy attribute could be obtained.

Table 4.30 Measurement Values of Functional Adequacy Attribute

Process Name	**Functional Adequacy For AS-IS Form**	**Functional Adequacy For TO-BE Form**
(1) Material Request	15 / 16 = 0.9375	6 / 6 = 1
(2) Meeting Material Request	18 / 18 = 1	6 / 6 = 1
(3) Material Purchasing	10 / 12 = 0.833	11 / 11 = 1
(4) Material Registration	2 / 4 = 0.5	4 / 4 = 1
(5) Material Counting	16 / 20 = 0.8	12 / 12 = 1
(6) Material Returning	13 / 13 = 1	7 / 7 = 1
(7) Material Record Deletion	12 / 13 = 0.9230	8 / 8 = 1
(8) Material Repair and Maintenance	5 / 6 = 0.833	5 / 5 = 1

- With the TO-BE form processes, "*activity in theory*" becomes closer to "*activity in practice*." As the rules and regulations defined in the Material Management Document are integrated into the IS supported processes, their functional adequacy was fully obtained with a rate of 1.

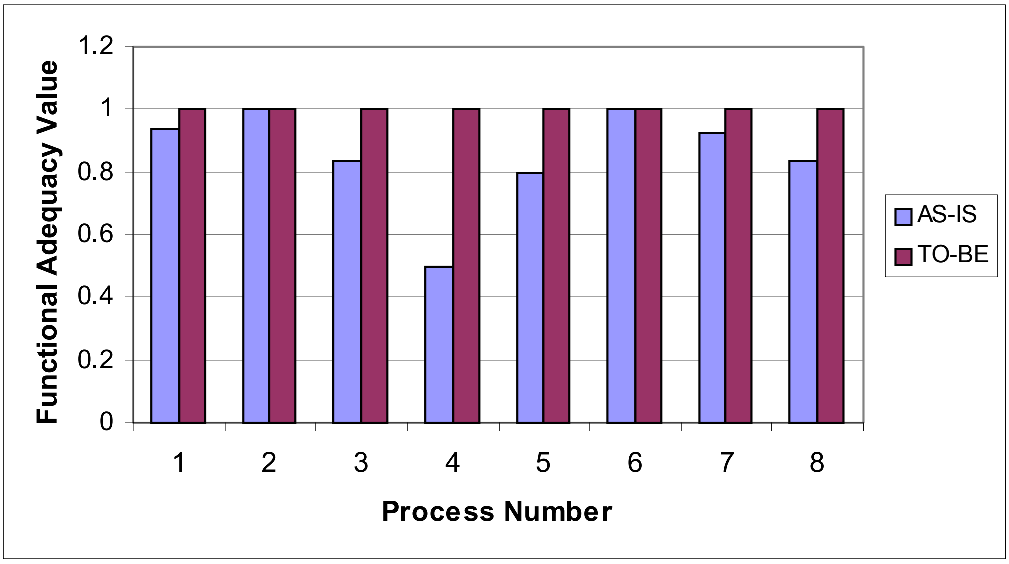

Figure 4.13 Functional Adequacy Values of AS-IS and TO-BE Processes

Functional Completeness Attribute: The activities defined in the Material Management Document, but missing in practice were measured by means of this attribute (see Table 4.31 and Figure 4.14).

Table 4.31 Measurement Values of Functional Completeness Attribute

Process Name	Functional Completeness For AS-IS Form	Functional Completeness For TO-BE Form
(1) Material Request	1 – 0 / 16 = 1	1 – 0 / 6 = 1
(2) Meeting Material Request	1 – 0 / 18 = 1	1 – 0 / 6 = 1
(3) Material Purchasing	1 – 1 /12 = 0.9167	1 - 0 / 11 = 1
(4) Material Registration	1 – 0 / 4 = 1	1 – 0 / 4 = 1
(5) Material Counting	1 – 0 / 20 = 1	1 – 0 / 12 = 1
(6) Material Returning	1 – 0 / 13 = 1	1 – 0 / 7 = 1
(7) Material Record Deletion	1 – 0 / 13 = 1	1 – 0 / 8 = 1
(8) Material Repair and Maintenance	1 – 1 / 6 = 0.834	1 – 0 / 5 = 1

The following comments can be made for the functional completeness attribute.

- Due to the internalized use of the AS-IS form processes, their functional completeness values were measured as high. Only two activities, one from Material Purchasing and other from Material Repair and Maintenance processes, were determined as missing in practice.

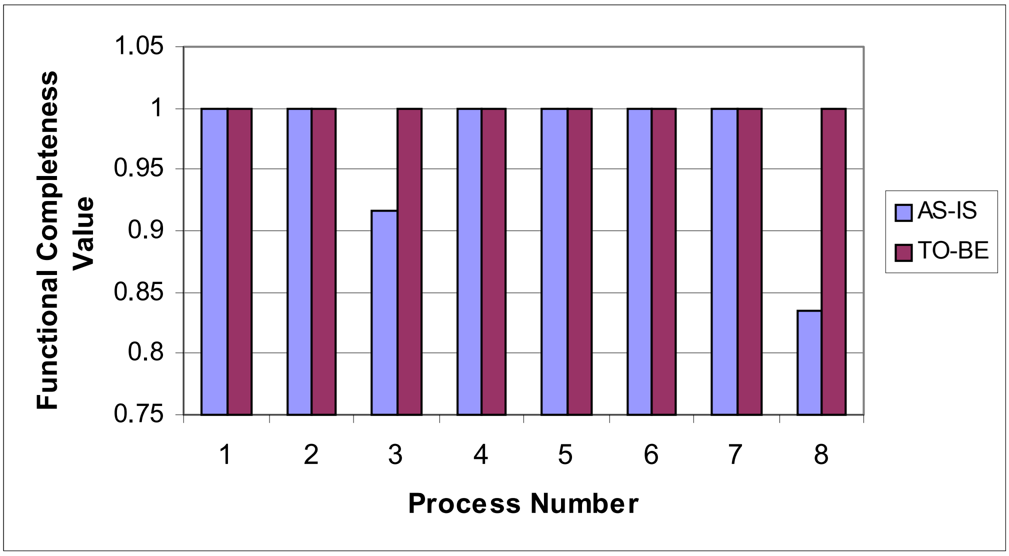

Figure 4.14 Functional Completeness Values of AS-IS and TO-BE Processes

- As the TO-BE form processes are designed and automated according to the Material Management Document, their functional completeness were fully obtained with a rate of 1.

IT Usage: The usage of IT applications for preparation, deletion, updating or searching purposes in activities was measured by this attribute. Each activity was examined to look for whether IT usage was present or not (see Table 4.32 and Figure 4.15).

Table 4.32 Measurement Values of IT Usage Attribute

Process Name	**IT Usage For AS-IS Form**	**IT Usage For TO-BE Form**
(1) Material Request	6 / 16 = 0.375	5 / 6 = 0.833
(2) Meeting Material Request	5 / 18 = 0.277	5 / 6 = 0.833
(3) Material Purchasing	5 / 12 = 0.416	11 / 11 = 1
(4) Material Registration	1 / 4 = 0.25	4 / 4 = 1
(5) Material Counting	5 / 20 = 0.25	12 / 12 = 1
(6) Material Returning	3 / 13 = 0.2307	5 / 7 = 0.7142
(7) Material Record Deletion	4 / 13 = 0.3076	7 / 8 = 0.875
(8) Material Repair and Maintenance	1 / 6 = 0.166	4 / 5 = 0.8

The following issues were observed for the IT usage attribute.

- The usage of IT applications in the AS-IS form processes is low. The highest value is 0.416 and the other values are within the range of 0.166 - 0.375. Most of the activities were performed manually in paper-based environment. There were limited and also separate IT application usages such as Microsoft Word and Microsoft Excel.
- There is considerable increase in IT usage values in TO-BE form processes. Most of the activities were supported by IT applications. Furthermore, these IT applications were integrated to each other for using one's outputs as the other's inputs.

With the IT usage attribute, only the existence of IT applications in a process can be measured. This attribute does not examine any connection or automation of an IT application with other IT applications. In order to have information about automation of IT application in the process, a new attribute, for instance, "*IT Automation*" should be developed. In this case, IT usage attribute becomes a prerequisite of this new attribute.

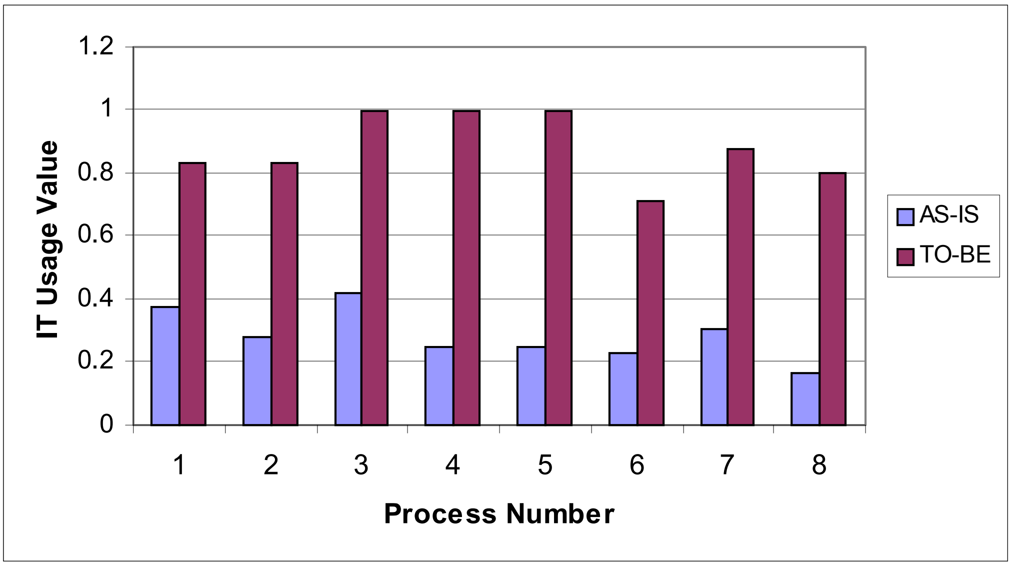

Figure 4.15 IT Usage Values of AS-IS and TO-BE Processes

IT Density: With the IT density attribute, operations such as preparation, updating, deletion and searching of forms, reports, archival records or similar other documents were examined and the usages of IT applications in these operations were counted (see Table 4.33 and Figure 4.16).

Table 4.33 Measurement Values of IT Density Attribute

Process Name	IT Density For AS-IS Form	IT Density For TO-BE Form
(1) Material Request	6 / 10 = 0.6	5 / 5 = 1
(2) Meeting Material Request	5 / 6 = 0.833	5 / 5 = 1
(3) Material Purchasing	6 / 8 = 0.75	10 / 10 = 1
(4) Material Registration	1 / 2 = 0.5	4 / 4 = 1
(5) Material Counting	5 / 12 = 0.416	5 / 5 = 1
(6) Material Returning	3 / 7 = 0.4285	5 / 5 = 1
(7) Material Record Deletion	4 / 7 = 0.5714	5 /5 = 1
(8) Material Repair and Maintenance	1 / 2 = 0.5	3 / 3 = 1

The following comments can be made for the IT density attribute.

- Since the forms like Material Request Form and Material Exit Form are recorded in the paper-based environment and since managers should sign the forms manually, IT density values are considerably low in the AS-IS form processes.

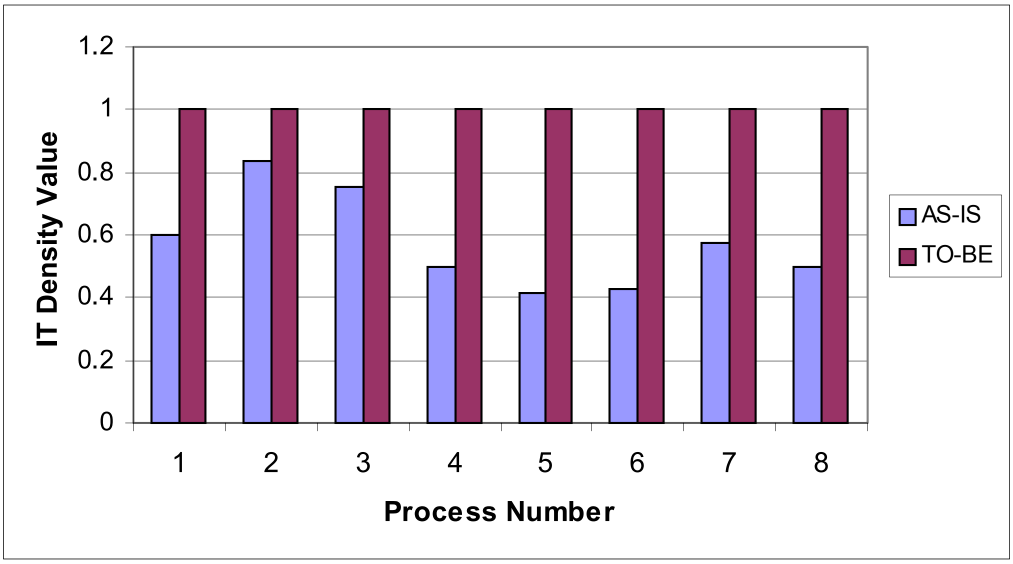

Figure 4.16 IT Density Values of AS-IS and TO-BE Processes

- As all forms are recorded automatically and managers can give approval or refusal by using IT applications in TO-BE form processes, the values of IT density attribute are higher than they are in AS-IS form processes.

Computational Accuracy: The existence of the accuracy requirements in activity definitions was measured by this attribute. For this purpose, the accuracy requirements defined in the Material Management Document were searched in activity definitions (see Table 4.34 and Figure 4.17).

The following interpretations can be made for the computational accuracy attribute.

- The computational accuracy values of the AS-IS form processes changes within the range of 0.4 and 1. The accuracy requirements about Material Registration, Material Counting and Material Returning were fully placed in the activity definitions, while 2 of 5 accuracy requirements were applied in the Material Record Deletion process.

Table 4.34 Measurement Values of Computational Accuracy Attribute

Process Name	Computational Accuracy For AS-IS Form	Computational Accuracy For TO-BE Form
(1) Material Request	5 / 6 = 0.83	2 / 2 = 1
(2) Meeting Material Request	8 / 8 = 1	3 / 3 = 1
(3) Material Purchasing	5 / 7 = 0.7142	5 / 5 = 1
(4) Material Registration	1 / 1 = 1	1 / 1 = 1
(5) Material Counting	8 / 8 = 1	6 / 6 = 1
(6) Material Returning	5 / 5 = 1	4 / 4 = 1
(7) Material Record Deletion	2 / 5 = 0.4	3 / 3 = 1
(8) Material Repair and Maintenance	1 / 2 = 0.5	2 / 2 = 1

- Contrary to the AS-IS form processes, accuracy requirements were fully handled in all TO-BE form processes. Due to the high number of IT supported activities, the existence of accuracy requirements was much higher in TO-BE form processes than it is in the AS-IS form processes.

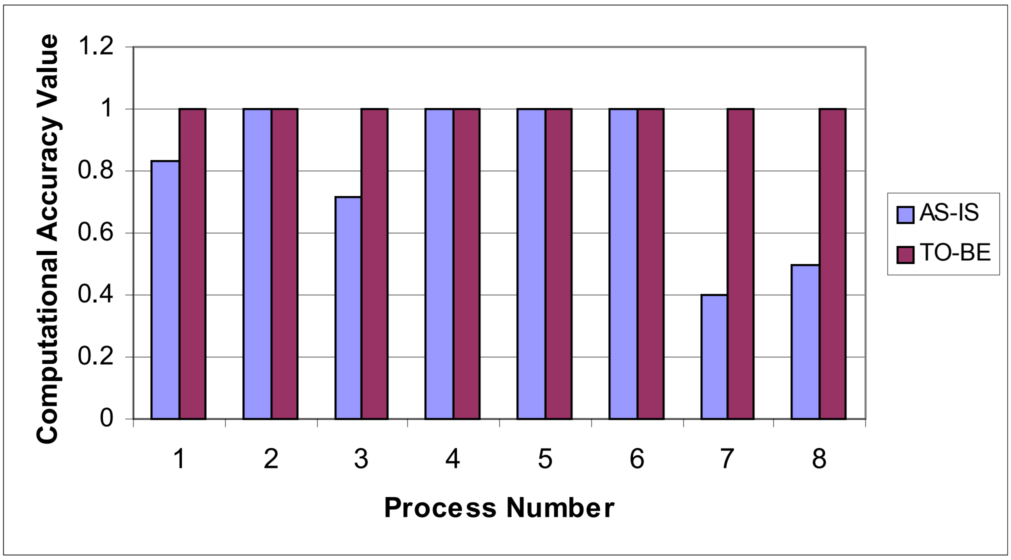

Figure 4.17 Computational Accuracy Values of AS-IS and TO-BE Processes

- It is important to be aware of that the computational accuracy attribute does not measure how accuracy requirements are implemented in activities or how much qualified they are. So, high value of computational accuracy does not guarantee completely accurate data production as this attribute considers only the existence of accuracy requirements in activity definitions.

Data Exchangeability: This attribute measured the usage of data that was transferred from another process. For this purpose, processes that have interaction with other processes were taken into consideration for the measurement. During the measurement, coupling attribute was thought as a prerequisite of data exchangeability, which made the measurement of this attribute easier.

With this attribute, the usage of the data coming from interacted process was into account. Since the crucial issue is to be able to use raw data after coming from interacted processes, this attribute aimed to measure the ability of the usage of these unprocessed data.

Table 4.35 Measurement Values of Data Exchangeability Attribute

Process Name	Data Exchangeability For AS-IS Form	Data Exchangeability For TO-BE Form
(1) Material Request	2 / 2 = 1	1 / 1 = 1
(2) Meeting Material Request	3 / 3 = 1	2 / 2 = 1
(3) Material Purchasing	1 / 2 = 0.5	1 / 2 = 0.5
(4) Material Registration	1 / 1 = 1	1 / 1 = 1
(5) Material Counting	0 / 0 No interaction	0 / 0 No interaction
(6) Material Returning	0 / 0 No interaction	0 / 0 No interaction
(7) Material Record Deletion	0 / 0 No interaction	0 / 0 No interaction
(8) Material Repair and Maintenance	0 / 0 No interaction	0 / 0 No interaction

The following comments were made for the data exchangeability attribute (see Table 4.35 above and Figure 4.18 below).

- The data exchangeability values of both the AS-IS and TO-BE form processes were equal to each other.

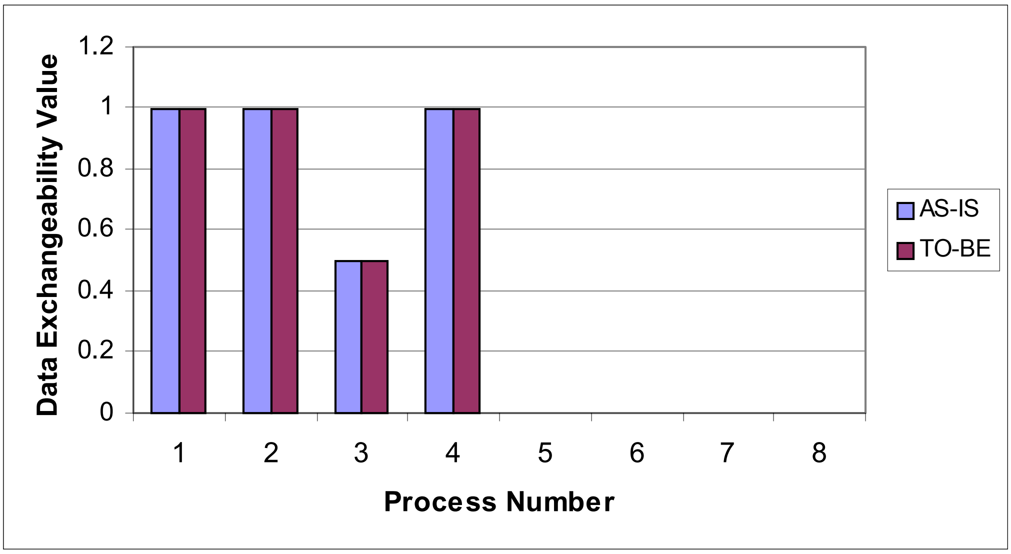

Figure 4.18 Data Exchangeability Values of AS-IS and TO-BE Processes

- The transferred data was used without any additional operation on them during Material Request, Meeting Material Request and Material Registration processes.
- In the Material Purchasing Process, for both AS-IS and TO-BE forms, there was a need to process purchasing data because the materials that would be purchased were determined after the extraction from Material Request Form. This operation was manually performed in the AS-IS form, while it was automatically extracted and also listed in the TO-BE form.
- In order to avoid undefined results coming from dividing by zero, the data exchangeability of the processes (Material Counting, Material Returning, Material Record Deletion and Material Repair and Maintenance) that have no interactions were set as "*no interaction.*" Therefore, their data exchangeability values are not depicted in the chart.

Access Auditability: The auditability of the accesses to data sources was measured by this attribute. For this purpose, activities that necessitate having accesses to data sources were taken into account within the measurement. The ability to identify the staff who access to the data sources was examined.

The following evaluations were made for the access auditability attribute (see Table 4.36 and Figure 4.19).

Table 4.36 Measurement Values of Access Auditability Attribute

Process Name	Access Auditability For AS-IS Form	Access Auditability For TO-BE Form
(1) Material Request	10 / 14 = 0.7142	6 / 6 = 1
(2) Meeting Material Request	8 / 15 = 0.533	5 / 6 = 0.833
(3) Material Purchasing	1 / 11 = 0.0909	11 / 11 = 1
(4) Material Registration	1 / 4 = 0.25	4 / 4 = 1
(5) Material Counting	8 / 12 = 0.666	12 / 12 = 1
(6) Material Returning	7 / 10 = 0.7	5 / 6 = 0.8333
(7) Material Record Deletion	2 / 7 = 0.2857	7 / 7 = 1
(8) Material Repair and Maintenance	0 / 5 = 0	4 / 5 = 0.8

- The access auditability values of the AS-IS form processes change within the range of 0 and 0.7142. The higher the number of staff within the section, the more difficult to identify the performer is. As most of the sections have more than one member and the mechanism that can provide identification of staff was not employed in the AS-IS form processes, the access auditability values become lower than they are in the TO-BE form processes.

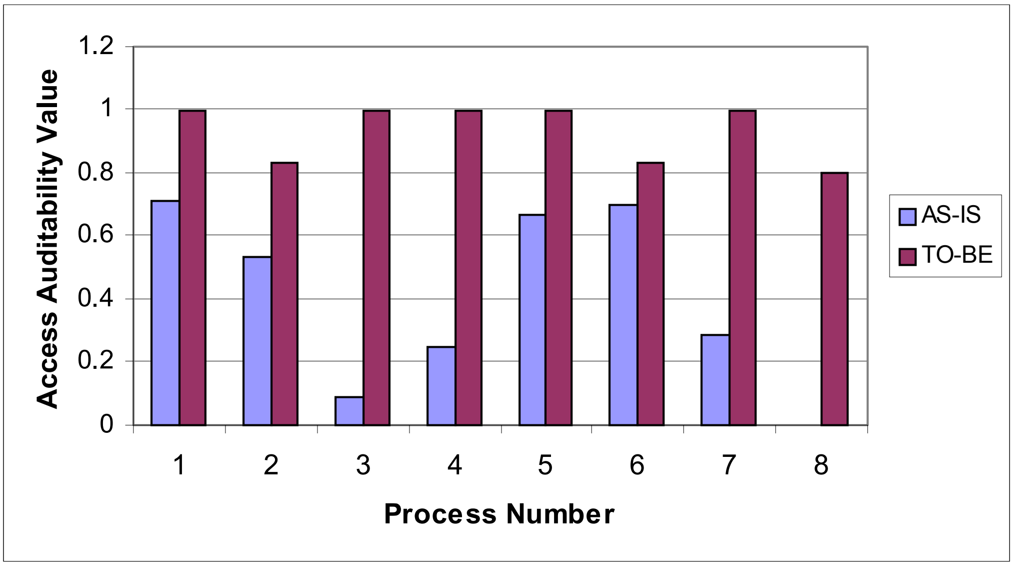

Figure 4.19 Access Auditability Values of AS-IS and TO-BE Processes

- Each member logins into the Supply Chain Information System by entering his user name and password. All operations performed by a member are recorded with username information, which makes the identification possible therefore, access auditability values become higher in the TO-BE form process. Although the values are higher here, there is still some room to go on because the staff who perform manual activities such as bringing materials to storing and taking materials from storing were not recorded and consequently could not be audited in the Meeting Material Request, Material Returning and Material Repair and Maintenance Processes.

4.5.1.4 Usability Measurements

There are five attributes in this category as functional understandability, existence in documents, input validity checking, undoability and attractive interaction.

Functional Understandability Attribute: With this attribute, difficulties encountered by staff for understanding activities were examined. In the scope of the attribute, understandability of job definition and associated rules were discussed and how much clear they are and how much they can guide to the staff were evaluated.

The following issues were discussed for the functional understandability attribute (see Table 4.37 and Figure 4.20).

Table 4.37 Measurement Values of Functional Understandability Attribute

Process Name	**Functional Understandability For AS-IS Form**	**Functional Understandability For TO-BE Form**
(1) Material Request	15 / 16 = 0.9375	6 / 6 = 1
(2) Meeting Material Request	18 / 18 = 1	6 / 6 = 1
(3) Material Purchasing	10 / 12 = 0.833	11 / 11 = 1
(4) Material Registration	2 / 4 = 0.5	4 / 4 = 1
(5) Material Counting	12 / 20 = 0.6	12 / 12 = 1
(6) Material Returning	11 / 13 = 0.8461	7 / 7 = 1
(7) Material Record Deletion	10 / 13 = 0.7692	8 / 8 = 1
(8) Material Repair and Maintenance	4 / 6 = 0.666	5 / 5 = 1

- Some rules were not clear enough in the AS-IS form processes. For instance, in Material Registration Process, reception section staff may get confused whether they should accept or refuse the materials that come to the Supply Chain Department since they have not enough clarifications about the characteristics of the ordered materials and they can not make comparisons between what was ordered and what has been received. The similar difficulties were experienced in Material Record Deletion Process. Storing section staff encounter some difficulties while deciding to make deletion because which materials should be deleted under which conditions is not clearly identified.
- Missing activity is the other reason that impedes understandability. For instance, in Material Purchasing Process, as the preparation of Material Purchasing List is missing, staff experience difficulties while determining the materials to be purchased according to the markings on Material Request Form.
- These two issues mentioned above were considered during the AS-IS form processes' measurement and functional understandability attribute values were measured within a range of 0.5 and 1.

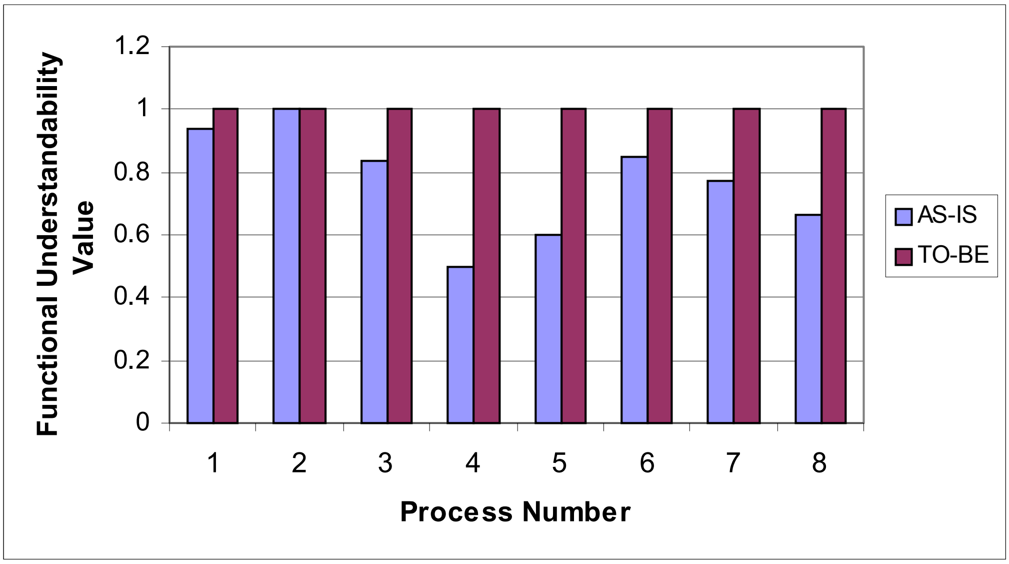

Figure 4.20 Functional Understandability Values of AS-IS and TO-BE Processes

- The difficulties stated about understandability for the AS-IS form processes were overcome in the TO-BE form processes. First of all, materials were classified and coded according to their feature descriptions. The operations such as registration, reception, counting and deleting were defined and associated with the material codes. Therefore, staff could give decisions while receiving new materials or counting fixture materials by using material codes. The TO-BE form processes are designed to guide staff according to the material operations that can be done on materials.

- Missing activity in the Material Purchasing Process, in the AS-IS form process, was completed in the TO-BE form process. Material Purchasing Form is prepared automatically by using requested material numbers given in Material Request Process after looking at the available numbers in Stock Card. The staff can order materials by using the Material Purchasing Form and follow their status.
- The resolution of the difficulties increased functional understandability of the TO-BE form processes. Their values were measured as 1.

Existence in Documents Attribute: With this attribute, Material Management and Help Facility Documents were examined and what proportion of activities was described in them was measured. During the measurement, only the existence of activity definitions was checked, however, completeness, adequacy or correctness of the descriptions were not considered.

The following issues were observed for the existence in documents attribute (see Table 4.38 and Figure 4.21).

Table 4.38 Measurement Values of Existence in Documents Attribute

Process Name	**Existence in Documents For AS-IS Form**	**Existence in Documents For TO-BE Form**
(1) Material Request	13 / 16 = 0.8125	6 / 6 = 1
(2) Meeting Material Request	17 / 18 = 0.944	6 / 6 = 1
(3) Material Purchasing	8 / 12 = 0.666	11 / 11 = 1
(4) Material Registration	4 / 4 = 1	4 / 4 = 1
(5) Material Counting	12 / 20 = 0.6	12 / 12 = 1
(6) Material Returning	11 / 13 = 0.8461	7 / 7 = 1
(7) Material Record Deletion	12 / 13 = 0.9230	8 / 8 = 1
(8) Material Repair and Maintenance	6 / 6 = 1	5 / 5 = 1

- During the measurement of the AS-IS form processes, activity definitions were searched in the Material Management Document. While searching, it was recognized that some of the activities such as "taking rendezvous for the approval of a prepared form" were accepted as detail and were not placed in the Material Management Document. In addition, some activities were thought as a natural part of the process and were not given in the document. "Informing material needs to the department secretary," and "finding current numbers of the requested materials in the department" activities for Material Request Process and "searching available firms that sell the requested materials" and "determining the price of the materials" activities for Material Purchasing Process can be given as examples for this kind of activities. Some of the form transfer activities such as "sending Material Counting Forms to all departments," "sending Material Counting Form to Supply Chain department," and "sending Material Counting Form to Storing Section" in Material Counting Process did not exist in the Material Management Document either.

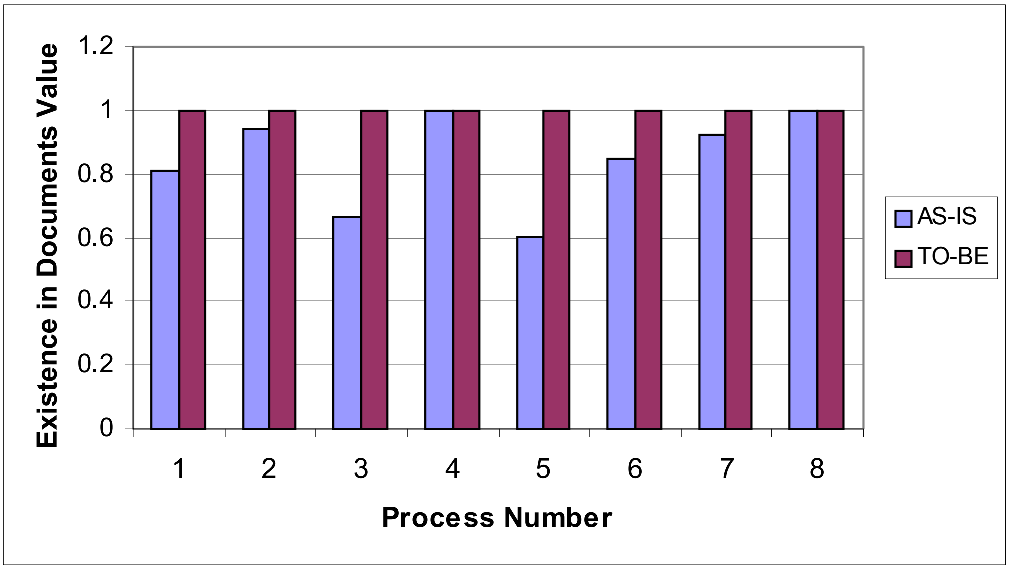

Figure 4.21 Existence in Documents Values of AS-IS and TO-BE Processes

- Identified issues were considered during the measurement of the existence in documents attribute for the AS-IS form processes and values between 0.6 and 1 were observed.

- As all activities whether critical or not are defined from the first activity to the last in the Help Facility Document, existence in documents attribute was measured as 1 for the TO-BE form processes.

Input Validity Checking Attribute: With this attribute, input parameters of the activities were examined and their validity checking was measured. In the scope of this attribute, only validity of the input parameters to perform the activity was considered. For instance, in Material Record Deletion Process, storing section staff can decrease the material numbers in stock cards when Material Record Deletion Form and Official Report are approved by the Supply Chain Department manager. If Material Record Deletion Form and Official Report are brought to the storing section without approval of the Supply Chain Department manager, storing section staff can recognize this missing activity and cancel or delay the update of the operations.

The following inferences can be made for the input validity checking attribute (see Table 4.39 and Figure 4.22).

Table 4.39 Measurement Values of Input Validity Checking Attribute

Process Name	**Input Validity Checking For AS-IS Form**	**Input Validity Checking For TO-BE Form**
(1) Material Request	14 / 16 = 0.875	6 / 6 = 1
(2) Meeting Material Request	18 / 18 = 1	6 / 6 = 1
(3) Material Purchasing	10 / 12 = 0.833	11 / 11 = 1
(4) Material Registration	4 / 4 = 1	4 / 4 = 1
(5) Material Counting	19 / 20 = 0.95	12 / 12 = 1
(6) Material Returning	13 / 13 = 1	7 / 7 = 1
(7) Material Record Deletion	11 / 13 = 0.8461	8 / 8 = 1
(8) Material Repair and Maintenance	6 / 6 = 1	5 / 5 = 1

- The staff can check validity of input parameters for most of the activities in the AS-IS form processes. Skipped activities can be identified by inspecting the fields on the form. However, input validity checking can not be done for some of the activities. For instance, in Material Request Process, department secretary can not check the validity of materials requested by section manager. As section manager generally informs his material needs on the phone and gives material feature descriptions without using material codes, department secretary can not check the validity of the material descriptions while preparing Material Request Form.

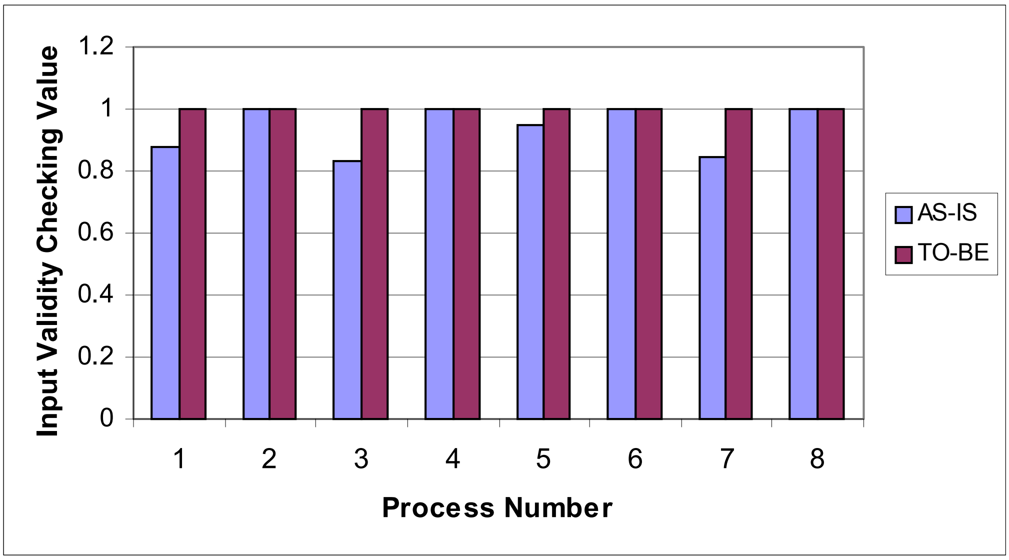

Figure 4.22 Input Validity Checking Values of AS-IS and TO-BE Processes

- As the activities are defined in an order with their input and output parameters in the TO-BE form processes, an employee can only start his operations when the activity requires his participation. The problem defined in the Material Request Form is also solved in the TO-BE form. Section manager fills Material Form with the codes selected from Material Catalogue and sends it to the department manager. By this way, department can check the validity of the materials by using Material Catalogue.

Undoability Attribute: With this attribute, undoability of the recorded activities was measured. The restorability attribute is the prerequisite of the undoability as only recorded activities may be undone. Between the first and second formula stated in Chapter 3, the second formula, (X = A / B, A = number of activities which can be undone, B = Number of recorded activities), was chosen in the case study by considering only recorded activities.

Table 4.40 Measurement Values of Undoability Attribute

Process Name	Undoability For AS-IS Form	Undoability For TO-BE Form
(1) Material Request	5 / 8 = 0.625	3 / 5 = 0.6
(2) Meeting Material Request	5 / 9 = 0.555	3 / 5 = 0.6
(3) Material Purchasing	5 / 7 = 0.7142	9 / 11 = 0.8181
(4) Material Registration	1 / 2 = 0.5	3 / 3 = 1
(5) Material Counting	5 / 12 = 0.4166	8 / 12 = 0.666
(6) Material Returning	3 / 7 = 0.4285	3 / 5 = 0.6
(7) Material Record Deletion	4 / 7 = 0.5714	5 / 7 = 0.7142
(8) Material Repair and Maintenance	1 / 2 = 0.5	4 / 4 = 1

The following evaluations were made for the undoability attribute (see Table 4.40 and Figure 4.23).

- The undoability attribute values of the AS-IS form processes change within a range of 0.4166 and 0.7142. The approvals of forms such as signing Material Returning Form and Material Record Deletion Form, recording forms to Document Records, markings on forms in paper-based environment like marking the most suitable price on the Firm List in Material Purchasing Process and writing comments on Material Record Deletion List in Material Record Deletion Process were accepted as non-undoable. These kinds of activities decrease the undoability of the AS-IS form processes.

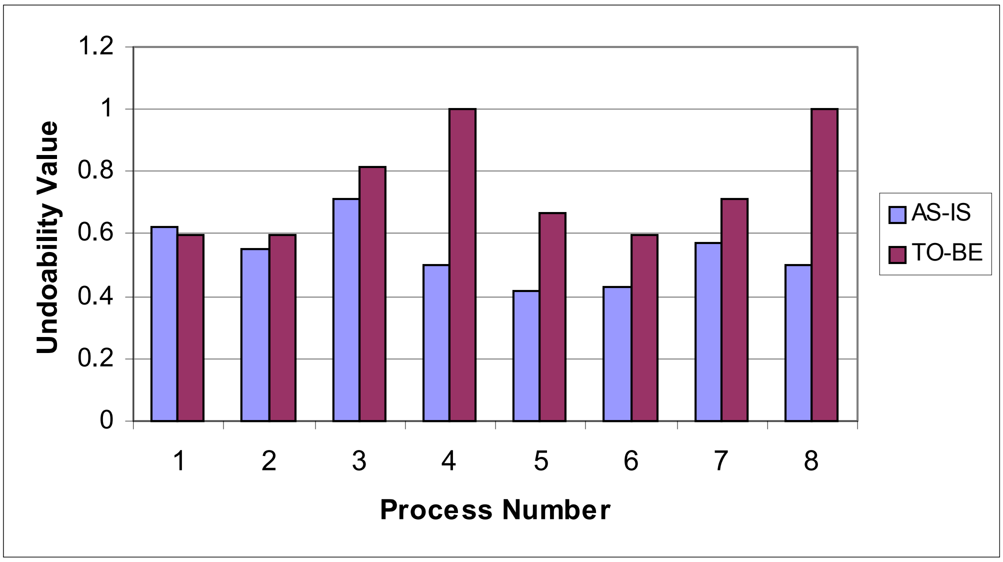

Figure 4.23 Undoability Values of AS-IS and TO-BE Processes

- Similar to the AS-IS form processes, signing of the forms can not be undo in the TO-BE form processes. When a manager approves, i.e. electronically signs, a form, he can not undo the activity. As for the other operations, marking, writing comments etc, they can be undo within the system differently from AS-IS form processes, resulting in an increase in the undoability attribute values in TO-BE form.

Attractive Interaction Attribute: With this attribute, design and usage of forms, reports and archival records or similar other documents in the process activities were examined and their attractive interactions were measured. Similar to the undoability attribute, restorability attribute is the prerequisite of the attractive interaction as only recorded activities have interfaces.

The second formula between the 2 formulas mentioned in Chapter 3, (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) was applied in the case study by considering only recorded activities.

The following inferences can be made for the attractive interaction attribute (see Table 4.41 and Figure 4.24).

Table 4.41 Measurement Values of Attractive Interaction Attribute

Process Name	Attractive Interaction For AS-IS Form	Attractive Interaction For TO-BE Form
(1) Material Request	10 / 13 = 0.7692	6 / 6 = 1
(2) Meeting Material Request	12 / 16 = 0.75	5 / 5 = 1
(3) Material Purchasing	10 / 11 = 0.9090	11 / 11 = 1
(4) Material Registration	3 / 4 = 0.75	4 / 4 = 1
(5) Material Counting	8 / 12 = 0.666	12 / 12 = 1
(6) Material Returning	6 / 8 = 0.75	5 / 5 = 1
(7) Material Record Deletion	7 / 8 = 0.875	4 / 4 = 1
(8) Material Repair and Maintenance	1 / 2 = 0.5	4 / 4 = 1

- During the measurement of the attractive interaction for the AS-IS form processes, reading hand written notes on the forms (e.g. reading manager refusal notes by department secretary on the Material Request Form and informing section manager), recording forms to the Document Record Book in paper-based and reading remarks on the forms while preparing new forms (e.g. preparing Material Purchasing Form by reading remarks on the Material Request Form) were accepted as non attractive interactions. These kinds of issues decrease attractive interaction values of the AS-IS form processes.

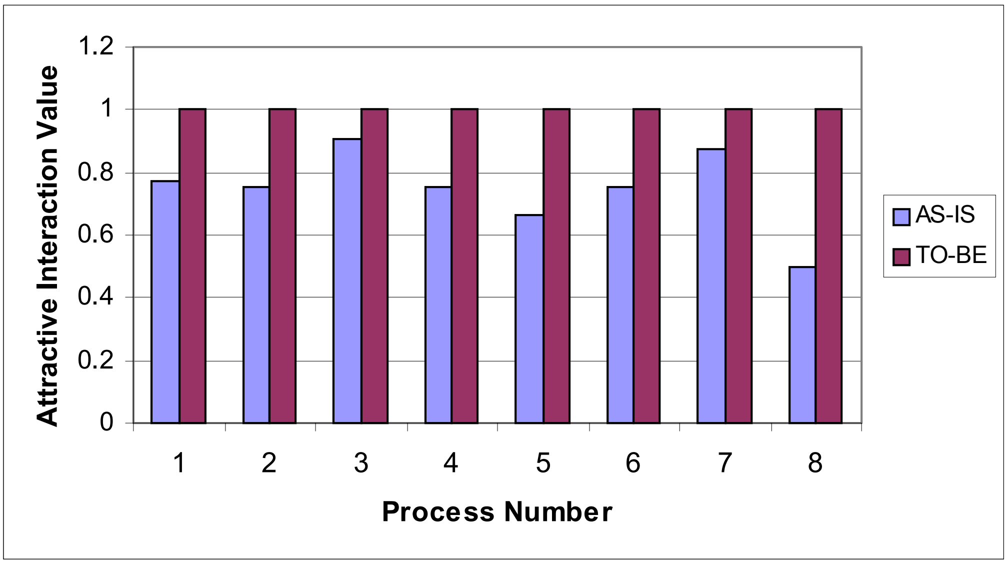

Figure 4.24 Attractive Interaction Values of AS-IS and TO-BE Processes

- Non interactive issues were removed in the TO-BE form processes. For instance, department manager writes the reasons about refusal or approval to the form in computerized environment and department secretary can read the notes and inform section manager. All forms were recorded automatically and there were no manual recordings. The last issue, reading remarks on the form, is also eliminated. New forms can be prepared automatically according to the remarks on the forms in computerized environment.

4.5.2 Relations among the Problems and Quality Attributes

The problems identified by the staff in the AS-IS form processes are used to indicate the validity of the process quality measurement. For this purpose, problems, solutions to these problems in the TO-BE form and their relationships with quality attributes are given for each process below.

4.5.2.1 Material Request Process

P1: Section managers experience difficulties while describing needed materials with their features to department secretary. Sometimes, department secretary misunderstands material descriptions made by section managers. There are no standard material name and feature descriptions such as material code.

S1: The usage of material code solves material description problem. When a material is needed, section manager and department secretary agree on material codes. Material Catalogue is prepared by the Supply Chain Department by listing materials and by coding each of them that are already defined with their features.

Explanation: This solution can be observed as an improvement in the value of "functional adequacy" from AS-IS to TO-BE form (from 0.9375 to 1). The usage of material code for defining materials makes the first activity of the Material Request Process adequate. Section manager can inform his material needs to department secretary by using material codes. Therefore, "*activity in theory*" occurs correctly in "*activity in practice.*"

The solution can be observed in "computational accuracy" attribute as well (from 0.83 to 1). The accuracy requirement, "*department secretary and section manager should reach an agreement about the requested materials,*" is fulfilled in the TO-BE form.

P2: Department secretary may request more or less materials than the need that section manager has expressed. Some of the materials may be forgotten and not be requested. In this case, department secretary has to make a new request for the missing materials from Supply Chain Department, which results in a second order.

S2: Section manager writes his needs to Material Form by using material codes and the needed quantity. Then, he gives the Material Form to department secretary. Department secretary prepares Material Request Form according to the details, not only materials but also their quantities, indicated in the Material Form. Therefore, the needs of the section manager can reach Supply Chain Department as requested in terms of both features and quantities.

Explanation: This solution can be observed as an improvement in the value of "failure avoidance" from AS-IS to TO-BE form (from 0.1875 to 0.8333). In the AS-IS form, as Material Request Form is not reviewed by section manager before being given to Supply Chain Department, materials may be requested in different quantities or from different features. The usage of Material Form and its review avoids the possible mistakes.

The solution also positively affects "restorability" as the material requests are recorded in the Material Form (from 0.5 to 0.8333). In the AS-IS form, section manager expresses his needs to department secretary on the phone and consequently, the needs cannot be recorded formally.

By using Material Form, department secretary can check the validity of the requested materials while preparing Material Request Form. This situation can be followed as an improvement in the "input validity checking" attribute (from 0.875 to 1).

P3: Department secretary records Material Request Forms and Material Exit Forms to Document Record Book manually and follows their detailed information. The information of "when the form is received or sent," "who has made the request" and request reasons stated by section managers are written manually to Document Record Book. Department secretary searches old Document Record Books for accessing detailed information when a problem occurs. However, department secretary may not find old Document Record Books or their related pages.

S3: Material Request Form, Material Exit Form and their movements in departments are recorded automatically. Department secretary or section manager can search logs for finding detailed information about past events. When a problem occurs in log files, they are restored from backup files.

Explanation: This solution can be observed as an improvement in the value of "restoration effectiveness" from AS-IS to TO-BE form (from 0.375 to 0.8333). As Document Record Book is kept as one copy in paper-based environment, its restoration effectiveness is accepted as negative in the AS-IS Form. This negative situation is changed to positive in the TO-BE form as backup files are used in computerized environment.

P4: Department secretary experiences difficulties while recording Material Request Form and Material Exit Form. First of all, she must write detailed information about the forms, which requires much more time. In addition, since the line reserved for each record is narrow, it creates some other difficulties in recording. Department secretary encounters difficulties in searching forms and in reading information within the narrow line.

S4: The usage of Document Record Book is given up in the TO-BE form. Material Request Form and Material Exit Form are automatically recorded to log files. Department secretary can search logs by using the fields in the forms. The valid forms are listed to the secretary.

Explanation: This solution can be observed as an improvement in the value of "attractive interaction" from AS-IS to TO-BE form (from 0.7692 to 1). Searching and listing facilities provided in the TO-BE form increases the value of the "attractive interaction" attribute.

4.5.2.2 Meeting Material Request Process

P1: Supply Chain Department secretary and storing section manager experience difficulties in following Material Request Forms. When a Material Request Form is received from a department, it is given to storing section manager by Supply Chain Department secretary after the approval of the Supply Chain Department manager. As Supply Chain Department secretary does not record any information about when the form is given to whom, it causes problems when the status of the form is asked to storing section. The increase in the number of Material Request Forms makes the situation worse.

S1: After the approval of the Supply Chain Department manager, Material Request Form is delivered to storing section and detailed information such as date and staff name is recorded automatically. Supply Chain Department secretary can search Material Request Forms that have been given to storing section by using form number, date, material codes or some other fields. In addition, Supply Chain Department secretary can follow the status, such as "in store," and "in purchase, of Material Request Form."

Explanation: This solution can be observed as an improvement in the value of "restorability" from AS-IS to TO-BE form (from 0.5 to 0.8333). Automatic record mechanism provides Supply Chain Department secretary with easiness in searching form status during the transfers. Change in the number of Material Request Forms has effect on neither Supply Chain Department secretary nor section managers.

P2: Storing section staff experience difficulties while updating Organization Stock Card and Store Stock Card according to Material Exit Form. After matching the stock card with the materials listed in Material Exit Form, stock updating should be done for all those materials before they are transferred. When Material Exit Form includes more materials, their updating takes a long time and the possibility of updating wrong materials' stocks increases.

S2: When storing section staff fill Material Exit Form and send it to the related department, the stocks of materials in Store Stock Card are updated automatically. The increase in the number of materials in Material Exit Form does not create any difficulty in their updating.

Explanation: This solution can be observed as an improvement in the value of "IT usage" from AS-IS to TO-BE form (from 0.277 to 0.8333). In the TO-BE form, storing section staff can benefit from the usage of IT applications in sending Material

Exit Form to related department and also in updating Store Stock Cards according to the content of the form.

P3: There are a few staff in storing section for delivering materials and updating stock cards. When a Material Request Form is received from Supply Chain Department secretary, it is assigned to one of the staff who has relatively less work. But, information such as which form is given to whom and the date of the assignment are not recorded. When a problem arise in Material Exit Form or in updating stock cards according to the form, it is very difficult to find who is the responsible of that form, i.e. that problem and consequently to solve the confusion.

S3: When a Material Exit Form is prepared, its information is logged with the date and creator information. Problems can be solved by finding related Material Exit Form with its details like the creator and creation date.

Explanation: This solution can be observed as an improvement in the value of "access auditability" from AS-IS to TO-BE form (from 0.533 to 0.8333). The operations of storing section staff are logged with their username information in the TO-BE form. Therefore, problematic Material Exit Form and its creator can be searched and found whenever needed.

P4: Storing section staff present Material Exit Form to Supply Chain Department manager for his review and approval. When the manager finds a writing error or makes a mistake while signing the form, these kinds of mistakes can not be undo and a new form must be prepared and presented to the manager.

S4: Storing section staff and Supply Chain Department manager can undo their mistakes on Material Exit Form. However, when the manager approves the form, it is sent to related department automatically and the manager cannot undo this approval. In the TO-BE form, correcting the mistakes is solved, but the problem arises in another stage, which is after the approval.

Explanation: This situation can be observed in the value of "undoability" from AS-IS to TO-BE form (from 0.555 to 0.6). The undoability of the process in both AS-IS and TO-BE form is nearly equal. The non-undoability of the activities remains the same.

4.5.2.3 Material Purchasing Process

P (a new problem in TO-BE form): Material Purchasing Form is prepared when the materials listed in Material Request Form are not available in the warehouse. In the former form (AS-IS form of Material Purchasing Form), after the approval of Material Purchasing Form by Supply Chain Department manager, materials could be purchased from contractual firms. In the present form, although Supply Chain Department manager approves Material Request Form, he examines Material Request Form, Material Purchasing Form and Firm List before the orders are given to contractual firms. If he refuses the Firm List, a new Firm List should be prepared and presented to him. Moreover, there is no rule stating under which conditions Supply Chain Department manager refuses or approves the Firm List. The refusal of the Firm List makes the purchasing section work difficult.

Explanation: This situation is observed as a decrease in the value of "complexity" in TO-BE form (from 0.9167 to 0.819) because the number of decision increases, from one to two. Furthermore, the new decision has semi-structured type as the approval or refusal of the Supply Chain Department manager is not associated with a written rule.

P1: There are difficulties in following the orders given to the firms. As the details of the orders such as when the order was given, who gave the order, what is the last status of the order are not recorded, it becomes difficult to manage the relationship with the firms. The higher the number of order, the more complex the situation is.

S1: The purchasing section staff write the details of the order into the Firm List. In addition, username of the staff who perform the activity is recorded automatically. The orders can be searched by using recorded data fields and related Material Purchasing and Material Request Form can be found easily.

Explanation: This solution can be observed as an improvement in the values of "restorability" (from 0.583 to 1) and "restoration effectiveness" from (0.416 to 1) from AS-IS to TO-BE form. In the TO-BE form, order details are recorded and can be restored from backup files when an abnormal event occurs. The "access auditability" attribute also increased as the staff who performed the activity can be found from the details (from 0.0909 to 1).

P2: Purchasing section staff experience difficulties while preparing Material Purchasing Form. Although storing section staff have to prepare a list for indicating the materials to be purchased, they mark materials in Material Request Form in paper-based environment. In this case, purchasing section staff examine Material Request Form, find out whether materials are available or not and then prepare Material Purchasing Form for the ones that are not available or that are missing.

S2: In the TO-BE form, Material Purchasing Form is prepared automatically by comparing numbers of materials in Material Request Form with the numbers in store cards. During the comparisons, material codes are used. Absent materials are listed in Material Purchasing Form. Therefore, purchasing section staff can use directly Material Purchasing Form, which results in a preparation with shorter time and less work.

Explanation: This solution can be observed as an improvement in the values of "functional adequacy" (0.833 to 1) and "functional completeness" (from 0.9167 to 1) from AS-IS to TO-BE form. The "receiving purchasing request from storing section" activity is performed adequately in the TO-BE form. The missing activity, "*preparation of Material Purchasing Form*" is completed there as well. Due to obtaining the adequacy in the activity and completing the missing activity, "computational accuracy" attribute value increased in the TO-BE form (from 0.7142 to 1). The accuracy requirements of "*storing section staff should inform purchasing section about materials that are going to be purchased,*" and "*purchasing section should buy materials that are requested from storing section*" are implemented in TO-BE form. In addition to the stated attributes, the new form of the process increases "functional understandability," (from 0.833 to 1) "existence in documents" (from 0.666 to 1) and “input validity checking” (from 0.833 to 1). Purchasing section staff can benefit from the definitions about the activities in help facility and understand the materials to be purchased. They can check input validity of the materials listed in Material Purchasing Form by using Material Request Form.

4.5.2.4 Material Registration Process

P1: Reception section staff experience difficulties in examining new materials during the reception. They have to compare the features of the shipped materials with the ones mentioned in Material Purchasing Form. According to this comparison, it is decided to admit or refuse new materials. But, as material features are not defined in the AS-IS form, reception section staff have difficulties while deciding whether new materials satisfy the definitions mentioned in Material Purchasing Form. Sometimes, wrong materials are received.

S1: Materials are classified and coded in the TO-BE form. Each code is detailed with feature descriptions and photographs. Reception section staff compare materials by using detailed explanations. Materials that fulfill defined characteristics are accepted.

Explanation: This solution can be observed as an improvement in the value of “complexity” in the TO-BE form (from 0.75 to 0.75). Although both AS-IS and TO-BE forms have the same value, decision type changes from semi-structured to structured. Material Catalogue is given to contractual firms to order materials by using same material codes. This new way of work increases “functional understandability” of the process (from 0.5 to 1). Reception section staff can understand under which conditions shipped materials are admitted or refused. When the materials do not satisfy the definitions in Material Purchasing Form, reception section staff can explain the reasons of the non-satisfaction or the refusals as well.

P2: Reception section staff have difficulties while marking shipped materials on Material Purchasing Form in paper-based environment. The markings of materials may be mixed up with each other. Moreover, when Material Purchasing Form is damaged, it is necessary to request one more copy of the same form from purchasing section for filling it by marking the materials again.

S2: In the TO-BE form, when new materials are transferred, Material Purchasing Form is marked according to the comparisons in computerized environment. If a problem occurs, Material Purchasing Form is recovered with the markings. Material Reception Form is prepared automatically according to the marks on Material Purchasing Form.

Explanation: This solution can be observed as an improvement in the values of "restoration effectiveness" (from 0.25 to 1) and "undoability" (0.5 to 1) in the TO-BE form. In the AS-IS form, as reception section staff mark only on one copy of Material Purchasing Form in paper-based environment, it is needed to prepare a new one for the same request when the form is damaged. In addition, it is not possible to undo mistakes while markings. On the other hand, in the TO-BE form, it is possible to recover the form when a problem occurs and undo mistakes on the form. This new way can also be observed in the values of "IT usage" (from 0.25 to 1) and "IT density" (from 0.5 to 1). Non-attractive interaction changes to attractive interaction as well.

P3: There is more than one worker in reception section. So, it is important to find the name of the staff and receive detailed information about past receptions when confusion happens. But, as the name of the staff is not recorded, it is difficult to determine who performed the reception or refusal.

S3: In the TO-BE form, Material Purchasing Form is associated with a reception section member. The name of the staff and his operations are recorded in detail. Therefore, the past receptions can be searched and related Material Admission Forms can be found.

Explanation: This solution can be observed as an improvement in the value of "access auditability" from AS-IS to TO-BE form (from 0.25 to 1). The name of the staff and his operations can be searched in the TO-BE form.

4.5.2.5 Material Counting Process

P1: There are difficulties in comparing materials and ensuring sameness of them in the AS-IS form. For instance, department manager examines Material Counting Form, listing existing fixture materials in the department, but, as materials are not defined in detail with their features, he has difficulties in understanding them during the approval. The other examples are comparison of Material Counting Form and Supply Chain Counting Form by storing section staff and examination of the Official Report by Supply Chain Department manager.

S1: Materials are classified and coded in the TO-BE form. Each code is detailed with its feature descriptions and photographs. During both examination and comparisons of Material Counting Form, Supply Chain Counting Form and Official Report, department manager, storing section staff and Supply Chain Department manager will not encounter any problem to this issue due to the material codes.

Explanation: This solution can be observed as a change in the decision type. There are three decisions in both AS-IS form and TO-BE form. Three semi-structured decisions changed to structured decisions in the TO-BE form. Although there is an improvement in the decision type, "complexity" attribute in the TO-BE form decreased due to the decrease from 20 to 12 in the number of activity (from 0.85 to 0.75).

The solution also affects "functional adequacy" attribute (from 0.8 to 1). The preparations and examinations of Material Counting Form, Supply Chain Counting Form and Official Report become adequate in the TO-BE form.

P2: The activities take a long time in the AS-IS form as preparation, recording to Document Record Book and form approvals are time-consuming activities. Most of these activities are performed in paper-based environment.

S2: In the TO-BE form, Material Counting Form and Supply Chain Counting Form are filled automatically by using fixture material definitions and material codes. The comparison of the forms are performed by the activities themselves and inconsistencies are indicated. In addition, recording of the activities to log files are realized automatically.

Explanation: This solution can be observed as improvement in the values of "IT usage" (from 0.25 to 1) and "IT density" (from 0.416 to 1) in the TO-BE form. The number of activity using IT applications increases in the TO-BE form.

P3: The staff such as department secretary, storing section staff and Supply Chain Department secretary have difficulties in understanding preparation, recording and comparisons of forms and getting assistances from existing documents in the AS-IS form. Any mistake requires repeating the activity.

S3: In the TO-BE form, all activities are defined in Help Facility. Their understandabilities are increased with the help of explanatory examples. The staff have some facilities such as selecting material codes from Material Catalogue, receiving inconsistency list as a result of Material Counting Form and Supply Chain Counting Form comparison for making the activity easier. They also have such a chance that they can make undo during the preparation of the forms, which is an important issue they can benefit from.

Explanation: This solution can be observed as an improvement in the values of "functional understandability" (from 0.6 to 1) and "existence in documents" (from 0.6 to 1) from AS-IS to TO-BE form. The understandability of the activities has increased and staff can get assistance from the documents. The easiness provided during the preparation and examination of the forms in the TO-BE form can be observed in the "undoability" (from 0.4166 to 0.666) and "attractive interactions" (from 0.666 to 1). However, the increase in "undoability" is limited as the managers cannot undo their approvals.

4.5.2.6 Material Returning Process

P1: In the AS-IS Form, there are inconsistencies between Material Returning Form and materials that have been physically returned to store. As stock cards are updated according to Material Returning Form, excess stock or the deficiency in the quantity of returned materials affects the reliability of stock cards. It is very difficult to examine past operations and correct the stocks in stock cards.

S1: The similar problems continue in the TO-BE form. The returned materials are not controlled according to Material Returning Form. Storing section staff may not check returned materials. They do not record the name of the staff who has brought materials to the warehouse either.

Explanation: This situation can be observed with “failure avoidance” attribute (from 0.2307 to 0.4285). The number of activity including review, inspection or similar techniques is not changed in the TO-BE form. A slight increase in “failure avoidance” attribute is due to the decrease in the number of total activities from 13 to 7. As the same review techniques are applied in the TO-BE form, there may be inconsistencies between stock cards and returned materials even there. The name of the staff who brings materials to warehouse is not recorded in the TO-BE form. The value of “restorability” attribute indicates non-recorded activity. The improvement in the value of “restorability” (from 0.6153 to 0.7142) is due to the decrease in the number of activity. In connection with the “restorability” attribute, “access auditability” cannot be performed for the non-recorded activity.

P2: In the AS-IS form, as approval of Material Returning Form is performed in paper-based environment, any mistake cannot be undo and necessitates preparing the form again. If this mistake occurs in the Supply Chain Department, Material Returning Form is requested from related department.

S2: In the TO-BE form, approval of Material Returning Form is performed in computerized environment. The nature of the approval changes in the TO-BE form, but non-undoability of the approval is not changed. Managers cannot undo the operation after they give their approvals.

Explanation: This situation can be observed in the value of “undoability” in the TO-BE form (from 0.4285 to 0.6). The number of activity which can be undo is not changed in the TO-BE form.

P3: In the AS-IS form, as most of the information about Material Returning Form is recoded to Document Record Book manually, it takes a long time for both department secretary and Supply Chain Department secretary. The transfer of Material Returning Form in paper-based environment is the other time consuming activity.

S3: In the TO-BE form, the details of Material Returning Form is recorded to log files automatically. Department secretary and Supply Chain Department secretary do not need to record the form manually because the transfers of the form are performed in computerized environment.

Explanation: This solution can be observed as an improvement in the value of "IT usage" from AS-IS to TO-BE form (from 0.2307 to 0.7142). The number of activity using IT applications increases in the TO-BE form.

4.5.2.7 Material Record Deletion Process

P1: In the AS-IS form, although Supply Chain Department determines which fixture materials are valid under which conditions for the record deletion, Material Record Deletion Form may include materials that are not defined in the scope of the deletion. Some of Material Record Deletion Forms return from Supply Chain Department manager during the approval as they include non valid materials.

S1: In the TO-BE form, for record deletion, Supply Chain Department lists fixture materials with their material codes. While storing section staff are preparing Material Record Deletion Form, they can select only material codes that are defined in the list as the valid ones for the deletion. Therefore, when Material Returning Form is sent to the Supply Chain Department manager for his approval, the form includes valid material codes for record deletion.

Explanation: This progress can be observed as an improvement in the value of "computational accuracy" attribute (from 0.4 to 1). As the computational accuracy requirements about record deletion are satisfied in the TO-BE form, "computational accuracy" attribute has a value of 1, which has a meaning of completely satisfied.

P2: Storing section staff prepare Material Record Deletion List and send it to maintenance section in paper-based environment for taking comments about the status of the materials. Maintenance section staff examine the materials and write their checking results to Material Record Deletion List. Sometimes, Material Record Deletion List is transferred to maintenance section more than once. In this case, it becomes difficult to follow past operations with their detailed information such as date and name of the maintenance section staff.

S2: In the TO-BE form, when Material Record Deletion List is sent to maintenance section, it is recorded with detailed information such as date and name of the operator from maintenance section. Past transfers can be searched by using these records and necessary details can be obtained whenever needed.

Explanation: This solution can be observed as an improvement in the values of "access auditability" in the TO-BE form (from 0.2857 to 1). The names of the maintenance section staff and other detailed information can be found from the records. As "restorability" attribute is assumed as the prerequisite of "access auditability", the "restorability" value increased as well (from 0.5384 to 0.875).

P3: Maintenance section staff have difficulties in the AS-IS form while writing their comments on Material Record Deletion List. When they make a mistake on the form, they cannot recover it and they have to request another copy of Material Record Deletion Form from storing section. In addition, because of the small space reserved for the explanation of the fixture materials' conditions, they cannot express their comments sufficiently. Consequently, storing section may need other details and need to make phone conversation for getting them.

S3: In the TO-BE form, maintenance section staff write their comments on Material Record Deletion List in computerized environment. When they make a mistake, they can undo it. In addition, the place reserved for writing the comments is enough to explain conditions of fixture materials.

Explanation: This solution can be observed as an improvement in the values of "undoability" (from 0.5714 to 0.7142) and "attractive interaction" (from 0.875 to 1) from AS-IS to TO-BE form. The number of activity using IT applications increases in the TO-BE form. The value of "undoability" attribute increased in the TO-BE form, but cannot be 1 as Supply Chain Department manager cannot undo his approval in computerized environment.

P4: In the AS-IS form, after taking maintenance section comments, storing section staff prepare Material Record Deletion Form. For this purpose, storing section staff read materials in Material Record Deletion List and write to Material Record Deletion Form. This way of work requires more time and attention.

S4: In the TO-BE form, Material Record Deletion Form is filled in computerized environment automatically according to the comments on Material Record Deletion List. Storing section staff only review the form.

Explanation: This solution can be observed as an improvement in the value of "IT usage" from AS-IS to TO-BE form (from 0.166 to 0.8). The number of IT application that storing section staff benefit from is increased in the TO-BE form.

4.5.2.8 Material Repair and Maintenance Process

P1: In the AS-IS form, when the number of Material Repair Form sent from storing section to maintenance section increases, the follow up of the forms and the identification of the performing staff with the related details become difficult. Which Material Repair Form is sent to whom or after the material repairs are completed, the updated Material Repair Form is sent back to whom is difficult to identify.

S1: In the TO-BE form, form transfers are recorded to log files. Past operations can be searched by using detailed information in the file. The date of the transfers and names of the staff can be found.

Explanation: This situation can be observed as an improvement in the values of "restorability" and "access auditability" attributes from AS-IS to TO-BE form. As the number of recorded activity is increased in the TO-BE form, “restorability” is increased (from 0.333 to 0.8). In parallel to the “restorability”, “access auditability” is increased (from 0 to 0.8) as the names of staff can be found by searching information within the records.

P2: In the AS-IS form, storing section staff have difficulties in following fixture materials that require periodical maintenance. They have deficiencies in following the materials, defined by Supply Chain Department, that require periodical maintenance. For this reason, some materials may not be repaired on time or they may be out of order when needed.

S2: In the TO-BE form, Supply Chain Department determines the list of material codes that belongs to the materials requiring maintenance. Storing section staff can prepare Material Repair Form according to this definition. When storing section staff forget repairing of a fixture material, a warning message is given to him as a remainder.

Explanation: This solution can be observed as an improvement in the values of “functional adequacy” (from 0.833 to 1) and “computational accuracy” (from 0.5 to 1) in the TO-BE form. The activities that include fixture materials following and preparing Material Repair Form become more adequate in the TO-BE form, especially, by associating maintenance to the material codes. With the warning mechanism, fixture materials requiring periodical maintenance are not forgotten by storing section staff. This way of work increases the value of “computational accuracy” attribute.

P3: In the AS-IS form, maintenance section staff have difficulties in updating Material Repair Form in paper-based environment. When they make a mistake on the form or when the form is damaged or lost, they cannot recover it and, a new form has to be requested from storing section.

S3: In the TO-BE form, maintenance section staff can write their operations on Material Repair Form in computerized environment. When they make a mistake, they can undo it. The restorability of the form is provided automatically as well.

Explanation: This solution can be observed as an improvement in the values of "restoration effectiveness" (from 0.166 to 0.8), "undoability" (from 0.5 to 1) and "attractive interaction" (from 0.5 to 1) from AS-IS to TO-BE form. As the number of activity that can be restored increased in the TO-BE form, the value of the "restoration effectiveness" changed positively from 0.166 to 0.8. In addition, in the TO-BE form, as maintenance section staff benefit from the new design of the form and the ability to make undo, "undoability" and "attractive interaction" attributes have been totally satisfied with a value of 1.

P4: In the AS-IS form, as most of the activities are performed in paper-based environment, they take a long time and require repetitive, time-consuming work.

S4: In the TO-BE form, preparation of the form, its transfer from storing section to maintenance section and update in the maintenance section are all done in computerized environment. As the updates made by maintenance section can be also followed by storing section, the repetitive work is eliminated.

Explanation: This solution can be observed as an improvement in the values of "IT usage" (from 0.166 to 0.8) and "IT density" (from 0.5 to 1) from AS-IS to TO-BE form. The number of IT application that storing and maintenance sections benefit from is increased in the TO-BE form.

4.5.3 Relations Among Quality Attributes

During the case study, while measuring quality attribute values, some sorts of relationships among quality attributes were recognized. The relations are given below with their definitions and some examples.

I. Prerequisite: This relation can be defined as "*if a quality attribute has a prerequisite, its value may be greater than zero when its prerequisite's value is* *greater than zero.*" For instance, coupling is the prerequisite of data exchangeability as data exchangeability can be measured for the processes that have interactions with other processes. So, data exchangeability may be different from zero if the value of coupling is greater than zero. Another prerequisite relation does exist between restoration and restoration effectiveness. Restoration is measured by counting recorded activities. Restoration effectiveness can only be meaningful for the activities whose restorability values greater than zero.

The other prerequisite relationships are seen between restorability and undoability, restorability and attractive interaction, restorability and access auditability.

II. One way: This relation can be defined as "*the value of a quality attribute increases when the value of the related quality attribute increases, but reverse is not true.*" For instance, there is one-way relation between failure avoidance and restorability. Failure avoidance is about review or inspection an activity. In order to review an activity, there must be a document. The document necessitates the activity to be recorded. So, when the value of failure avoidance increases, it is expected that the value of restorability increases. But, the reverse is not always true as even though there is a recorded document, it may not be reviewed.

The other one-way relationships are seen between restorability and undoability and restorability and access auditability.

III. Togetherness: This relation can be defined as "*the value of a quality attribute is more meaningful when its value is considered with the other quality attribute value.*" For instance, there is togetherness relationship between existence in documents and functional understandability. The value of the existence in documents only show how much explanation there is in the documents about the activity but it does not show or mention anything about he understandability of the explanation. Since there is always a possibility for an explanation of not being understood, existence in documents should be evaluated with functional understandability.

The other togetherness relationships are seen between restorability and restoration effectiveness, IT usage and IT density and undoability and attractive interaction.

IV. Two way: This relation can be defined as "*the value of a quality attribute increases when the value of the related quality attribute increases, and reverse is also true.*" For instance, there is two-way relationship between restoration effectiveness and undoability. Because both of them have been affected inherently from the usage of IT applications. When the value of restoration effectiveness increases, it means IT usage increases. The increase in IT usage also positively affects undoability and it increases as well. The reverse is also true for the same reason.

The other two-way relationships exist between restoration effectiveness and IT usage, computational accuracy and IT usage, access auditability and IT usage.

4.5.4 Answering the Research Questions

As the result of the case study, the research questions determined at the planning phase are answered as follows.

Research Question 1: Can software quality characteristics of maintainability and reliability and software techniques of complexity and coupling be adapted to the measurement of the process quality?

This research question is related to the suitability and adaptability of the software quality characteristics and software techniques to measure process quality.

For answering the question, the definitions of complexity and coupling quality attributes were used. After the measurement, the processes were compared with each other to evaluate their complexity and coupling attribute values.

As mentioned above, the maintainability characteristic of the processes was measured by using complexity and coupling attributes. These metrics were easily applied to the process definitions such that complexity was measured by counting decision points that require different branch and coupling was measured by counting interactions with other processes in the department.

Based on the definitions of complexity and coupling, the maintainability of a process becomes difficult when the number of decision points and interactions with other processes increase in its process definition.

Similar to the maintainability characteristic, the reliability characteristic was easily applied to the process definitions. Failure avoidance, restorability and restoration effectiveness were measured for identifying the reliability. Failure avoidance attribute was measured for counting activities that include review or inspection, restorability attribute was measured for counting activities that include recording and restoration effectiveness attribute was measured by counting activities which could be restored when an abnormal event occurs.

Based on the definitions of failure avoidance, restoration and restoration effectiveness, the reliability of a process increases when the number of its activities that include review methods, recordings and precautions aiming to minimize data lost increase.

Research Question 2: Is it possible to measure process quality by means of the proposed characteristics and metrics?

The problems in the AS-IS form processes and their solutions in the TO-BE form processes were used to find out the relationships between the improvement and the quality attributes. The relationships are given in the part 4.5.2 Relations Among the Problems and Quality Attributes. Observations given in this part indicate the parallelisms between the solutions and quality attributes. The process qualities of the Supply Chain Department’s processes were measured in the scope of the quality attribute definitions.

Research Question 3: How can the metrics be applied to measure the quality attributes of a process?

The process definitions (from Process Definition Document) and quality attribute definitions (from Quality Attribute Definition Document) were utilized by the participation of two staff. Empty forms were used for recording the measurement values of quality attributes (written to Quality Measurement Document). In this way, the model was applied to the 8 processes of Supply Chain Department.

During the measurement, the quality attribute definitions were checked. The purpose was to form attribute definitions that concentrate on only one issue. For instance, complexity attribute considers only decision points, restorability attribute considers only recording points and IT usage considers only existence of IT applications in the process definitions. This approach eliminated contradictions in attribute definitions and made their understandability easier. In addition, the relationships between quality attributes such as prerequisite, one-way, and two-way increase the understandability and applicability of the model.

Research question 4 is answered below in 4.5.5 Closure Part of the Case Study.

4.5.5 Closure Part of the Case Study

Research Question 4: How can the model be refined and therefore be improved?

The arrangements in quality attributes for increasing their understandabilities contribute to the improvement of the model. The identifications of relationships among quality attributes assist the refinement of the model by increasing its applicability and also understandability.

A list of questions was used at the end of the case study to get the participators' points of view about the model and its implementation. The following questions were asked to the 2 staff members and their answers are shortly summarized below.

Question 1: Are the applications of the quality attributes and metrics difficult or easy?, If it is difficult, how can it be easier?

Answer: It is not difficult to comprehend quality attribute definitions and recognize their focuses while doing the measurement. However, the application of the model requires time and attention especially when the number of activity and quality attributes increase because, the model necessitates evaluating each activity definition for all quality attributes. For the later applications, the usages of relationships among quality attributes may decrease this difficulty.

Question 2: Are the definitions of quality attributes and metrics adequate?, If it is inadequate, how can it be proved?

Answer: Detailed definition of each quality attribute is adequate for the measurement. The explanations given in "focus" and "guidance for identifying the attribute" are useful for evaluating activity definitions. The formulas of quality attributes for calculating values are simple.

Question 3: Can you apply quality attributes and metrics by yourself?, If you can not, what do you suggest for increasing the understandability and applicability of the model?

Answer: The objectives and applications of the quality attributes can be learned by reading their definition tables. Then, the model can be applied to a set of process when the necessary time is provided.

Question 4: What is your opinion about the definitions and usages of complexity and coupling for measuring process quality?

Answer: The measurement of complexity and coupling attributes are not difficult. Complexity is measured by counting decision points in process definitions. There are two critical issues while measuring it. One of them is finding decision points which branch off different flows. The other is about deciding structuredness of the decisions. Coupling is measured only by counting interactions with other processes and relatively easier than complexity. The complexity and coupling measurements provide useful insights for the maintainability of processes.

Question 5: Can the quality attributes and metrics address the problems encountered during the application of the processes?

Answer: During the case study, the improvement from AS-IS to TO-BE form was observed in the quality attribute values. This situation shows that the problems identified in the application of the processes can be associated with quality attributes. So, the arrangements in process definitions can be planned to increase or decrease specific quality attribute values.

Question 6: Does the usage of the metrics within for processes increase their quality? What is your opinion about it?

Answer: The application of the model gives an idea about the process quality. The repetition of the application will provide the opportunity to recognize the changes in the quality attribute values. New targets can be defined for specific quality attribute values. The effects of the arrangements on the processes can be measured by reapplying the model. According to the priorities of the processes, suitable quality attribute values can be improved. In this way, the department can increase their processes' qualities.

In addition, the implementation of the model makes regulatory documents closer to the process application due to putting the theory into the practice.

Question 7: Do you recommend the usage of the metrics for other organizations to measure their process quality?

Answer: An organization can measure process quality by using this model. When management level commitment is provided and periodical applications are performed, the organization can be more satisfied with the results.

CHAPTER 5

CONCLUSIONS

This chapter consists of three sections: the first section indicates the contributions of the study. Following to these contributions, the limitations of the study are clarified as the second section and finally the chapter is concluded with recommendations for future research in the third section.

5.1 Contribution of the Study

In addition to time and cost aspects, the other conventional aspect for the process is quality. Although many post-execute metrics can be used for measuring time and cost related attributes, there is limited number of attributes in the quality aspect. However, the measurement of quality attributes such as complexity and coupling can provide valuable insights and reveal critical problems before the processes are put into practice.

In order to provide complementary information about the quality, a process quality measurement model is developed in this study. Not only process characteristics that are determined during the literature review but also similarities between process and software are used for developing the model. In order to present better structure, the model is built on the basis of ISO/IEC 9126 Software Product Quality Model. ISO/IEC 9126 provides validated and widely accepted metrics with its six characteristics (ISO/IEC FCD 9126-1.2, 2000).

Software quality characteristics in ISO/IEC 9126 are redefined according to the process specific attributes and new characteristics unique to the business processes are identified to extend the model. Based on these definitions process metrics are specified.

A case study is performed to investigate applicability, usability and suitability of the model. Detailed process definitions within activity level and quality attribute definitions are used to measure quality attributes. During the measurement, quality attribute definitions are evaluated with two participators. As each quality attribute definition concentrates on only one issue such as considering only decisions for measuring complexity attribute or considering only recording points for measuring restorability attribute, this approach eliminates most of the contradictions in the attribute definitions and make their understandability easier. In addition, the relationships between quality attributes such as prerequisite, one way and two ways increase the understandability and applicability of the model.

The suitability and adaptability of the software quality characteristics and software techniques to measure process quality are also examined in the case study. The maintainability characteristics of the processes are measured by using complexity and coupling attributes. These attributes are easily applied to process definitions. Complexity is measured by counting decision points that require different branch. On the other hand, coupling is measured by counting interactions with other processes within the organization. Based on the definitions of complexity and coupling, the maintainability of a process becomes difficult when the number of decision points and interactions with other processes increase.

Similar to the software maintainability characteristic, the software reliability characteristic is easily applied to process definitions. Failure avoidance, restorability and restoration effectiveness are measured for identifying reliability. Failure avoidance attribute is measured by counting activities that include review or inspection, restorability attribute is measured by counting activities that include recording and the last attribute, restoration effectiveness, was measured by counting activities which can be restored when an abnormal event occurs. Based on the definitions of failure avoidance, restoration and restoration effectiveness, the reliability of a process increases when the number of its activities that include review techniques, recordings and precautions for minimizing data lost increase.

The problems in the AS-IS form processes and their solutions in the TO-BE form processes are used to find out the relationships between the solutions and quality attributes. The case study results indicate that the problems and their solutions can be followed by related quality attributes (as explained in *4.5.2 Relations among the Problems and Quality Attributes*). The examples used in the part 4.5.2 point out the meaningful relations between the solutions in the TO-BE form and quality attribute values.

Case study results are reviewed with the participators at the closure part of the study. The understandability, applicability and suitability of the model are evaluated with mutual questions and answers. The answers provide another point of view in the validation. During the case study, participators measured four pairs of processes by themselves. By reading activity and attribute definitions, they could measure quality attribute values. According to their experiences, they stated positive opinions about understandability and applicability of the model. When the problems in the AS-IS form processes, and their solutions in the TO-BE form processes were evaluated and the relationships between quality attributes were identified, they also agreed on the suitability of the model for measuring process quality.

The case study results indicate that, with the model, organizations will be able to acquire feedback about quality attributes by using process definitions before processes are put into practice. According to the measurement results, organizations can have opportunities to make necessary modifications on their processes. In this way, organizations will be able to measure the impacts of business process change studies such as process improvement studies on the process quality in terms of quality attributes. In addition, IS effects on the process quality can be measured directly by using restoration effectiveness, IT usage and IT density attributes.

5.2 Limitations

As performed in the case study, in Chapter 4, process quality attributes are measured by examining detailed process definitions within activity level. The preparation of the process definitions with their activities can be thought as the first difficulty for the application. This requires time and attention to prepare activity definitions in the same granularity. The absence of written process definitions in the organization makes the application more difficult. In this case, firstly, process definitions should be formed by examining the procedures performed in the organization. Then, activity specifications are defined by using the designed process definitions.

The absence of regulatory documents in the organization can be supposed as the second difficulty for the application. The application of the model necessitates existence of regulatory documents to measure functional adequacy, functional completeness, computational accuracy and existence in documents attributes. These attributes can only be measured by comparing activities in practice with rules and constraints defined in the regulatory documents.

The third limitation is about the scope of the model. The model has now 4 quality characteristics and 17 quality attributes. In this circumstance, the model provides feedback about the process quality to a certain extent. New quality attribute definitions moving down to deeper level and therefore providing more specific feedbacks can be added to the model. For instance, IT usage attribute examines only existence of IT applications in activity definitions. However, this attribute does not interest in integration with other IT applications, largeness, type and contribution of the IT application. It may be needed to add such an attribute to fill in that need.

There are also limitations about the case study research. One of them is application of the model on the single case. The other limitation is conduction of the case study with two participators.

5.3 Future Research

New studies for overcoming the limitations and also providing different points of view for measuring the process quality are addressed as future work. New case studies especially in different sectors may provide valuable feedbacks to the model by increasing understandability and applicability. During the application in the various domains, new quality characteristics and attributes can be developed and added to the model.

New quality attributes will provide deeper examinations. In this context, portability characteristic and related attributes, defined in ISO/IEC 9126 Software Product Quality Model, can be investigated and new attributes can be developed for measuring the process quality. By means of these types of attributes, more specific feedbacks about the process quality can be obtained. As well as, new relationships among quality attributes can be identified. The increase in the number of these relationships makes the measurement simple and, in these conditions, validation of the application becomes easier.

While extending the model, new fields such as “priorities” or “weights” can be added to the attribute definitions as well. This kind of information will be an important guide to the staff depending on the objectives of the studies.

The automation of the measurement by developing a tool is another future study. By means of the tool, quality attribute values can be set during the process modeling. In this way, process quality measurement can be integrated to the process modeling. Some attributes such as complexity and coupling can be measured easily by counting number of decisions and interactions with using specific notations on the modeling.

REFERENCES

Basili, V.R. (1992). Software modeling and measurement: The Goal / Question / Metric Paradigm. Technical Report, CS-TR-2956, Department of Computer Science, University of Maryland, College Park, MD 20742.

Beath, C.M., Goodhue, D.L. and Ross, J.R. (1994). Partnering for business value: The shared management of IS infrastructure. In J.I. DeGross, S.L. Huff and M.C. Munro (Eds.), Proceedings of the Fifteenth International Conference on Information Systems, Vancouver, British Columbia, pp. 459-460.

Benbasat, I., Goldstein, D.K., Mead, M. (1987). The Case Research Strategy in Studies of Information Systems. MIS Quarterly, pp. 369-386.

Boehm, B.W., Brown, J.R., and Lipow, M. (1976). Quantitative Evaluation of Software Quality. International Conference on Software Engineering, Proceedings of the 2nd International Conference on Software Engineering.

Brynjolfsson, E., Hitt L. (1994). The Three Faces of IT Value: Theory and Evidence. Proceedings of the Fifteenth International Conference on Information Systems, Vancouver, pp. 263-276.

Danziger, J.N. (1987). Politics, Productivity and Computers: A Contingency Analysis in Local Governments. Proceeding of the Ninth Annual Society for Management Information Systems Conference, pp. 213-221.

Davenport, T.H. (1993). Process Innovation: Reengineering Work Through Information Technology. Boston, Mass: Harvard Business School Press, 062117110523.

DeLone, W.H., McLean, E.R. (1992). Information System Success: The Quest for the Dependent Variable. Information Systems Research, 3, (1) pp. 60-95.

DeLone, W.H., McLean, E.R. (2003). The DeLone and McLean Model of Information Systems Success: A Ten-Year Update. Journal of Management Information Systems, Vol. 19, No. (4) pp. 9-30.

Demirors, O., Guceglioglu, A.S. (2005). A Model for Using Software Quality Characteristic to Measure Business Process Quality. Technical Report, METU/II-TR-2005-08, Department of Information System, University of METU.

Emery, J.C. (1971). Cost/Benefit Analysis of Information Systems. SMIS Workshop Report Number 1, The Society for Management Information Systems, Chicago, IL.

Harrington, H. J. (1991). Business Process Improvement, New York: McGraw-Hill.

Hammer, M., Steven S. (1994). The Reengineering Evolution. New York: Harper Business, 062117110523.

Hammer, M. (1996). Beyond Reengineering: How The Process-Centered Organization is Changing Our Work and Our Lives. New York: Harper Business, 062117110523.

Hammer, M. (2001). The Agenda: What Every Business Must Do To Dominate The Decade. New York: Crown Business, 062117110523.

Griffin, R.C. (1998). The fundamental principles of cost-benefit analysis. Water Resources Research, v34, n8, pp. 2063-2071.

Guceglioglu, A.S., Demirors, O. (2006). A Case Study for Measuring Process Quality Attributes. Technical Report, METU/II-TR-2006-29, Department of Information System, University of METU.

ISO/IEC FCD 9126-1.2 (2000). Information Technology, Software Product Quality, Part 1: Quality model.

ISO/IEC 9126-2 TR (2000). Software Engineering– Product quality Part 2: External Metrics.

ISO/IEC 9126-3 (2000). Software Engineering– Product quality Part 3: Internal Metrics, ISO/IEC JTC1/SC7/WG6.

King, W., R., Xia, W. (2004). Assessing the Organizational Impact of IT Infrastructure Capabilities. Information Management Research Center, Mayo, http://www.imrc.ie.edu.

Markus, M.L. and Soh, C. (1993). Banking on information technology: Converting IT spending into firm performance. In R.D. Banker, R.J. Kauffman and M.A. Mahmood (Eds.), Strategic Information Systems Technology Management: Perspectives on Organizational Growth and Competitive Advantage. Harrisburg, PA: Idea Group Publishing.

Mason, R.O. (1978). Measuring Information Output: A Communication System Approach. Information & Management, 1, (5), pp. 219-234.

McCabe, T.J. (1976). A Complexity Measure, IEEE tokens is superior to the other metrics as a measure. Trans. Software Eng. SE-2, 4, pp. 308-320.

McCall, J.A., Richards, P.K., and Walters, G.F. (1977). Factors in Software Quality. Nat'l Tech. Information Service, no. Vol. 1, 2 and 3.

Mooney J.G., Gurbaxani V., Kraemer K.L. (1996). A Process Oriented Framework for Assessing the Business Value of Information Technology. The Data Base for Advances in Information Systems, Vol. 27, No. 2.

Myers, M.D. (1997). Qualitative Research in Information Systems. MIS Quarterly, (21:2), pp. 241-242 MISQ Discovery, archival version, June 1997, http://www.misq.org/discovery/MISQD_isworld/. MISQ Discovery, updated version, last modified: July 26, 2005 http://www.qual.auckland.ac.nz.

Myers, B.L., Kappelman L.A., Prybutok V.R. (1997). A Comprehensive Model for Assessing the Quality and Productivity of the Information Systems Function: Toward a Contingency Theory for Information Systems Assessment. Information Resources Management Journal, Volume 10, Issue 1, pp. 6-25, PA, USA, Idea Group Publishing Hershey.

Osterweil, L. (1987). Software Processes are Software Too. Proceedings of the Ninth International Conference on Software Engineering, Monterey, CA, pp. 2-13.

Özkan, S. (2006). PB-ISAM: A New Framework for the Assessment of Information Systems Effectiveness, Ph.D. Thesis, Informatics Institute, METU, Ankara, Turkey.

Sambamurthy, V. and Zmud, R.W. (1994). IT management competency assessment: A tool for creating business value through IT. Working Paper, Financial Executives Research Foundations

Saunders, C.S., Jones, J.W. (1992). Measuring performance of the information systems function. Journal of Management Information Systems, 8(4), pp. 63-82.

Scheer, A.W. (2003). ARIS, **Ar**chitecture of integrated **I**nformation **S**ystems. IDS Scheer AG, Version 6.2.0.30285, www.ids-scheer.com

Seddon, P.B., Staples S., Patnayakuni R., Bowtell M. (1999). Dimensions of Information Systems Success. Communications of the Association for Information Systems, Vol. 2, Article 20.

Shannon, C.E., Weaver W. (1949). The Mathematical Theory of Communication. Urbana, IL: University of Illinois Press.

Soh, C. and Markus, M.L. (1995). How IT creates business value: A process Theory Synthesis. Proceedings of the Sixteenth International Conference on Information Systems, Amsterdam, The Netherlands, pp. 29-42.

Tunney, P.B., and Reeve, J. M. (1992). The Impact of Continuous Improvement on the Design of Activity Based Cost Systems. Journal of Cost Management, pp. 43-50.

Vural, I., (2004). Success Factors in Public IS Outsourcing: A Case Study of a Selected Turkish Public IS Outsourcing Project. Master Thesis, Department of Information Systems

Yin, R.K. (1984). Case Study Research Design and Methods. Second Edition, Applied Social Research Methods Series Volume 5, Sage Publications, ISBN 0-8039-5662-2.

VITA

A.SELÇUK GÜCEĞLİOĞLU

He was born in Gaziantep on April 17, 1972. He received his B.S. degree in Computer Science Engineering from the Hacettepe University in 1994. In 1992-1993, he deserved scholarship from the Scientist Development Program of The Scientific and Technological Research Council of Turkey (TÜBİTAK). He graduated from the Computer Science Engineering Department in the second rank.

He received his M.Sc. in Information Systems from the Middle East Technical University in 2001. He received his Ph.D. in Information Systems from the Middle East Technical University in 2006.

He received conference grant from The Scientific and Technological Research Council of Turkey (TÜBİTAK) for the Business Process Modeling (BPM) 2005 Conference in France.

He has been working in Turkish Prime Ministry as a software engineer since 1994. His main areas of interest are software process improvement, process assessment, process modelling, system analysis and design methodologies and tools.

His publications and conference presentations are given below.

Demirors, O., Yildiz, O., Guceglioglu, A.S. (2000). Using Cost of Software Quality for a Process Improvement Initiative, 26th EUROMICRO Conference ,Volume 2, September, pp. 2286.

Demirors, O., Guceglioglu, A.S. (2001). Application of Poor Quality Indicator Model in an Emergent Software Organization, 27th EUROMICRO Conference, September, pp. 225.

Guceglioglu, A.S., Demirors, O. (2005). Using Software Quality Characteristics to Measure Business Process Quality, Business Process Management 3rd International Conference, BPM 2005, Nancy, France, September 5-8, Proceedings Series: Lecture Notes in Computer Science, Vol. 3649 ISBN: 3-540-28238-6.

Guceglioglu, A.S., Demirors, O. (2005). A Process Based Model for Measuring Process Quality Attributes, 12th European Conference, EuroSPI 2005, Budapest, Hungary, November 9-11, Proceedings Series: Lecture Notes in Computer Science, Vol. 3792 ISBN: 3-540-30286-7.