A RISK MANAGEMENT METHOD
FOR
A TURKISH DEFENCE INDUSTRY FIRM

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ABSTRACT

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In this study, a risk management methodology for the business development phase of a Turkish defense industry firm's projects is proposed. The proposed method is based on the contemporary risk management practices and offers the integration of risk management process on top of existing project management processes in the business development phase, besides being cost effective and applicable. The method suggests a format for a risk management plan with two new sections, results, and compliancy. Furthermore, the method suggests the development of risk response plans prior to the implementation of quantitative risk analysis contrary to the applications in the literature, in order to reduce the size and the complexity of data to be analyzed. The method proposed also benefits from software tools that are easy to use and compatible with the existing project management practices executed in the firm. The method also aims to lead the construction of necessary risk databases that are specific to projects of the firm. The method also discusses the risk management framework under the scope of organizational aspects and decisions. Furthermore, a sample project of the firm is evaluated both with the current method and with the proposed method in order to put forward the advantages of the proposed system over the existing risk management practices of the firm.

Keywords: Risk management, project management, risk management plan, risk analysis, Turkish defense industry

ÖZ

BİR TÜRK SAVUNMA SANAYİİ FİRMASI İÇİN
RİSK YÖNETİM YÖNTEMİ

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Bu çalışmada Türk Savunma Sanayi'nde faaliyet gösteren bir Firmanın iş geliştirme safhasında kullanılmak üzere bir risk yönetim yöntemi önerilmektedir. Önerilen yöntem, uygun maliyetli ve uygulanabilir olması yanında, güncel risk yönetim uygulamaları baz alınarak iş geliştirme safhasında halihazırda uygulanmakta olan proje yönetim süreçleri üzerine inşa edilmiştir. Yöntem, sonuçlar ve uygunluk başlıkları altında iki yeni bölüme sahip bir risk yönetim planı formatı önermektedir. Bunun yanında, yöntem analizi yapılacak verinin miktarını ve karmaşıklığını azaltmak adına risk tepki planlarının nicel risk analizinden önce uygulanmasını önermektedir. Yöntem ayrıca kolay kullanılabilir ve firmanın projelerine uygun yazılımların kullanımından da faydalanmaktadır. Önerilen yöntemin bir başka amacı da risk yönetimi için önemli olan risk veritabanlarının oluşturulmasına öncülük etmektir. Yöntem, risk yönetiminin kurumsal ve karar verme mekanizmaları açısından değerlendirmesini de yapmaktadır. Ayrıca varolan yöntem ve önerilen yöntemi karşılaştırmak ve önerilen yöntemin avantajlarını ortaya koymak adına iki yöntem firmaya ait bir proje üzerinde uygulanmıştır.

Anahtar Kelimeler: Risk yönetimi, proje yönetimi, risk yönetim planı, risk analizi, Türk Savunma Sanayi Endüstrisi

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LIST OF ACRONYMS

BMP	: Best Manufacturing Practices
DOD	: Department of Defense
EADS	: European Aeronautic Defense and Space Company
ERP	: Enterprise Resource Planning
ILS	: Integrated Logistic Support
MoD	: Ministry of Defense
MIL-HDBK-881	: Military Handbook 881
NASA	: National Aeronautics and Space Administration
NATO	: North Atlantic Treaty Organization
OGC	: Office of Government Commerce
PMBOK	: Project Management Body of Knowledge
PMI	: Project Management Institute
PMWS	: Program Manager's WorkStation
PRINCE	: PRojects IN Controlled Environments
RFP	: Request for Proposal
SAP	: Systems Applications and Products
TAF	: Turkish Armed Forces
TAFF	: Turkish Armed Forces Foundation
TRIMS	: Technical Risk Identification and Mitigation System
UDI	: Undersecretariat for Defense Industries
UK	: United Kingdom
USA	: United States of America
VAT	: Value Added Tax
WBS	: Work Breakdown Structure

CHAPTER I

INTRODUCTION

1.1 Background

The history of the Turkish defense industry dates back to the mid 1970's, to the foundation of ASELSAN in 1974. The foundation goal of ASELSAN and the Turkish defense industry was the development of Turkey's own national radios. In the past thirty-three years, the industry has developed at an accelerating pace. Today, Turkish defense industry firms are capable of supplying over 30% of the defense needs of the country, with products varying in a range from national vessels to satellite communication systems. Along with demand for new defense products, the number of projects and the number of players in the market increased swiftly. The volume of sales of Turkish defense industry firms reached over one billion dollars per year (Turkish Armed Forces Foundation [TAFF], 2006).

The increasing volume and the number of the projects brought the need for advanced project management practices throughout the industry. The production based characteristics of the industry shifted to project based activities, and Turkish defense industry firms started to adapt project management practices.

Risk management is an integral part of the project management framework that can neither be distinguished from other project management activities nor compromised. However, the risk management concept and practices are mostly inadequate, primitive and intuitive applications in the Turkish defense industry. There are various reasons why risk management could not find the necessary grounds for application in the Turkish defense industry. Some of the reasons may be stated as follows:

- The industry dynamics had been highly static and monopolistic, therefore the need for risk management was not felt,

- There were only a few firms in the market that had strict niche roles holding the competition at bay
- The firms were only serving for the Turkish Armed Forces and the market needs were limited with the requirements of the Turkish Army.
- Through the first decades of the industry, the focus was on product developments and the technological advancement level of the firms was limiting the number of research and development projects.

However, in recent years the defense industry has been experiencing changes. The above-mentioned characteristics became obsolete, especially with the level reached in technological advancements due to the endeavors that have been put forward since the foundation of the industry. The above-mentioned conditions have been transformed into the forms below.

- The sector became highly dynamic. Competition became fierce with the penetration of new foreign and domestic firms into the industry.
- Turkish defense industry firms have penetrated into foreign markets (Asia, Europe, North and South America, North Africa).
- The number of research and development projects increased, and high technology products, and some of which are pioneers in the world, emerged. The highly correlated character of risk and uncertainty with new technology and research and development introduced new risks.

The competitive environment in domestic and foreign markets, the dynamic structure due to new technologies, economical circumstances, and new research and development projects substantiate the need for the application of risk management practices in the industry.

1.2 Aim and Scope

The above-mentioned conditions in the Turkish defense industry indicate the need for a sector specific, organized risk management approach, and methodology.

In this research, an integrated risk management method is proposed for the business development phase of a Turkish defense industry firm's projects, where the risks are identified, qualified, and quantified, and risk response plans are developed within a project management plan. The proposed method is founded on the recommendations of project and risk management literature.

There is no single "best" technique for managing risk even for projects belonging to the same industry or even the same company (Heerkens, 2002). Bearing that in mind, the purpose of this study is to develop a risk management framework for a Turkish defense industry firm's projects.

The firm investigated under the scope of this study is one of the major defense industry firms in Turkey. The firm has a wide range of products, and evaluating projects in different areas of defense electronics. In recent years, the firm has been exporting its products to foreign markets. The operation areas of the firm concentrates on the development of military electronics hardware and software products. The firm is referred to as "the firm" or "Company X" throughout the thesis.

In order to construct a risk management method for the firm's projects, the current situation is investigated and exemplified by a sample project. After the drawbacks of the current method in risk management are put forward, the new method is constructed and the same sample project is evaluated with the proposed method. After the evaluation of both methods on the same sample project, the advantages of the proposed method over the existing practices are discussed.

1.3 Organization of the Thesis

In Chapter 1, the changing circumstances of the Turkish defense industry that led to the necessity for a suitable risk management method for the firm's projects, the research problem, and the approach to the problem throughout the thesis are described.

In Chapter 2, the current project and risk management practices applied during the business development phase of the firm’s projects are defined.

In Chapter 3, a sample project is evaluated by the aid of the current project and risk management practices defined in Chapter 2, in order to construct a basis for the comparison of the proposed method with the existing practices.

Chapter 4 presents the details of the risk management method developed in this thesis and in this chapter, the sample project is evaluated with the proposed method.

In Chapter 5, the results of the proposed method are discussed, and its advantages over the existing practices are detailed. The conclusions drawn for this study along with the recommendations for future studies are presented

CHAPTER II

PROJECT AND RISK MANAGEMENT PRACTICES IN COMPANY X

2.1 Introduction

In this chapter, the typical project management and risk management practices of the Turkish defense industry firm, Company X are investigated. Along with the project and risk management practices used, the shortcomings of the system from the standpoint of risk management are defined in order to construct the basis for the risk management method proposed in this thesis. The baseline for the application of the system on a sample project that is assessed in Chapter 3 of the study is also constructed.

2.2 Adaptation of Project Management in the Firm

The project management concept does not have a considerable history in the Turkish defense industry. Defense firms and Turkish government bodies related to defense procurement projects, Undersecretariat for Defense Industries (UDI) and Ministry of Defense (MoD) began to incorporate project management practices for the last two decades. The Turkish defense industry market has been in an inclination of getting more and more national in terms of procurement and the number of procurement projects is increasing day by day. Since there are many projects regarding the industry, the players in the market whether they are the authorization bodies (customers) or the suppliers (defense industry firms), have to adopt project management practices in order to achieve success. Due to these developments taking place in the industry, all of the parties recognize the necessity to change the way of doing business including Company X.

Since project management practices require being an integral part of the organization, in order to adapt these practices to the firm, organizational structures need to be modified. Thus, Company X has been going through business process reengineering activities.

Formerly, the firm had "functional organization structures" with a hierarchical composition and grouping of staff members by their specialties such as production, engineering, and logistics support. However, with the changing conditions of the industry and the business getting more project based, the firm is undergoing a structure change that is adapting the organization to the project based business environment. Figure 2.1 shows the key project-related characteristics of the known organizational structures. Based on the classification given in Figure 2.1, the firm nowadays has a "strong" and even "composite matrix" organizational structure with its project-related characteristics. The standard forms of strong and composite matrix structures are given in Figure 2.2 and Figure 2.3, respectively. The firm has established project management units around functional units and has formed program directorates, where the program directors are the managers of the project managers.

Organization Structure / Project Characteristics	*Functional*	*Matrix*			*Projectized*
		Weak Matrix	Balanced Matrix	Strong Matrix	
Project Manager's Authority	Little or None	Limited	Low to Moderate	Moderate to High	High to Almost Total
Resource Availability	Little or None	Limited	Low to Moderate	Moderate to High	High to Almost Total
Who controls the project budget	Functional Manager	Functional Manager	Mixed	Project Manager	Project Manager
Project Manager's Role	Part-time	Part-time	Full-time	Full-time	Full-time
Project Management Administrative Staff	Part-time	Part-time	Part-time	Full-time	Full-time

Figure 2.1 Project Related Characteristics of Organizational Structures

Source: Project Management Body of Knowledge, Third Edition, 2004

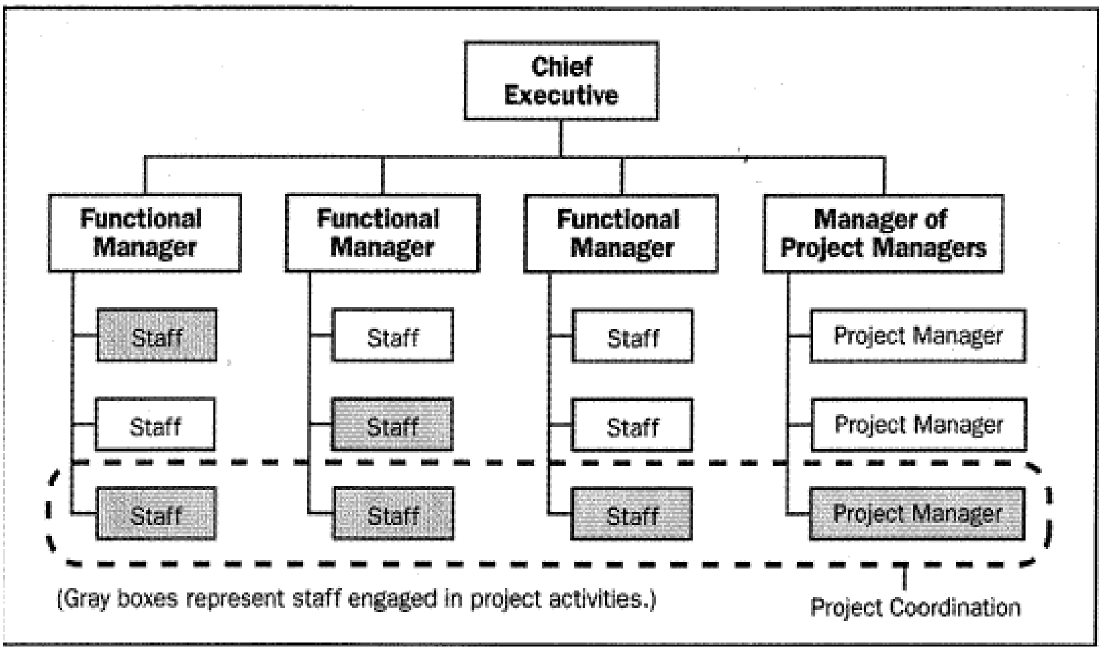


Figure 2.2 Strong Matrix Organizational Structure

Source: Project Management Body of Knowledge, Third Edition, 2004

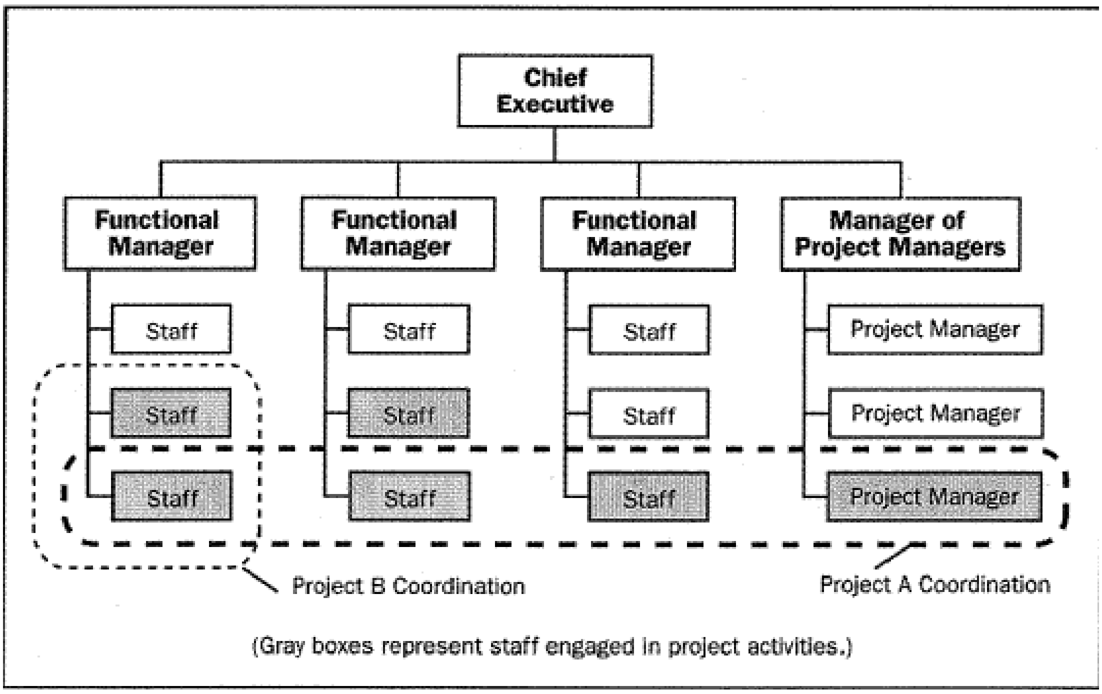


Figure 2.3 Composite Organizational Structure

Source: Project Management Body of Knowledge, Third Edition, 2004

Along with the organizational structure change, the firm has been experiencing changes in the ways of doing business. The organizational information system has been changed in order to adapt the "management by projects" notion, replacing the old manufacturing and production based Enterprise Resource Planning (ERP) system MANMAN, with a project based, advanced ERP system of Systems Applications and Products (SAP) AG.

The next step in the adoption of the management by projects notion is related to the changes in the policies and the procedures of the firm. The firm is very strict on the usage of policies and procedures that define the aspects of the operations and business activities. In this process of migration to the project-based environment, these written documents play a significant role. The firm has been developing new procedures that describe how the business system should operate project based. These procedures define the steps for applying project management practices. They reflect the firm's perception of the project management concept and the project management practices. These procedures include the project management methodology derived from universal project management practices, modified specifically in line with the firm's interpretation of internal (organizational structure, information systems used and organizational culture) and external business environment (competitive, economic, technological, political and legal) applicable to the general structure of the Turkish defense industry projects.

In terms of project management methodology, there are two major and universally accepted organizations and their publications, the Project Management Institute (PMI) of the United States of America (USA) and its rule book Project Management Body of Knowledge (PMBOK), and the United Kingdom's (UK) Office of Government Commerce (OGC) and its rule book PRojects IN Controlled Environments (PRINCE). These are the most influential organizations and publications in the general management sense for project management. Along with these, there are agencies and their publications specific for the defense and aeronautics industries. The most dominant studies are developed by the Department of Defense (DOD) of USA, the National Aeronautics and Space Administration (NASA) of USA and by other organizations like the Defense Departments of various governments, UK, Australia, and Canada, and the North Atlantic Treaty Organization (NATO). Among these various options and role model organizations globally, the firm has generally been adopting PMI and DOD applications, methodologies, and publications. That is, for managing defense projects, the PMBOK approach is applied by the firm. The policies and procedures defined for carrying out the projects of the firm get their nature and contents specifically from PMBOK.

2.3 Project Management Practices in Company X

Project management practices are defined through the internal procedures of the firm and they are confidential (Commercial in Confidence) and cannot be disclosed. These procedures are the customized versions of the activities defined in PMBOK. They are tailor-made for the defense industry projects that the firm mostly deals with. In this study, the content of these procedures are described by the aid of PMBOK defined processes and sub-processes, in order to put forward the shortcomings of these procedures in terms of risk management.

Before going into the detail of the processes, the lifecycle of projects in the firm is described. There are two main types of projects with respect to their sources, that is regarding their authorization. The first type includes projects that are authorized by external bodies. These authorization bodies are UDI and MoD for Turkish defense projects, and global organizations like NATO or the ministries of defense of other countries for foreign originated projects. In this group of projects, the start-up is the invitation to the bidders to propose an offer by the authorization body, namely the publication of a Request for Proposal (RFP).

The second group of projects is the development projects that originate internally and are authorized and funded by the firm itself. The department initiating the new development idea proposes the project to senior management rather than giving a proposal to external authorization bodies.

In terms of the life cycle of these two groups of projects, the activities that are performed from the start-up to the submittal of the proposals are called the "business development phase". In the procedures of the firm, the business development phase is equivalent to the feasibility study in the general management jargon. As emphasized in PMBOK, this phase can be treated as a separate project. The firm's project management procedures also define and treat this phase as a separate project.

The business development phase is followed by the project management phase. The project management phase starts with the award of the contract to the firm by the external authorization body based on the proposal submitted and the result of the negotiations between parties (authorization body and the firm), or the approval of the necessary fund release by senior management for development projects. The project management phase is executed with the application of the defined processes in the procedures and continues until the end of the project.

As the definition implies, project management is accomplished through the application and integration of the project management processes of initiating, planning, executing, monitoring and controlling, and closing to achieve the project objectives in terms of scope (performance), time and cost by using project management knowledge, skills, tools, and techniques (PMBOK, 2004). As the business development and project management phases are treated as two distinct projects, these processes are applicable for both business development and project management. The processes are introduced in a sequential order and they are recommended to be applied through the projects' lifecycles. However, in project management there are no set rules, and the application of these processes are based on certain features of projects such as complexity, size, resources, risk, experience, availability of historical data and project management maturity levels. It is not mandatory to uniformly use all of the processes, and project managers must select the appropriate ones and apply them throughout the project. In Company X, the procedures are well established and strict. Therefore, in the firm, the decision maker about the applicability of the processes is not the project manager but the procedures in most of the cases. This indicates the importance of adequate and accurate procedures for project management. For the business development and project management phases the procedures define which processes should be used and to what extent.

In conclusion, the projects of the firm are handled in two phases, which are treated as separate projects, and the procedures define two distinct flows of project management activities for these two phases, both derived from the processes defined in PMBOK. In the following part of the study, the processes applied for the business development phase are analyzed, emphasizing the shortcomings regarding risk management.

2.4 Business Development Phase

In most cases, the business development phase is initiated by an RFP published by an authorization body. A Request for Proposal is an invitation for the firms, to submit a proposal on a specific product or service, namely for project deliverables. RFPs may differ in context for different types of projects. However, the content in defense industry RFPs are almost the same for all type of projects. Furthermore, the authorization bodies in most of the cases, UDI and MoD have standard RFP formats that are used for all projects. The differing parts are the specific technological contexts. The firm prepares and submits its proposals for external projects in line with these RFP formats; the procedures defined for internal development projects require the preparation of the feasibility reports in the same context. Therefore, the project management activities defined in the procedures for the business development phase are applicable for all projects external or internal, with minor exceptions; the procedures define the general context and the chosen processes and activities are applicable for this defined context.

As stated in previous parts of the study, the knowledge, skills and processes described are not always applied uniformly in all projects. Thus, the processes, knowledge, and skills for the evaluation of the business development phase are customized. The ones that are seen most relevant and applicable to project management in the Turkish defense industry have been chosen among the group of processes and sub-processes of the project management framework and these are described in the business development and project management procedures of the firm. These processes and their sub-processes for the business development phase are described below. Table 2.1 shows the flow of these processes and their sub-processes in the business development phase of the firm's projects. The sub-processes accomplished until the risk management planning sub-process lay the basis for the implementation of the risk management sub-processes.

Table 2.1 Business Development Phase Processes

	Project Management Processes and Sub-processes in Business Development Phase
1	Business Development Phase
1.1	Initiating Process Group in the Business Development Phase
1.2	Planning Process Group in the Business Development Phase
1.2.1	Developing Proposal Preparation Plan
1.2.2	Developing Project Management Plan
1.2.3	Scope Definition
1.2.4	Creating WBS
1.2.5	Activity Definition
1.2.6	Activity Sequencing
1.2.7	Activity Resource Estimating
1.2.8	Activity Duration Estimating
1.2.9	Human Resource Planning
1.2.10	Production Planning
1.2.11	Schedule Development
1.2.12	Quality and Configuration Management Planning
1.2.13	Purchases and Acquisitions Planning
1.2.14	Contracting Planning
1.2.15	Cost Estimating and Cost Budgeting
1.2.16	Risk Management Planning
1.2.17	Risk Identification
1.2.18	Qualitative Risk Analysis
1.2.19	Quantitative Risk Analysis
1.2.20	Risk Response Planning

The flow of the processes and the related sub-processes in the business development phase starts with the release of an RFP or the development idea as defined above. In the following part of the study, the flow of the business development phase sub-processes are described and these are exemplified by a sample project in Chapter 3. The project management activities begin with the initiating process group.

2.4.1 Initiating Process Group in the Business Development Phase

The *project charter* in the business development phase is the RFP or the business development idea that ignite the phase. As the RFP prepared and released by the authorization body, defines all the business needs and states the project and deliverable requirements, product requirements, boundaries of the project, methods of acceptance and high level scope control of the project, it determines the project charter.

The preliminary project scope statement as a requirement of the initiating process group is stated within the forms that are prepared for the approval of senior management under the scope of this process group. A form is prepared by the project manager under the scope of the project charter. The developed project charter is used for getting the necessary approval of senior management. This approval is needed in order to continue the business development processes. This form includes a brief summary of the project charter, and mainly the scope statement that helps the judgment of senior managers to continue with the project. If the project falls under the scope of the strategic plan of the directorate and firm, the project is found appropriate; senior management approves the continuation of the business development phase and releases the necessary funds and human resources for the business development.

A business development team is formed with the participation of the staff members from the related functional units who will work in the business development phase. If the contract is awarded, or the senior level approves the development of an internal project, these staff members will also be part of the team who will work in the next phase, namely project management phase.

After the approval and the formation of the project team, the business development phase continues with the planning process group.

2.4.2 Planning Process Group in the Business Development Phase

The planning process group includes all the necessary studies to be performed by the business development team, and especially by the project manager, in order to respond to the RFP for externally authorized projects, or in order to prepare the feasibility report for the internally authorized development projects. Thus, it can be said that, the planning phase is the most important part of the business development phase that lays the ground for the project management phase.

The planning process group is composed of twenty-one sub-processes as defined in PMBOK. However, in the business development phase not all of them are executed. The ones that are performed in this phase are detailed below.

2.4.2.1 Developing the Proposal Preparation Plan

Developing a proposal preparation plan is not defined in PMBOK. However, in the business development procedures of Company X it takes place. This sub-process is evaluated with the attendance of the all project team members in order to plan the activities that will be performed during the proposal preparation. In this sub-process, the work responsibilities regarding the project management plan, the timeline of the planning process, and the content of the proposal that will be submitted in line with the RFP are decided.

2.4.2.2 Developing the Project Management Plan

The project management plan includes all the deliverables information, data, and preliminary plans in response to the RFP, or within the perspective of the report that will be submitted to senior management for the approval of the development project.

To develop the project management plan, a detailed study is undertaken by the members of the project team. The assigned project manager develops the project management plan based on a standard format that refers to various subsidiary plans that are the preliminary versions created by appointed divisions. In this plan, the project management activities, which will take effect during the project management phase, are stated. This may be thought as the root that covers all subsidiary plans, and includes information that is derived from the outcome of the sub-processes described below.

2.4.2.3 Scope Definition

The preliminary project scope statement is extended with the detailed definition of the scope of the project in a way to include all relevant information regarding the statement of work that is defined within the RFP document. If it is a development project, the statement of work that will be executed in the project management phase is put forward.

2.4.2.4 Creating the Work Breakdown Structure

The work breakdown structure (WBS). It is a deliverable-oriented hierarchical decomposition of the work to be executed by the project team during the project management phase, to accomplish the project objectives and create the required deliverables; it is one of the major building blocks of a project. The work breakdown structures in defense industry projects are created according to the rules and procedures defined in the Military Handbook 881 (MIL-HDBK-881) – Work Breakdown Structure written and published by Department of Defense of USA. This handbook presents guidelines for preparing, understanding, and presenting a work breakdown structure for defense industry projects. Preparing an adequate WBS is essential for the achievement of the activities of the business development phase, as well as the project management phase, since it represents the breakdown of the work to be performed in line with the project scope statement and the statement of work. The WBS of a project also constructs the basis for activity definition, activity sequencing, schedule development, cost estimating, human resources planning, production planning, and risk management. Defense industry firms have some defined structures for the work breakdown trees, and project management is responsible for filling out the details of these predefined work breakdown trees.

A WBS is important for managing risk in projects, since it indicates all of the work, which inherits risks in the project. The identification of the risks becomes easier and more accurate with a well-defined and adequate WBS.

2.4.2.5 Activity Definition

After creating the Work Breakdown Structure within the perspective of the Military Handbook-881, the activities needed for executing these works are defined. Each work in the breakdown is expanded and detailed with the relevant activities that are to be performed within the project management phase. The definition of the activities can be seen as the interpretation of the scope statement and the statement of work.

2.4.2.6 Activity Sequencing

When the activities to be performed for each work are defined, they are put in a sequence in order to construct the schedule. This sequencing indicates the interdependencies between the activities defined. Activity sequencing is the groundwork for schedule development.

2.4.2.7 Activity Resource Estimating

This step involves the determination of the necessary resources needed to perform the activities defined and sequenced in the previous steps. In this sub-process, all the relevant data regarding total man and machine working hours are collected from the functional units that will perform the defined activities. The project team members analyze the activities and identify the man hours and machine hours (for production units).

2.4.2.8 Activity Duration Estimating

After the necessary resources are identified in working hours, the duration of the activities must be defined. The duration may not be the same as the total of man and machine hours divided by the one-day working hours, since capacities can change due to the availability of men and machines when considering the workloads of the other projects carried out in functional units. In other words, resources taken up by other projects limit available capacity and therefore affect the completion time. The activity duration estimation is related to human resources planning, since the available human resources play an important role in the duration estimation of the project. Along with the human resources, the machine resources are also important in terms of planning. Therefore, production planning is also evaluated for the estimation of activity durations.

2.4.2.9 Human Resources Planning

Human resource planning is a parallel process to resource estimation and especially duration estimation. As mentioned in the activity duration estimation sub-process, the availability of the human resources during the project management phase is important, and this availability must be well planned in order to prevent conflicts in the execution of multiple projects.

2.4.2.10 Production Planning

In this sub-process, the planning regarding the resources used in the production activities is handled. The required machine resources are matched with each activity of the project. The availability of these resources during the implementation of the project activities is important for the activity duration estimations and therefore for the schedule development. Production plans are also important in order to prevent conflicts within multiple projects of the firm.

2.4.2.11 Schedule Development

Schedule development is the last step before going into the financial dimensions of the project. The sub-processes above; activity sequencing, resource estimating, duration estimating, human resources planning, and production planning constitute the base for schedule development, namely the project plan. Besides that, the schedule development and the previous sub-processes are iterative among themselves. Since projects have time limitations, the schedule developed must obey these limitations. In order to achieve the schedule goals, the project manager and the project team go back and forth in between these sub-processes and try to optimize the schedule (project plan).

Schedule risk is an intergral part of the risk management process that also affects the scope and cost risks of the project. The risk factors regarding the schedule must be treated with special attention. However, the procedures as they stand do not imply the application of the risk management practices regarding the schedule of the projects. Therefore, the schedule planning sub-process is lacking the necessary risk management applications in the business development phase of the Company X's projects.

2.4.2.12 Quality and Configuration Management Planning

Quality and Configuration Management Plans are two deliverables in defense industry projects. Generally, the RFPs require the submittal of the Quality and Configuration *Management* Plans, which explicitly define how quality and configuration activities will be managed throughout the project management phase. These plans define the methods to be applied in order to manage the quality and configuration activities in the project management phase. These plans are important for risk management practices, since the quality and configuration issues embody risks in terms of the performance of the project. The authorization bodies pay special attention to quality and configuration issues since they are two of the most important criteria in the performance of the projects. That is why this sub-process is carried out with the outmost care in Turkish defense industry projects.

2.4.2.13 Purchases and Acquisitions Planning

In this sub-process, what is to be purchased or acquired, how and when the purchases and acquisitions are to take place, and possible suppliers for these purchases and acquisitions are determined. In this phase, the project manager works closely with the purchasing and acquisition departments.

In terms of purchases and acquisitions, the evaluation of this sub-process may vary extensively between projects. In some projects, there may be only direct purchases that do not require sub-contracts, and in others, there may be one or more sub-contractors, where the acquisitions are regulated with detailed contracts.

In the case of direct purchases, all of the possible suppliers are investigated and their price quotations are requested. These price quotations from various firms are evaluated by relevant units of the project team in terms of the terms and conditions of the supplier firm; prices, lead times, technical specifications (most important determinant), required customs procedures and regulations (this issue is especially important for defense equipments and systems). Regarding all information in hand, the firms with the most appropriate terms and conditions for the project are selected, and the purchasing activities are planned in terms of these terms and conditions. The purchase plans are inserted into the schedule in order to see if the lead times fit with the schedule. The delivery times, custom clearances, acceptance tests may take a considerable amount of time that would affect the schedule, and purchases that are in line with the time constraints of the project are extremely important. If these determinants are not satisfactory for the project objectives, the terms and conditions are negotiated with the suppliers. At the end of the negotiations, the suppliers meeting the project criteria are determined and the terms and conditions of suppliers are inserted into the relevant parts of the project management plan, or the approval forms that are prepared for senior management.

If the project requirements indicate needs for acquisitions, and the project team decides that there should be sub-contractor(s) involved in the project, the process applied is different and more complex than direct purchases planning. The project team investigates possible sub-contractor candidates, as they do for purchases. However, in order to get proposals from these candidates, the project team prepares detailed RFP documents that reflect the project requirements within the perspective of the RFP published by the external authorization body for external projects, or the requirements of the project that are determined by the project team for internal development projects. The RFPs include the draft sub-contract agreement documents. With the RFP documents prepared, the compliance answers of the candidate sub-contractor firms are collected. Then, these proposals are evaluated by the project team in order to determine the best firm that is most compliant with the project requirements. In an acquisition process, the determinants are more complicated and the number of determinants is not limited with the above-mentioned ones; prices, lead times, technical specifications, required customs procedures and regulations. Issues like warranty, logistic support, financial obligations, property rights, liabilities, force majeure also come into the scene in the decision process. After the determination of the most suitable sub-contractor candidates, the terms and conditions of the possible sub-contracts are inserted into the project management plan and the issues regarding time are inserted into the schedule.

In terms of risks and risk management, the purchases and acquisition sub-process is extremely important. Since scope, time, and cost are three main objectives, this sub-process is directly related to the achievement of these objectives. Purchases and acquisitions bear high levels of risk and uncertainty. The risks arising out of the supplier or sub-contractor firms are out of the control of project management to a certain extent, even when the relationships and liabilities are regulated with the provisions of the terms and conditions or the sub-contracts agreed on. Scope, schedule, and costs may deviate from the planned objectives with the poor performances of the suppliers and sub-contractors. These risks are coming out of external sources and they must be determined and handled with care. The sub-contract agreements are good ways to transfer the project risks to the sub-contractor.

Purchases and acquisitions are directly related to the contracting planning sub-process and they cannot be thought as distinct processes.

2.4.2.14 Contracting Planning

Contracting planning has two aspects, which deal with the contracts between the authorization body and the firm on one hand, and the contracts between the firm and its sub-contractors on the other hand. However, in internal development projects the main concern is only the sub-contracts most of the time.

The draft version of the contract between the authorization body and the firm is the main part of the published RFP. It is supported by various annexes that set the special requirements of the project in subject areas. The annexes include the statement of work, technical requirements, and integrated logistic support requirements documents along with some additional financial annexes. The general contents of the RFPs published by the Turkish defense industry authorization bodies is given in Table 2.2 below. The contract is the backbone of a project and the project team must pay special attention to contracts.

The contract planning sub-process is extremely important in terms of risk management in a project, since the contracts regulate the relationships and liabilities between the parties in the project. The main contract between the firm and the authorization body bring their own risks on to the projects in terms of scope, time, and costs. Firms try to negotiate the terms and conditions of the contracts with the authorization bodies in order to secure better positions for themselves within this sub-process. Therefore, the contract planning phase is the sub-process where the risks regarding the main contract may be reduced through negotiations between the authorization bodies and the firms.

The preparation and the management of sub-contracts for acquisitions is also one of the main objectives of the contract planning sub-process as detailed in purchases and acquisitions sub-process above. As the sub-contracts inherit risks onto the projects, the sub-contracts must be prepared in order to minimize the amount of risk. The terms and conditions of the sub-contracts must be designed in a way to keep the risks at minimum levels with the sanctions applied to the sub-contractors. Furthermore, the sub-contracts are the media to share and reflect the risks of main contracts to sub-contractors.

Table 2.2 Typical RFP Format for Turkish Defense Industry Projects

	REQUEST FOR PROPOSAL
1	Tender Provisions Document
1.1	Draft Contract Text
1.1.1	Statement of Work
1.1.1.1	Work Breakdown Structure (To be filled by Contractor)
1.1.1.2	List of Deliverable Supplies and Services
1.1.1.3	Data Requirements List (Deliverable Documents List)
1.1.1.4	Test and Evaluation Master Plan (To be filled by Contractor)
1.1.2	Technical Specifications
1.1.3	Integrated Logistic Support (ILS) Requirements
1.1.4	Quality Management Plan (To be filled by Contractor)
1.1.5	Configuration Management Plan (To be filled by Contractor)
1.1.6	Price Breakdown Tree (To be filled by Contractor)
1.1.7	Delivery Schedule (To be filled by Contractor)
1.1.8	Payment Plan
1.1.9	Models of Securities
1.1.12	Model of Certificate of Acceptance
1.1.13	List of Export Licenses (To be filled by Contractor)
1.1.14	List of Spare Parts (To be filled by Contractor)
1.1.15	Model of Certificate of Conformity
1.1.16	Model of Change Proposal
1.1.17	Progress Report Format

2.4.2.15 Cost Estimating and Cost Budgeting

In the previous sub-processes all the data needed for estimating the costs in the project management phase are gathered.

The WBS that clearly defines activities constitutes the main input to cost estimating and budgeting. In Company X, the spreadsheet method for cost estimating and cost budgeting is mostly used. The work breakdown structure and its detailed activities, which are defined and sequenced, are the main inputs for the cost estimation spreadsheet. The costs regarding all work packages and related activities are input to the spreadsheet, and an analysis macro is run in order to determine the total costs of the project. Additional factors that affect the proposal price of the project are identified and input into the analysis. These additional determinants are the profit mark-up, general management expenditures mark-up, purchasing and acquisition expenditures mark-up, contract expenditures (stamp, contract tax) mark-up, positive and negative cash flows mark-up, Value Added Tax and finally the risk mark-up under the name of unexpected expenditures.

Other than the risk mark-up (named unexpected expenditures), all other determinants are based on detailed and adequate analysis performed by appointed functional units (Finance department, marketing department, procurement department, contract department). However, in the cost estimating and cost planning sub-process the missing part is an adequate risk approach. The only assessment of risk for cost considerations in Turkish defense industry projects is the risk mark-up that is only determined by the intuitive understanding of management. The risks are determined by senior management and by the project manager and are reflected as a simple percentage mark-up without any analysis and quantification.

2.4.2.16 Risk Management Planning

Risk management planning is the starting point of risk management activities in projects, where the project team decides how to approach, plan and execute risk management activities for the project management phase. The risk management plan must be a documented outcome of the meetings held by the project team. This document must cover the risk identification outcomes (risk register), qualitative and quantitative risk analysis results, and a risk response plan. In order to establish a risk management plan, the following sub-processes, risk identification, qualitative risk analysis, and quantitative risk analysis must be evaluated by the project team under the leadership of the project manager. Presently, the procedures regarding the business development phase in Company X only require the preparation of a table with simple and cursory inputs for risk identification, qualitative risk analysis and risk response planning. The format of the risk table currently developed in the business development phase in Company X is given in Table 2.3 below.

Table 2.3 Current Risk Table Format of Company X

No	**RFP Ref. No**	**Risk Definition**	**Risk Level** (Low, Medium, High)	**Risk Response Approach**	**Preventive Action in Labor Hours**	**Corrective Action In Labor Hours**	**Total Labor Hours (Preventiv e + Corrective)**
TOTAL							

In brief terms, there is no satisfactory risk management plan prepared by the project team in the business development phase of Company X's projects. In some projects, a draft risk management plan is a requirement of the RFP. In such a situation, a risk management plan is prepared that reflects only the risk identification and a simple qualitative risk assessment without any adequate analysis. Some risk response approaches are also inserted into the plans for inadequately determined risks.

2.4.2.17 Risk Identification

In terms of risk identification, the risk table that is required to be prepared by the project team includes only the definitions of the risks that are foreseen for the project management phase. The only determinants in terms of risk management regarding the risk identification sub-process are the simple definitions of the risks. These risk definitions are not based on any known and applicable methods or techniques. They are dependent on the intuition of the project manager. The use of risk identification tools and techniques are not used in this sub-process. Yet, the results of qualitative and quantitative risk analysis are crucial for the risk management plan.

2.4.2.18 Qualitative Risk Analysis

After the identification of the risks regarding the project, the procedures postulate the qualitative classification of each risk in a three level approach. The risks are given importance levels of low, moderate or high. Each level also corresponds to a certain scale between 0 (zero) and 1 (one). These scales are determined as 0.3, 0.6, and 1.0 for low, moderate, and high level risks respectively. However, in Company X this scale corresponds to neither the risk probabilities nor their impacts. The qualitative risk analysis sub-process again lacks the usage of accountable tools and techniques. The outcome of this sub-process is the rating of risks on a scale between 0 (zero) and 1 (one).

2.4.2.19 Quantitative Risk Analysis

The risks are defined and rated with spontaneous and intuitive approaches that are not based on adequate techniques as described above. Quantitative risk analysis applications require the usage of necessary tools, including advanced software packages and simulation methods. However, currently, the quantification of risks at the business development phase at Company X is limited to the determination of the man-hours that would be needed to prevent the risks and to react to the risks in case of occurrence. After the determination of the working hours needed for these purposes, these numbers are multiplied with the ratings derived in the qualitative risk analysis sub-process and input to the risk table. This approach only takes into consideration the man-hours required to deal with risk. Therefore, the outcome of the quantitative risk analysis sub-process in its current state is useless in the business development phase, since it cannot be used as a determinant in any other process and elsewhere in the proposal.

Currently, the procedures governing quantitative risk analysis in Company X do not mention any other risk impact. Major risks that could have great impact on the cost and schedule objectives of the project are totally omitted. They are tried to be amortized and traded of with the intuitive percentage mark-up determined in the cost estimating sub-process. The lack of sufficient quantitative risk analysis can have negative impacts on the firm. The use of intuitive risk mark-up may cause over or underestimation of the cost of risks in projects. Underestimations may cause considerable amount of profit losses and may force the firm to carry out unprofitable projects. On the other hand, over estimations may cause higher prices that may lead to the loss of contracts in today's competitive environment. Over estimation may also end up with high profit projects that may cause the loss of reputation of the firm for prospective projects.

Consequently, a well-established quantitative risk analysis sub-process is vital for a firm operating in the Turkish defense industry facing a business environment that is getting more and more competitive.

2.4.2.20 Risk Response Planning

Risk response planning is the process of developing options and planning the actions against the risks that may occur during the implementation of the project activities (Hillson, 2004). The risk responses must be appropriate to the significance of the risk, cost effective, timely, and realistic. The following responses are commonly used approaches against risks in projects (Chapman, 2006).

i. Risk Avoidance: For the risk avoidance, response plans are developed for eliminating the root causes and/or the consequences of the risks.

ii. Risk Transfer: In this approach, the entire risk issue or a certain part of it is planned to be transferred to any other stakeholder of the project, in order to reduce the negative impacts that this risk may cause on the objectives of the project.

iii. Risk Mitigation: This approach aims to reduce the impact and the probability of a risk event by developing different solutions for the activities causing risk. Assigning more employees for the execution of an activity, purchasing adequate machines, or conducting more tests can be certain examples of risk mitigation plans.

The last information that must be inserted into the risk table is about the responses of the project team to the risks. The responses that must be mentioned with respect to each risk must indicate the proactive approaches and the actions that can be performed in order to prevent or minimize the effects of the risky conditions, or to prevent them, as well as the actions that must be performed when a risky condition is faced with. Presently, in Company X the responses in the risk table are mostly narrative action descriptions, which do not rely on specific tools and techniques just like the other risk related sub-processes. These risk response plans are also used for the contract planning sub-process. Since the mentioned responses are not based on any definite and concrete methods, they cannot be used efficiently in contract planning.

The planning process ends up with the collection of all the output documents of the aforementioned sub-processes as a proposal submitted to the external authorization body, or a feasibility report submitted to senior management. The methodology defined above reflects the adequate usage of project management practices, tools, techniques and methods dictated by the literature, and best practices except for the ones regarding risk management, as underlined above. The sub-processes regarding the risk management knowledge area are not given the necessary importance and attention in the business development phase in the firm. However, changing market conditions in terms of competitiveness, the increasing number of research and development projects bearing high levels of risks, the efforts to penetrate into foreign markets increase the necessity of adequate, well-established and well-applied risk management practices for the firm.

In this chapter, the flow and description of processes in the business development phase of Company X's projects have been defined within the framework of project management knowledge areas. In the following chapter, the defined processes in the current procedures of the firm in the business development phase are illustrated and evaluated for a sample project. The application on a sample project is aimed to underline the drawbacks of the current procedures and constructs a basis for the comparison of the method proposed in this thesis with the current practices of the firm under the scope of the risk management.

CHAPTER III

EVALUATION OF A SAMPLE PROJECT WITH CURRENT PROJECT AND RISK MANAGEMENT PRACTICES OF THE FIRM

3.1 Introduction

In this chapter, the current project and risk management practices detailed in Chapter 2 are illustrated for the business development phase through a sample project for Company X. The sample project is an electronics defense product development project, which embodies design, production, system engineering, project management, test and evaluation, and logistic support activities. This project starts with the release of an RFP in standard format as given in Table 2.2 by an external authorization body. The business development sub-processes are evaluated in order to reflect the aspects of the project under the scope of risk management practices.

3.2 Business Development Phase of the Project

The business development phase of the sample project begins with the release of the RFP document by the authorization body and continues until the submittal of the proposal by the firm. As stated in the previous chapter, the business development phase is handled within two process groups, the initiating process group and the planning process group.

3.2.1 Initiating Process Group

The project charter that is the RFP documents released by the authorization body is the root of the project. In the initiating process, the RFP documents are investigated by the assigned project manager who will be in charge for the evaluation of the project. After the investigation of the documents, the project manager determines the relevant functional units, shares the relevant parts of the RFP documents with these units, and invites the units to a meeting. In the sample project, the following functional units involved in the preparation of the proposal by the project manager.

- Electronics Design
- Electronics Production
- Production Planning
- System Engineering
- Purchases and Acquisitions
- Contracts
- Electronics Testing
- System Integration and Testing
- Integrated Logistics Support
- Finance
- Marketing
- Project management

The assigned personnel from these units constitute the business development team namely the project team of the sample project. The functional units investigate the RFP documents and an initiation meeting is held with the contribution of the assigned personnel. During this meeting, the approval form for the continuation of the project is prepared and submitted to senior management. After the approval, the planning process of the sample project is started by the project team.

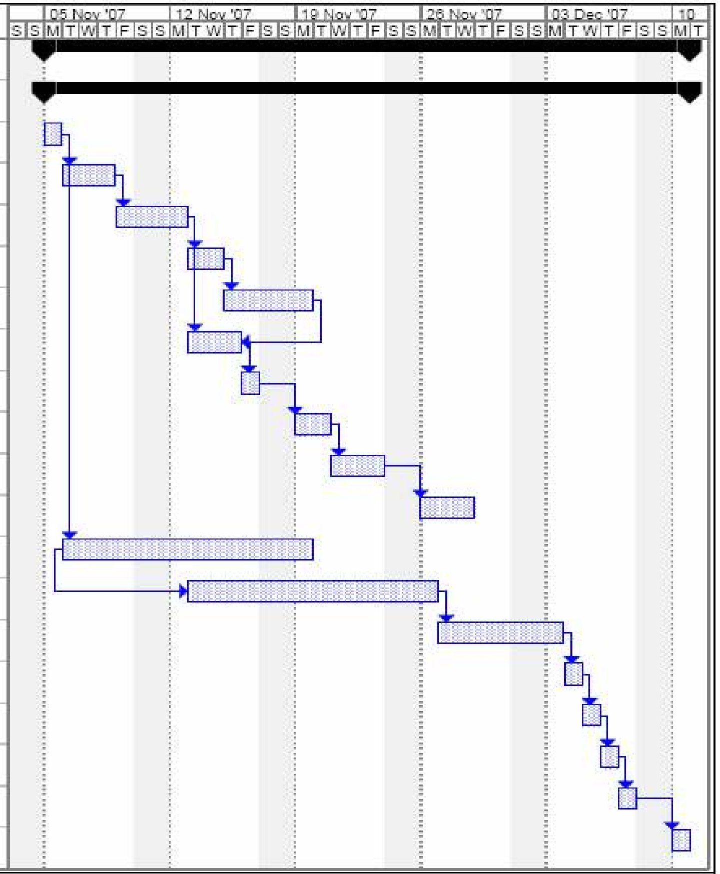
3.2.2 Planning Process Group

All of the sub-processes defined in the previous chapter are carried out for the sample project for the planning process group. The relevant sub-processes for the evaluation of the risk management process and the current risk management practices are detailed in the following part of the study.

3.2.2.1 Developing the Proposal Preparation Plan

Before the evaluation of the core sub-processes, the team develops a proposal preparation plan. The plan developed for the sample project in this thesis is given in Figure 3.1.

ID	Task Name	Duration	Start	Finish	Predecessors
1	**Planning Phase of the Sample Project**	**26 days**	**Mon 05.11.07**	**Mon 10.12.07**	
2	**Developing Project Management Plan**	**26 days**	**Mon 05.11.07**	**Mon 10.12.07**	
3	Scope Definition	1 day	Mon 05.11.07	Mon 05.11.07	
4	Creating WBS	3 days	Tue 06.11.07	Thu 08.11.07	3
5	Activity Definition	2 days	Fri 09.11.07	Mon 12.11.07	4
6	Activity Sequencing	2 days	Tue 13.11.07	Wed 14.11.07	5
7	Activity Resource Estimating	3 days	Thu 15.11.07	Mon 19.11.07	6
8	Activity Duration Estimating	3 days	Tue 13.11.07	Thu 15.11.07	7FF;5
9	Human Resource Planning	1 day	Fri 16.11.07	Fri 16.11.07	8
10	Production Planning	2 days	Mon 19.11.07	Tue 20.11.07	9
11	Schedule Development	3 days	Wed 21.11.07	Fri 23.11.07	10
12	Quality and Configuration Management Planning	3 days	Mon 26.11.07	Wed 28.11.07	11
13	Purchases and Acquisitions Planning	10 days	Tue 06.11.07	Mon 19.11.07	3
14	Contracting Planning	10 days	Tue 13.11.07	Mon 26.11.07	13SS+1 wk
15	Cost Estimating and Cost Budgeting	5 days	Tue 27.11.07	Mon 03.12.07	14
16	Risk Management Planning	1 day	Tue 04.12.07	Tue 04.12.07	15
17	Risk Identification	1 day	Wed 05.12.07	Wed 05.12.07	16
18	Qualitative Risk Analysis	1 day	Thu 06.12.07	Thu 06.12.07	17
19	Quantitative Risk Analysis	1 day	Fri 07.12.07	Fri 07.12.07	18
20	Risk Response Planning	1 day	Mon 10.12.07	Mon 10.12.07	19



Page 1

Figure 3.1 Proposal Preparation Plan of the Sample Project

As seen in the proposal preparation plan of the sample project, the sub-processes are sequenced in order to develop a proposal for the project. Some sub-processes are carried out in parallel, and these sub-processes have interdependent outputs such as activity sequencing and activity duration estimating. On the other hand, the project management plan, the main document that constitutes the proposal of the firm regarding the project is the cover for all of the outputs of the planning sub-processes and the other sub-processes are appraised for the construction of the project management plan as shown in the proposal preparation plan of the sample project.

The main outputs of the planning sub-process that are important for the assessment of the risk management sub-processes are the work break down structure, the project schedule and the cost estimating spreadsheet. These outputs also constitute the basis for the application of the proposed method in the following chapter of the study. The remaining sub-processes have outputs that are relevant to one or more of the above-mentioned sub-processes, and these remaining sub-processes are supplementary ones that assist the development of the work breakdown structure, the project schedule and the cost estimating spreadsheet. Therefore, the relevant supplementary sub-processes are detailed under the scope of the main sub-processes that generate the most important outputs for risk management, creating the work breakdown structure, schedule development, and cost estimating and cost budgeting sub-processes.

3.2.2.2 Creating the Work Breakdown Structure

The work breakdown structure (WBS) for the sample project is a highly important output of the planning phase, since the WBS defines the works to be executed in order to accomplish the project objectives and create the required deliverables. However, before the construction of the WBS, the scope of the project must be determined in order to decompose the work to be executed. The *scope statement* developed for the sample project, where the confidential content has been left blank is as follows.

“The scope of the project is developing a …….. system composed of ……… subsystems that operates in …… conditions and aims to execute ……. functions. The development of one prototype and two product systems are aimed, where the two systems will be accepted with the application of defined factory and platform acceptance tests. Two products are aimed to be delivered within a six month period after the effectivity date of the contract between (the firm) and the (authorization body), and there will be two months warranty under the scope of the logistic support activities after the successful completion of the acceptance of the two systems on the platform. The project will be composed of design, production, system engineering, project management, test and evaluation, and logistic support activities, which will be executed by the relevant functional units under the management of (name of the assigned directorate) and the (name of the assigned project management department the project manager works for). The estimated cost of the project is under the magnitude of $ 100,000.”

The scope statement of the project defines the boundaries and general structure of the project that lays the ground for the development of the WBS of the project. The main activities are defined under the scope statement and these activities are detailed within the WBS developed for the sample project as given in Table 3.1.

After the construction of the WBS for the sample project the details of the activities for the evaluation of the defined works are stated. The detailed activity definitions are not given because of the confidential nature of the sample project. When the details of these activities are defined within the perspective of activity definition sub-process, the responsible functional units are assigned for each activity defined under the WBS. The WBS with the assignment of the functional units is given in Table 3.2.

Table 3.1 Sample Project WBS

SAMPLE PROJECT WBS				
LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
Sample System				
	(A) Design			
		(A1) Subsystem-1 Design		
			(A1A) Design Activity-1	
			(A1B) Design Activity-2	
		(A2) Subsystem-2 Design		
			(A2A) Design Activity-1	
			(A2B) Design Activity-2	
	(B) Production			
		(B1) Prototype Production		
			(B1A) Prototype Production Subsystem-1	
			(B1B) Prototype Production Subsystem-2	
			(B1C) Prototype Production System	
		(B2) Serial Production		
			(B2A) Serial Production Subsystem-1	
			(B2B) Serial Production Subsystem-2	
			(B2C) Serial Production System	
		(B3) System Integration		
			(B3A) System Platform Integration Activity	
	(C) System Engineering			
		(C1) System Design		
			(C1A) System Design Activity-1	
			(C1B) System Design Activity-1	
	(D) Project Management			
		(D1) Purchases and Acquisitions Management		
			(D1A) Purchase of Raw Materials	
			(D1B) Purchase of Supplies	
			(D1C) Sub-contract Management	
			(D1D) Investment Management	
		(D2) Main Contract Mangement Activities		
		(D3) Production Management Activites		
		(D4) Human Resource Mangement Activites		
	(E) Test and Evaluation			
		(E1) Dry-run Tests		
			(E1A) Subsystem Dry-run Test Activity	
				(E1A1) Subsystem-1 Dry-run Test Activity
				(E1A2) Sub-system-2 Dry-run Test Activity
			(E1B) System Dry-run Test Activity	
		(E2) Acceptance Tests		
			(E2A) Factory Acceptance Test Activity	
			(E2B) Platform Acceptance Test Activity	
	(F) Logistics			
		(F2) Integrated Logistic Support Activities		
			(F2A) Customer Training Activity	
		(F1) Warranty Activities		
	(G) Facilities and Infrastructure			
		(G1) Investment for Facilities		
			(G2) Production Equipment Investment	

Table 3.2 Sample Project WBS with Assigned Functional Units

SAMPLE PROJECT WBS					
LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5	Responsible Functional Unit(s)
Sample System					
	(A) Design				
		(A1) Subsystem-1 Design			
			(A1A) Design Activity-1		Electronics Design
			(A1B) Design Activity-2		Electronics Design
		(A2) Subsystem-2 Design			
			(A2A) Design Activity-1		Electronics Design
			(A2B) Design Activity-2		Electronics Design
	(B) Production				
		(B1) Prototype Production			Production Planning
			(B1A) Prototype Production Subsystem-1		Electronics Production
			(B1B) Prototype Production Subsystem-2		Electronics Production
			(B1C) Prototype Production System		Electronics Production
		(B2) Serial Production			Production Planning
			(B2A) Serial Production Subsystem-1		Electronics Production
			(B2B) Serial Production Subsystem-2		Electronics Production
			(B2C) Serial Production System		Electronics Production
		(B3) System Integration			
			(B3A) System Platform Integration Activity		System Integration and Testing
	(C) System Engineering				
		(C1) System Design			
			(C1A) System Design Activity-1		System Engineering
			(C1B) System Design Activity-1		System Engineering
	(D) Project Management				
		(D1) Purchases and Acquisitions Management			Project Management and Purchases and Acquisitions
			(D1A) Purchase of Raw Materials		Project Management and Purchases and Acquisitions
			(D1B) Purchase of Supplies		Project Management and Purchases and Acquisitions
			(D1C) Sub-contract Management		Project Management and Purchases and Acquisitions
			(D1D) Investment Management		Project Management and Purchases and Acquisitions
		(D2) Main Contract Management Activities			Project Management and Contracts
		(D3) Production Management Activites			Project Management and Production Planning
		(D4) Human Resource Mangement Activites			Project Management
	(E) Test and Evaluation				
		(E1) Dry-run Tests			
			(E1A) Subsystem Dry-run Test Activity		
				(E1A1) Subsystem-1 Dry-run Test Activity	Electronics Testing
				(E1A2) Sub-system-2 Dry-run Test Activity	Electronics Testing
			(E1B) System Dry-run Test Activity		Electronics Testing
		(E2) Acceptance Tests			
			(E2A) Factory Acceptance Test Activity		System Integration and Testing
			(E2B) Platform Acceptance Test Activity		System Integration and Testing
	(F) Logistics				
		(F2) Integrated Logistic Support Activities			
			(F2A) Customer Training Activity		System Engineering and Integrated Logistics Support
		(F1) Warranty Activities			Integrated Logistics Support
	(G) Facilities and Infrastructure				
		(G1) Investment for Facilities			Project Management and Purchases and Acquisitions
			(G2) Production Equipment Investment		Project Management and Production Planning

After creating the WBS, stating the detailed activity definitions, and assigning the relevant functional units, the sub-processes related to the WBS are accomplished. The following main sub-process is the development of the project schedule with the evaluation of the relevant supplementary sub-processes.

3.2.2.3 Schedule Development

A major sub-process for the planning process is the development of the schedule of the project. The schedule is directly related to the time constraints of the project requirements. Since the performance and scope constraints are defined in the WBS, the WBS given in Table 3.1 lays the ground for the development of the schedule. In the WBS, all of the project works to be executed are defined and in the schedule, the time constraints of these works are determined. Before the construction of the project schedule, five supplementary sub-processes must be carried out. These supplementary sub-processes are activity sequencing, activity resource estimating, activity duration estimating, human resources planning, and production planning.

In the *activity sequencing* sub-process, the works defined in the WBS are put in a logical order in order to successfully accomplish the objectives of the project. The sequencing of the project activities is visualized by the Gantt Chart of the Microsoft Project output of the project schedule as given in Figure 3.2.

After the sequence of the activities is determined, the resources (man and machine) to be used in the project management phase of the project are estimated. This estimation is also an input for the cost estimating spreadsheet of the project. However, before using this data in the cost estimation, the time consideration of these estimated resources must be put forward. In that respect, each functional unit determines the resources needed in the project management phase.

After the resources needed for the project are determined, the man and machine hours that will be spent must be estimated. The man-hours to be spent in the project management phase are determined by the managers of the functional units and approved by the project manager. The machine hours are determined by the relevant production and testing departments and approved by the project manager. The total amount of resources needed is obtained at the end of this activity duration estimating sub-process. The outputs of the *activity duration estimating* sub-process are input to the cost estimating spreadsheet and the hours determined for the project are shown in Figure 3.3, the cost estimating spreadsheet for the sample project.

Estimating the duration of the activities and the resources needed to accomplish these activities are not sufficient for the determination of the schedule of the project. Since there may be overlaps and resource sharing among other projects of the firm, the use of human and machine resources must be planned in order to construct a more realistic schedule. The human resources planning and production planning sub-processes determine the time and duration of the resource usage in the sample project. The effects of these planning sub-processes cause a differentiation between the schedule and the duration of the activities. After these sub-processes are carried out, the prototype production activities for subsystem-1 and subsystem-2 are found to be the activities, where the durations and their scheduled times are different. For the prototype production of subsystem-1 the total working hour that will be spent is 40 hours for production engineers and production technicians that correspond to 5 working days as given in Figure 3.3, in the cost estimating spreadsheet. However, due to the resource sharing with other projects, the total duration of the activity is 7 days as given in Figure 3.2, the project schedule. For the prototype production of subsystem-2, the total duration and estimated working hours are also different. The total working hours is 56 hours that correspond to 7 working days, however, the total duration of the activity is planned as 10 days as given in the schedule.

After the evaluation of above-mentioned supplementary sub-processes, the data obtained is put together by the aid of Microsoft Project software. The project schedule constructed for the sample project is given in Figure 3.2 below.

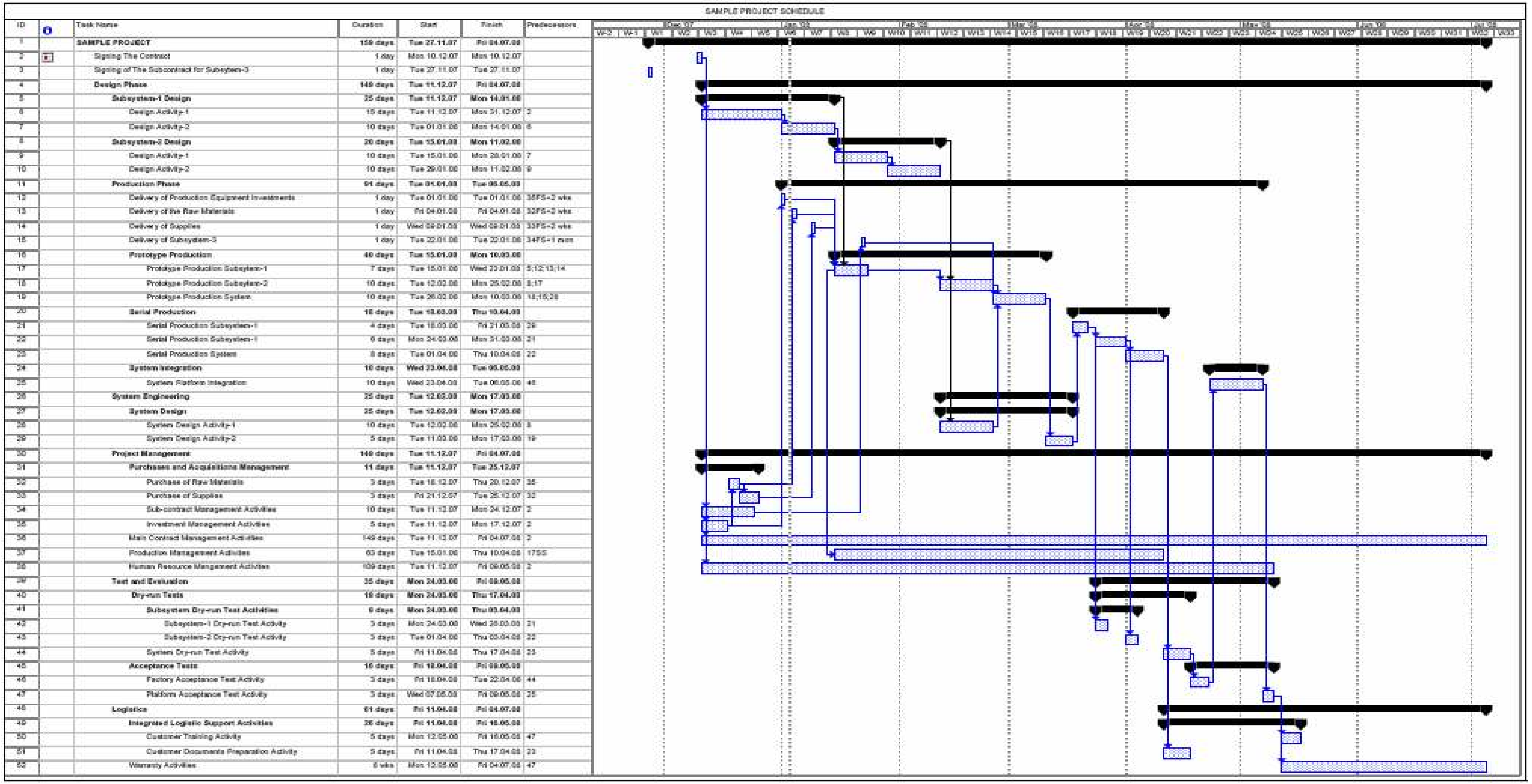


Figure 3.2 Sample Project Schedule

3.2.2.4 Cost Estimating and Cost Budgeting

After the construction of the project schedule that reflects the time constraints of the project, the cost constraints are evaluated through the cost estimating and cost budgeting sub-processes with the aid of the outputs of the activity duration estimating sub-process, and two more sub-processes; purchases and acquisitions planning, and contracting planning.

At this stage, the project team determines the needs for raw materials, supplies to be procured and the subsystem(s) to be sub-contracted. For the execution of the project, the raw materials needed for the production of subsystem-1 and subsystem-2, the supplies needed for the production of sub-system-2 and the whole system, and another subsystem needed for the production of the whole system are put forward by the project team. In the purchases and acquisitions planning sub-process of the sample project, the project team determines the possible suppliers and sub-contractors for the project. The project team under the leadership of the project manager prepares RFP documents for the procurement of raw materials, supplies to be procured, and the subsystem(s) to be sub-contracted. These RFP documents include draft sub-contracts and terms and conditions documents that are prepared in line with the RFP documents published by the authorization body. The contracting planning sub-process is carried out as a step of the cost estimating and cost budgeting sub-process. The prepared RFP documents are published to the possible suppliers and sub-contractors in order to collect the proposals of these firms. For the sample project, three suppliers and two possible sub-contractors are determined. After the submission of the proposals by these supplier and sub-contractor candidates to the firm, the project team decides the most appropriate ones for the execution of the project. The proposed amounts within these proposals are input to the cost estimating spreadsheet into the relevant cells as given in Figure 3.3.

After the prices regarding the raw materials, supplies and sub-contract are input, the remaining fields of the cost estimating spreadsheet are filled out. In this step, the machine and man-hours are input, along with the respective labor and machine usage rates. Additionally, the expected exchange rates, expected inflation rates, general management overhead rates and value added tax rate are input to the spreadsheet by the finance department and the project manager. These rates are given in Figure 3.3, the cost estimating spreadsheet for the sample project.

For the contracting planning sub-process, the contracts department and the project manager work together to determine the effects of the contract that is to be signed between the firm and the authorization body. The most important aspect of these studies is the determination of the risk mark-up shown as unexpected expenditures as given in the spreadsheet. The rate determined for the unexpected expenditures of the sample project is 5% (five percent). That means the total costs of the project is multiplied by 1.05 in order to find the risk mark-up of the project, This markup is purely determined by the intuitive judgments of the project team.

After the spreadsheet is filled with the relevant data, an excel macro is run in order to find out the respective costs of the activities and the overall cost figure of the sample project. The final output of the cost spreadsheet for the project is given in Figure 3.3 below.

With the construction of the cost estimating spreadsheet, all inputs for the evaluation of risk related sub-processes are ready. The risks can be handled in terms of scope and performance by the aid of the WBS, in terms of time by the aid of the project schedule and in terms of cost by the aid of the cost estimating spreadsheet.

Sample Project Cost Spreadsheet	Raw Material (€)	Supplies (TRY)	Sub-contract ($)	Total Material Cost ($)	Design Engineer 2007 (Hours)	Design Engineer 2008 (Hours)	Production Engineer (Hours)	Production Technician (Hours)	System Engineer (Hours)	Project Management Engineer-2007 (Hours)	Project Management Engineer-2008 (Hours)	Test Engineer (Hours)	Test Technician (Hours)	Logistic Support Engineer (Hours)	Logistic Support Technician (Hours)	Total Labor Cost ($)	Travelling Costs ($)	Other Costs ($)	Total Cost ($)
Design																7680			7680
Subsystem-1 Design																			
Design Activity-1					120,00											2400,00			2400,00
Design Activity-2						80,00										1760,00			1760,00
Subsystem-2 Design																			
Design Activity-1						80,00										1760,00			1760,00
Design Activity-2						80,00										1760,00			1760,00
Production				4448,63												12707,20			18655,83
Prototype Production																			
Prototype Production Subsystem-1	100,00			142,73			40,00	40,00								1452,00			1594,73
Prototype Production Subsystem-2	150,00	50,00		256,11			40,00	56,00								1680,80			1936,91
Prototype Production System		100,00	1000,00	1084,03			80,00	80,00								2904,00			3988,03
Serial Production																			
Serial Production Subsystem-1	200,00			285,46			24,00	32,00								985,60			1271,06
Serial Production Subsystem-2	300,00	100,00		512,23			40,00	48,00								1566,40			2078,63
Serial Production System		200,00	2000,00	2168,07			32,00	64,00								1619,20			3787,27
System Integration																			
System Platform Integration Activity							80,00	160,00	40,00							2499,20	1500,00		3999,20
System Engineering																2640,00			2640,00
System Design																			
System Design Activity-1									80,00							1760,00			1760,00
System Design Activity-2									40,00							880,00			880,00
Project Management																21632,96			21632,96
Purchases and Acquisitions Management																			
Purchase of Raw Materials										24,00						480,00			480,00
Purchase of Supplies										24,00						480,00			480,00
Sub-contract Management - Subsystem-3										80,00						1600,00			1600,00
Investment Management										40,00						800,00			800,00
Main Contract Mangement Activities										22,92	252,15					6005,85			6005,85
Production Management Activites											126,00					2772,00			2772,00
Human Resource Mangement Activites										48,44	387,56					9495,11			9495,11
Test and Evaluation																4936,80			4936,80
Dry-run Tests																			
Subsystem Dry-run Test Activity																			
Subsystem-1 Dry-run Test Activity												24,00	24,00			871,20			871,20
Subsystem-2 Dry-run Test Activity												24,00	24,00			871,20			871,20
System Dry-run Test Activity												40,00	40,00			1452,00			1452,00
Acceptance Tests																			
Factory Acceptance Test Activity												24,00	24,00			871,20			871,20
Platform Acceptance Test Activity												24,00	24,00			871,20			871,20
Logistics																8826,40			11376,40
Integrated Logistic Support Activities																			
Customer Training Activity									40,00							880,00	1000,00		1880,00
Customer Documents Preperation									40,00						8,00	994,40		50,00	1044,40
Warranty Activities														160,00	240,00	6952,00	1000,00	500,00	8452,00
Facilities and Infrastructure				4201,68															4201,68
Investment for Facilities																			
Production Equipment Investment		5000,00		4201,68															4201,68
																TOTAL COST			88122,28
														TOTAL COST WITH UNEXPECTED EXPENDITURES					92528,34

Cost Determinant Parameters	Engineer Labor Rate 2007 ($/h)	Engineer Labor Rate 2008 ($/h)	Technician Labor Rate 2007 ($/h)	Technician Labor Rate 2008 ($/h)	Exchange Rate (€/$)	Exchange Rate (TRY/$)	Inflation Rate (2008)	General Management Overhead Rate	Unexpected Expenditures Rate	Value Added Tax Rate (VAT)
	20	22	13	14,3	1,43	0,84	1,1	1,05	1,05	1,18

Figure 3.3 Cost Estimating Spreadsheet for the Sample Project

3.2.2.5 Risk Related Sub-processes

All inputs for the evaluation of the risk issues are in the hands of the project team through the evaluation of the prior sub-processes. However, as defined in Chapter 2 of the study, the project team does not pay the necessary attention to the risk issues in the current procedures of the firm. The applications currently carried out for the sample project in terms of risk management are detailed in the following part of the study.

Risk management practices start with risk management planning based on the procedures of the firm. However, a formal risk management plan is not developed for the sample project, as it is not a mandatory requirement of the RFP published by the authorization body. The only risk related application practiced by the project team is the development of the risk table the format of which is given in Table 2.3. In order to fill out the risk table, the project team carries out simple and intuitive risk identification, qualitative risk analysis, and quantitative risk analysis sub-processes.

In terms of risk identification, the project team determines the following issues risky for the execution of the project.

- Design of subsystem-1,
- Design of subsystem-2,
- System design,
- Purchases and acquisitions management,
- Prototype production, and
- Main contract management

After the identification of the risks with an intuitive judgment, the project team qualifies these risk issues as low, moderate and high with the following measures for each risk identified.

- Design of sub-system-1 → Moderate,
- Design of subsystem-2 → Moderate,
- System design → Moderate,
- Purchases and acquisitions management → High,
- Prototype production → Moderate
- Main contract management → Low

After the qualification of the risks, the quantification, and risk response planning sub-processes are carried out for the risks that are identified and qualitatively analyzed by the project team. The outputs of these sub-processes are then input to the risk table of the firm. The risk table for the sample project is given in Table 3.3 below.

3.3 Results and Conclusion

This chapter has described the current practices in terms of risk management in Company X, illustrated through a sample project.

The results are significant in that they set the basis for the proposal to be submitted by the firm to the authorization body. The cost estimating spreadsheet is extremely important as it sets the limits of the proposal of the Company X that in turn determines its competitiveness and likelihood of winning the contract. Furthermore, the cost estimating spreadsheet is directly related to the profitability of the project via the submitted proposal.

The results of the current practices illustrated in this chapter show a total cost of 92528 $. The next chapter introduces the new risk management methodology developed in this thesis and illustrates its results for the same sample project described in this chapter.

Table 3.3 Risk Table of the Sample Project

No	WBS Ref. No	Risk Definition	Risk Level	Risk Response Approach	Preventive Action in Labor Hours	Corrective Action in Labor Hours	Total Labor Hours (Preventive+ Corrective)
1	A1	Design of subsystem-1	Moderate	Benchmarking from similar previous projects	20	40	60
2	A2	Design of subsystem-2	Moderate	Benchmarking from similar previous projects	20	40	60
3	C1	System design	Moderate	Benchmarking from similar previous projects	20	40	60
4	D1	Purchases and acquisitions management	High	Choosing known and reliable sub-contractors and suppliers. Signing beneficial contracts	30	20	50
5	B1	Prototype production	Moderate	Use of adequate production tools and techniques	20	20	40
6	D2	Main contract management	Low	Keep in touch with the authorization body in every phase of the project and handle beneficial negotiations	40	20	60
TOTAL					**150**	**180**	**330**

CHAPTER IV

A RISK MANAGEMENT METHOD FOR COMPANY X

4.1 Introduction

In Chapter 2, the current project and risk management practices in a Turkish defense industry firm, Company X, have been described and these practices are illustrated through a sample project in Chapter 3. The analyses in the previous chapter reveal several shortcomings. Even simple risk management practices in the business development phase are lacking. Therefore, the risks related to the scope and the performance of projects, which often contribute to cost and schedule deviations are not taken into account. Proper risk management can produce better performance, cost, and schedule estimates during the business development phase, which would lead to the achievement of project objectives without considerable deviations and undesirable results.

Risk management practices are not straightforward applications of the same processes for all types of projects and industries. The varying features of projects require the application of different approaches against risk, even in projects belonging to the same firm. This chapter proposes and describes a risk management method suitable for the conditions of the defense industry projects of Company X. The method concentrates on the shortfalls of project management in the firm in terms of risk management. The method is a comprehensive framework that leads to the derivation of the risk management plan. The sample project that is presented in Chapter 3 is reevaluated within the framework of the proposed method, and the outcomes of the proposed method are compared with those obtained in Chapter 3. The sub-processes that constitute the framework to derive the risk management plan are the following:

- Risk Identification
- Qualitative Risk Analysis

- Risk Response Planning
- Quantitative Risk Analysis
    - Schedule Risk Analysis
    - Cost Risk Analysis

The flow of the sub-processes proposed in this method is different from that described in Chapter 2 (Table 2.1). The risk response planning sub-process has been moved to precede quantitative risk analysis for reasons that will be clarified in section 4.5.

The method also incorporates the use of appropriate risk management tools and techniques for the defense industry projects of Company X. These tools and techniques are derived from those suggested in PMBOK. Furthermore, the method proposes specific software tools to be used in the analysis phases.

The risk management plan is the umbrella document that covers the results and outputs of the risk management sub-processes. The method also develops a document format for this plan incorporating the results of risk management sub-processes.

As described in Chapter 2, risk management requires the prior implementation of fifteen sub-processes in the planning process of the business development phase. The sub-processes regarding risk management get their inputs from these sub-processes, and the outputs of the risk management sub-processes must be used for updating the outputs of these sub-processes under the scope of risk issues. The work breakdown structure, the schedule, the cost estimating spreadsheet, the main contract, and the sub-contracts derived from these previous sub-processes are the main inputs for risk management. On the other hand, these prior sub-processes must be revized in the light of the results of the risk management sub-processes. This iteration will lead to a proposal or a feasibility report that will reflect a better picture of the performance, cost, and schedule estimates for the project management phase.

4.2 A Risk Management Method for the Business Development Phase

The need for adequate risk management application in Company X's projects, the current situation in terms of project and risk management practices, the contemporary and traditional applications in the risk management literature have been identified through the previous chapters. Under the light of these, a method for managing risk through the business development phase of Company X's defense projects is suggested in the following section of the study. The first process of the risk management method is risk management planning.

4.2.1 Risk Management Planning

The planning sub-process of risk management is a critical issue for the firm's projects. Since lack of proper documentation is a major drawback of project management in the firm, the plans developed through the risk management method play an important role in order to achieve better risk monitoring and control during the project management phase. Furthermore, the formation of well-documented risk management plans will be valuable for future projects and constitute an input for the creation of risk databases for Company X.

The key inputs for the risk management plan are the work breakdown structure (WBS), the project schedule, the cost estimating spreadsheet, the main contract between the firm and the authorization body, and the sub-contracts between the firm and its possible sub-contractors.

The risk management plan is organized as a guidebook to be used for evaluation during the project management phase. The risk management plan is a live document to which project managers refer to identify possible risks, to check if the identified risks are threatening the project, and whether the risk analyses are reflecting actual parameters, and to assess the handling techniques suggested in the plan. Therefore, the risk management plan guides the project manager and the project team through the project management phase. Most of the content of the sections of the risk management plan are the outputs of the other risk management sub-processes; risk identification, risk analysis and risk handling. A risk management plan format for Company X is proposed and is composed of the following parts (Figure 4.1).

4.2.1.1 Introduction

The introductory part of the risk management plan includes the purpose of the document, the summary of the project and the tasks that will be performed during the project management phase. Then, the tools, techniques, and approaches to be applied for risk management are identified. Finally, the reference documents to be used during risk management are identified. These documents are the WBS, project schedule, the contracts, and the cost estimating spreadsheet.

4.2.1.2 Risk Management Process and Implementation Steps

After the introduction, the plan specifies the implementation steps of the risk management method. For each risk management sub-process of the method, the inputs, assumptions, the tools that are used, and how these tools are used are identified. The outputs of these sub-processes are included in this part of the risk management plan.

The first step in implementation is the identification of risks. As it will be detailed in the following sub-section, the output of the risk identification sub-process is the risk register. The risk register is included in the risk management plan as a guide for the other sub-processes following the risk identification sub-process.

The second step, the qualitative risk analysis is explicitly defined in the risk management plan. The output of the qualitative risk analysis that is built on the risk register is also included in the plan. In the third step, before going into the quantitative risk analysis, the risk handling methods against risks are determined and documented regarding each identified risk. Evaluating the risk handling alternatives prior to quantitative risk analysis carries certain advantages as will be discussed in risk response planning sub-process of the method.

The fourth step is the quantitative risk analysis. The quantitative risk analysis is handled in two parts. The first part of the analysis is concerned with the risks over the schedule and called schedule risk analysis. The second part of quantitative analysis is concerned with the risks over the cost and the budget of the project and called cost risk analysis. The output of schedule risk analysis affects the project schedule and the output of the cost risk analysis affects the cost estimating spreadsheet. These outputs of the quantitative analysis are put forward in this part of the plan.

Schedule risk analysis is also directly related to the costs and the scope of the project and therefore, this analysis is carried out before the cost risk analysis. The schedule that reflects the risky points and the worst and best case scenarios are a part of the risk management plan.

The cost budgets regarding the overall costs and each individual WBS element costs are included in the risk management plan following cost risk analysis, in order to show the effects of the identified risks on the costs of the project.

4.2.1.3 Results

In this part of the plan, the results of the risk identification, qualitative and quantitative risk analysis, and the risk response plans are stated clearly, in order to construct a base for controlling and monitoring during the project management phase. The effect of the results on the proposal and/or the feasibility report and the performance of the project during the project management phase are stated in this section. This section is dedicated to the lessons learned from the evaluation of the sub-processes and the risk response plans suggested for handling the identified and analyzed risks.

4.2.1.4 Compliancy

The last part of the project management plan is the compliancy part that is left open at the end of the business development phase, to be filled during the implementation of the project management phase. This part is included in the risk management plan, in order to construct the necessary risk database for the industry, and to leave relevant experience for future projects. In this part of the plan, the project team, especially the project manager, compares the outcomes in the results section of the risk management plan with the actual risks that are encountered during the project management phase. This compliancy part indicates the compliancy of the actual risks in the project with the identified risks in the business development phase. Furthermore, the qualitative and quantitative risk analysis outputs are compared with the actual effects of the risks in the project management phase. The consequences of the compliancy part are also added to the end of the risk register.

This section has presented the format as given in Figure 4.1 and the content of the risk management plan. The next section describes the risk management sub-processes that need to be carried out in order to fill the risk management plan. The first sub-process regarding risk in the business development phase is the risk identification sub-process.

RISK MANGEMENT PLAN

1. INTRODUCTION

1.1. Purpose

1.2. Project Summary

1.3. Risk Management Methodology

1.4. Reference Documents

2. PROCESS AND IMPLEMENTATION

2.1. Risk Identification

2.1.1 Risk Register

2.2. Qualitative Risk Analysis

2.2.1 TRIMS Output Reports

2.3. Risk Handling – Risk Response Planning

2.3.1 Avoidance Plans

2.3.2 Transferring Plans

2.3.3 Mitigation Plans

2.4. Quantitative Risk Analysis

2.4.1 Cost Risk Analysis Results

2.4.1.1 Default Cost Estimates

2.4.1.2 Cost Estimates with Risk

2.4.2 Schedule Risk Analysis Results

2.4.2.1 Default Schedule

2.4.2.2 Schedule with Risk

3. RESULTS

4. COMPLIANCY

Figure 4.1 Risk Management Plan Template

4.2.2 Risk Identification

In the risk identification sub-process the sources of risk, in other words “what can go wrong” during the project management phase are identified. Risk identification is a critical milestone of risk management, so it must incorporate a well-defined flow of activities. In this section of the study, a specific flow of activities is proposed in order to achieve risk identification in the defense projects of Company X.

Risk can be associated with all aspects of a project; operational needs, constraints, performance parameters, threats, technology or design processes (Department of Defense, 2006). In order to identify the risks, the decomposition of the project into several minor parts is important. This decomposition may be done in terms of requirements, processes, functional areas, technical baselines, or acquisition phases. However, as defined in the previous chapters, there is a work breakdown structure in the hands of the project team. This work breakdown, decompositions the project tasks according to the activities to be carried out during the project management phase. Thus, the WBS is the starting point for risk identification.

However, before identifying risks based on the work breakdown structure, two points must be evaluated. The first one is the identification of the stakeholders of the project. The roots of the risks may only come from the stakeholders of the project. Therefore, the stakeholders for each element of the work breakdown structure must be determined in order to identify the risks that can emanate from them. The main stakeholders in the defense projects of Company X are the authorization body, the firm itself, the sub-contractors, or the suppliers.

- **The authorization body:** In the Turkish defense industry, the authorization bodies are UDI or MoD in most of the cases for externally authorized projects. However, in recent years, the technological advancements experienced in the industry led to the interest of foreign authorization bodies such as defense ministries of foreign countries and international organizations like NATO, or foreign contractors that would like to do business with Company X as a sub-contractor, like BOEING, the European Aeronautic Defense and Space Company (EADS) and BAE Systems Inc. For internal development projects, the authorization body is the senior management of the firm itself. The contracts for externally authorized projects and the feasibility reports for internal development projects are the means that regulate the relationship between the project management team and the authorization body. Therefore, in order to identify the risks regarding the authorization bodies, the project team must investigate the contracts and its annexed documents.

- **<u>The firm itself:</u>** The risks regarding the performance of the project are directly related to the firm itself. In Company X, the sources of risks are the functional units involved in the project management phase. Therefore, each WBS element must be matched with the functional unit responsible for the performance of the work. The statement of work documents annexed to the proposal and prepared by the authorization bodies are useful means in order to make that association.

- **<u>The sub-contractors or the suppliers:</u>** Two critical players in projects are the sub-contractors and the suppliers. The performance of projects heavily depends on the performances of the sub-contractors and the suppliers. Their roles must be clearly defined and managed, since they are potential sources of risk.

The determination of the stakeholders regarding each element of the WBS is crucial in order to identify the risks emanating from them. The information derived from this process is an input to the risk response planning sub-process.

The second important point that must be clarified regarding the WBS elements is determining the success criteria that each WBS element is related to. Performance, cost and schedule are the three main success criteria for projects, and matching these criteria with the WBS elements is fundamental in order to know which objective will be affected by probable risks. These two points namely the determination of the stakeholders and the success criteria for each WBS element, are important for the identification of risks and therefore, the proposed method includes these as two determinant columns in the risk register.

After the determination of the stakeholders and the related objectives for each WBS element, possible risks regarding each WBS activity must be identified. At this point, tools and techniques in the risk management literature for risk identification must be used.

Among these techniques, brainstorming during project team meetings dedicated to risk identification is an integral part of the method proposed in this thesis. In addition, interviews with functional units must be carried out to identify the risks regarding each WBS element. Along with that, the use of software to evaluate these findings must be established. In this thesis, the Technical Risk Identification and Mitigation System (TRIMS) software is proposed as an appropriate tool to be used in risk management sub-process of defense projects of Company X. It is easy to use, configurable and specifically developed for US government defense (DOD) projects, which highly resemble the defense projects of Company X. Moreover, TRIMS is a freeware program, downloadable with full configuration and options.

- **TRIMS (Technical Risk Identification and Mitigation System)**: TRIMS has been developed by the Best Manufacturing Practices (BMP) Community of the US government. This software is a part of the Program Manager's WorkStation (PMWS) package, which is developed for managing US government acquisition projects. The package is composed of three main parts. The first part includes all the documents needed for a project to be evaluated (technical and managerial documents, standards, procedures and rule books), which have also been developed by US government authorities. The second part of the package is the TRIMS software, where the risks regarding the projects are identified, qualified and handling issues are recorded. The last part of the package is the BMP database, where more than 2,500 successful practices that have been documented. This database constitutes the experiences and lessons learned from the projects, which is an extremely important tool to be used in future projects.

  The TRIMS software has several advantages. The software includes inherent elements, which refer to WBS elements typical to defense industry project WBSs. There are four default templates that correspond to four different types of projects. These templates have been developed for system engineering, software design, testability, and integration projects. The most relevant template to the projects of Company X is the system engineering project template, because its predefined WBS elements fit the general WBS structure of the firm. The WBS elements in the system engineering template are funding, design, test, production, transition plan, facilities, logistics and management. Each of these elements are also sub-divided into relevant WBS activities. Furthermore, each activity has several inherent questions that aim to identify the risk level of each activity. The most important feature of the software is the questions that are grounded on experience gained during projects that highly resemble projects of Company X. Besides, its configurable structure makes it practical and applicable for the firm. The WBS elements, the activities, and related questions can be configured according to the needs and the features of each project. In fact, even with its default configuration this software is applicable to Company X's projects. The only thing to do for the project team in order to identify the risks of the project is answering the questions, qualifying each risk regarding the WBS activities, assigning the responsible people or bodies regarding each activity, and defining the action list to handle the risks incorporated within each WBS element. Qualifying the risks and determining risk handling actions are not within the scope of risk identification, but in the scope of subsequent risk management sub-processes that will be detailed further in the study.

The flexibility of the software allows project managers and the project team members to define questions applicable to specific projects and define new WBS elements over the default ones. The default form of the software is silent on the contracting, and purchasing and acquisitions WBS elements. Nevertheless, these two sources of risk can easily be added for the firm's projects. The questions that lead to the examination of the risk issues regarding these two WBS elements can be added to the risk template of TRIMS in order to identify the risks regarding contracting, and purchases and acquisitions. One other risk aspect of Company X, which is not applicable to US projects, is the exchange rate. Although most transactions would be in Turkish Liras, the sub-contracts or supplier contracts may include foreign currencies (Euros or US Dollars). Moreover, the main contracts between the authorization bodies and the firm are usually in foreign currencies. Therefore, the risks regarding the exchange rates must also be included in the risk identification sub-process and its determinants must be added to TRIMS.

The specifically configured form of the software for the sample project is given in Figure 4.2 below.

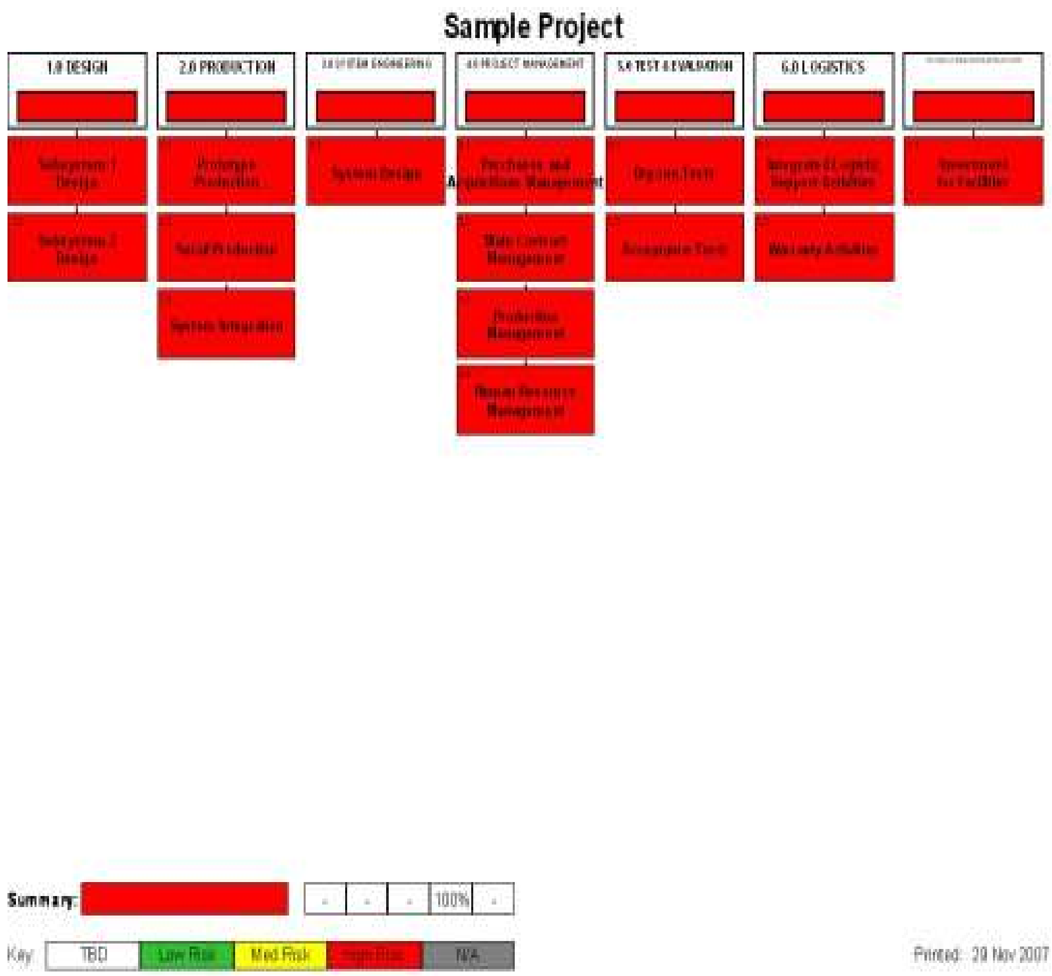


Figure 4.2 TRIMS Configuration for the Sample Project

The configuration of TRIMS for specific projects is achieved through the "baselining" option of the software. By means of the baselining feature; new milestones and their dates are defined, the WBS element properties are adjusted, new weight algorithms are assigned. The personnel who will be in charge for each activity's risk are assigned, the WBS elements may be modified, the definitions of low, medium and high risks may be changed, and finally the impact of risks regarding success criteria may be adjusted. Through these functions, the baseline template can be customized for unique projects. TRIMS also supports various output formats. Graphical maps indicate the risk picture of the whole project within the perspective of WBS elements and activities supporting the visualization of the project risks in one shot. The detailed summary report includes every single WBS element with the risk questions and the answers associated with them, shows responsible personnel for each risk, indicates the milestones and includes a summary table at the end. Another output from TRIMS is a risk matrix that indicates the impacts of identified risk factors on the success criteria (performance, schedule, and cost). With all these features, TRIMS is an integral risk management tool with qualitative risk management and risk response planning opportunities.

The risk identification sub-process is summed up in a risk register. The risk register is a summary table that indicates the outcomes of risk identification. The risk register puts together the outputs of TRIMS, simplifying and integrating the outcomes for the project management phase. The risk register must be supported with additional data obtained from the subsequent sub-processes of risk management, and lessons learned during the project management phase. The risk register proposed in this thesis includes the following data and the tabular form of this risk register is given in Table 4.1 below. The risk register developed for the sample project is given in Table 4.5 that is filled out after the evaluation of all of the sub-processes of the proposed method.

- Definition of the identified risk (TRIMS Output)
- The source of the identified risk (In terms of Stakeholders)
- The affected success criteria with that risk (Performance, Schedule, Cost)
- The WBS element which risk emanates from
- The responsible person
- Recommendations for handling that risk

- Expected occurrence date of the risk within the project management phase
- Qualified risk level (Output of Qualitative Risk Analysis)
- Impact of risk on schedule (Output of Schedule Risk Analysis)
- Impact of risk on cost (Output of Cost Risk Analysis)
- Compliancy in project management phase (Lessons learned in the project management phase)

After the identification of risks, the next step in the method is the qualitative risk analysis.

Table 4.1 Proposed Risk Register Format

Risk No	Related WBS No	Risk Source (Stakeholder)	Related Success Criteria	Risk Definition	Responsible Personnel	Risk Response	Expected date of Occurence	Risk Level	Impact on Schedule	Impact on Cost	Compliancy

4.2.3 Qualitative Risk Analysis

Qualitative risk analysis is used for qualifying the identified risks. Through qualitative risk analysis, each risk element is weighted according to its impacts on the project using three success criteria: performance, cost, and schedule. Qualitative risk analysis lays the foundation for the identification of risk response plans regarding each risk element, and quantitative risk analysis.

Even though there are various tools and techniques to evaluate the qualitative risk of projects, the use of TRIMS is suggested in this study. TRIMS offers the following advantages. The first advantage is the possibility of loading weight files for different projects with different baseline configurations. In that respect, a standard weight file may be created for Company X, and it may be used for all projects of the firm. If the project manager finds it necessary, this weight file may be adjusted for the specific needs of each project. After loading the weight files, each WBS activity risk is weighted in terms of performance, cost, and schedule The weights given to individual risk elements reflect the probability of occurrence of that risk event. Two main types of output reports can be obtained from TRIMS for the qualitative risk analysis. A summary report shows the risk picture of the project where, the risk level of each WBS element is indicated by color codes. After each WBS element is weighted, the program automatically gives color codes in order to identify the risk level, as low, medium or high for each element respectively. The levels of risk are determined according to the answers given to the questions and the weights given for each WBS activity. The impact weights are also important in terms of determining the risk levels. The other type of output obtained from the software is the probability-impact matrices. These matrices are created by the system indicating the probability of risk versus its impact regarding each WBS activity in terms of performance, schedule, and cost separately. Using these matrices, the project team can realize the risk picture of the project in terms of performance, schedule, and cost that correspond to each WBS element. The overall risk picture of the sample project is given in Figure 4.3. Furthermore, the probability output matrices obtained for the sample project for performance, schedule, and cost are given in Figures 4.4, 4.5, and 4.6, respectively.

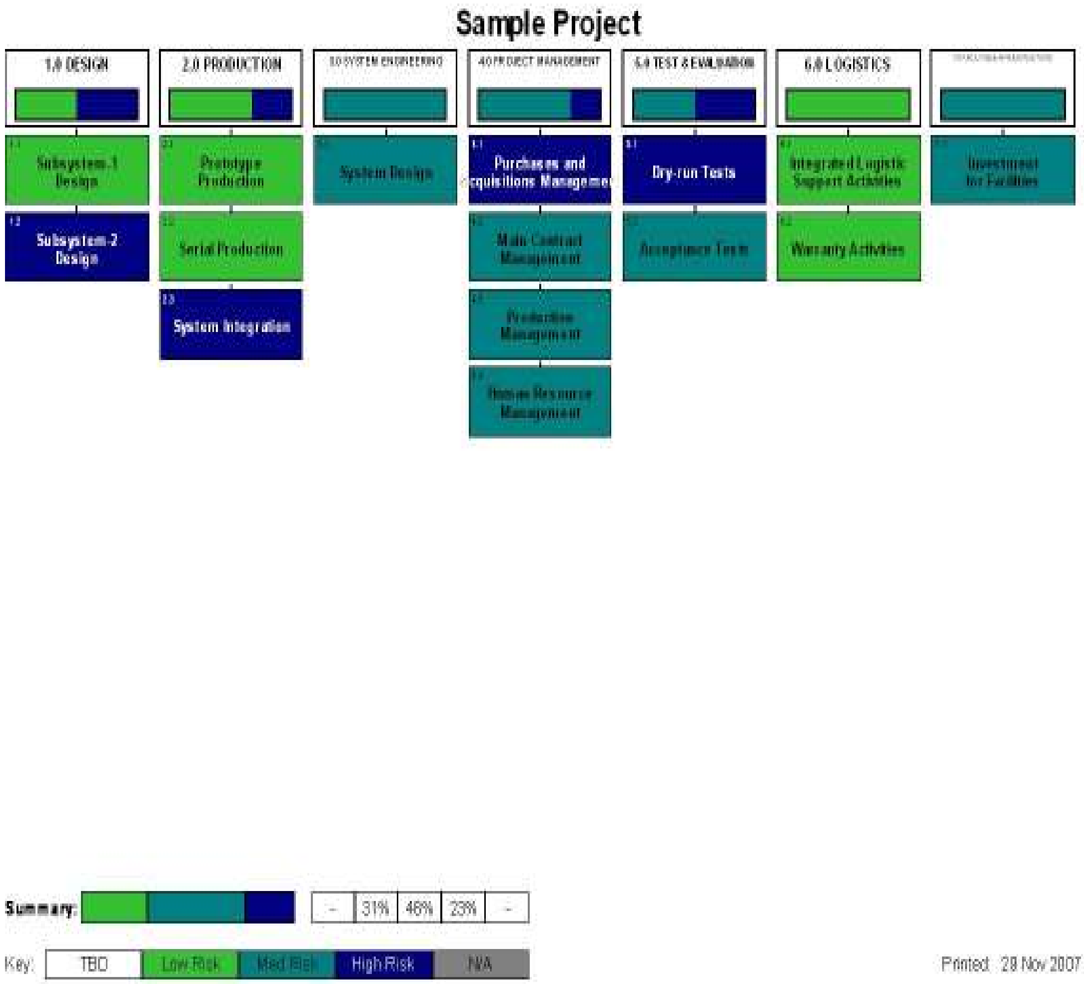


Figure 4.3 TRIMS Output for the Sample Project

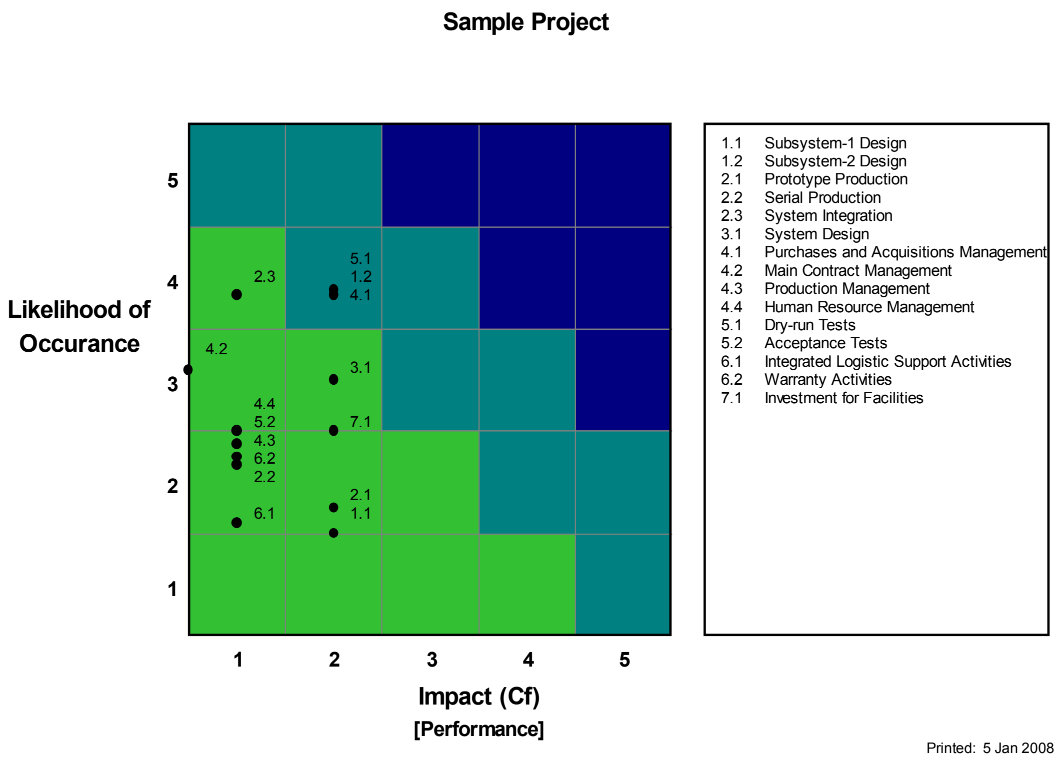


Figure 4.4 Performance Probability-Impact Matrix Output of the Sample Project

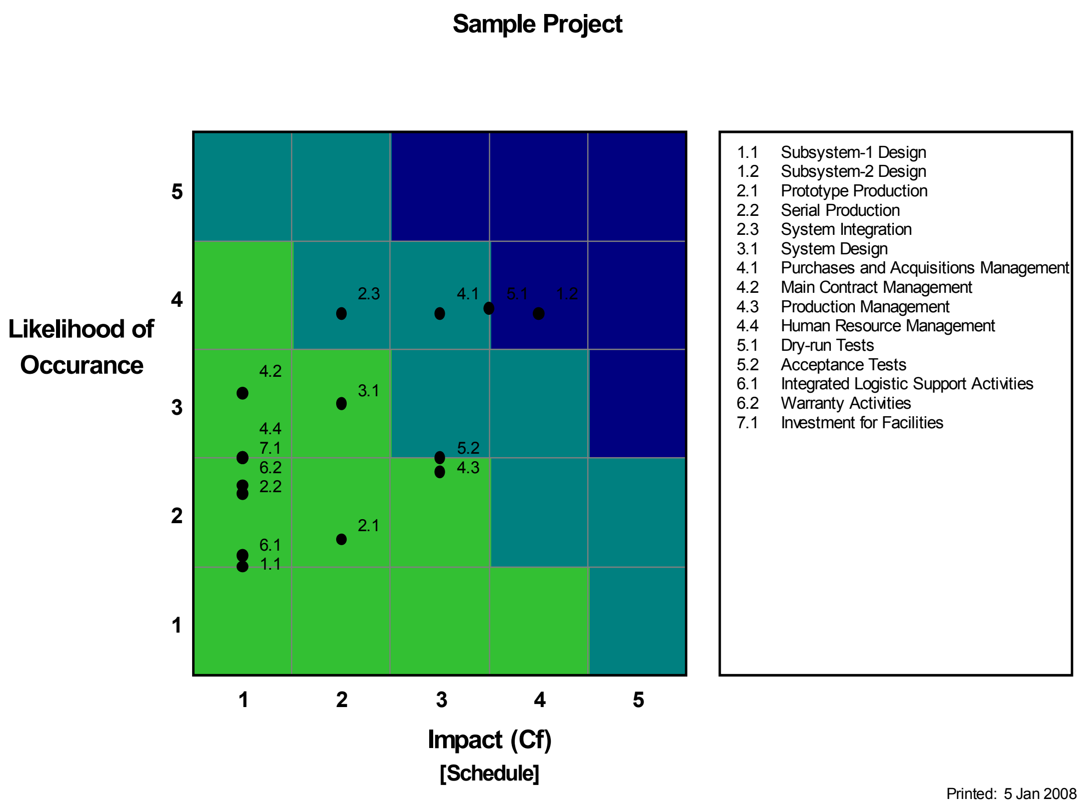


Figure 4.5 Schedule Probability-Impact Matrix Output of the Sample Project

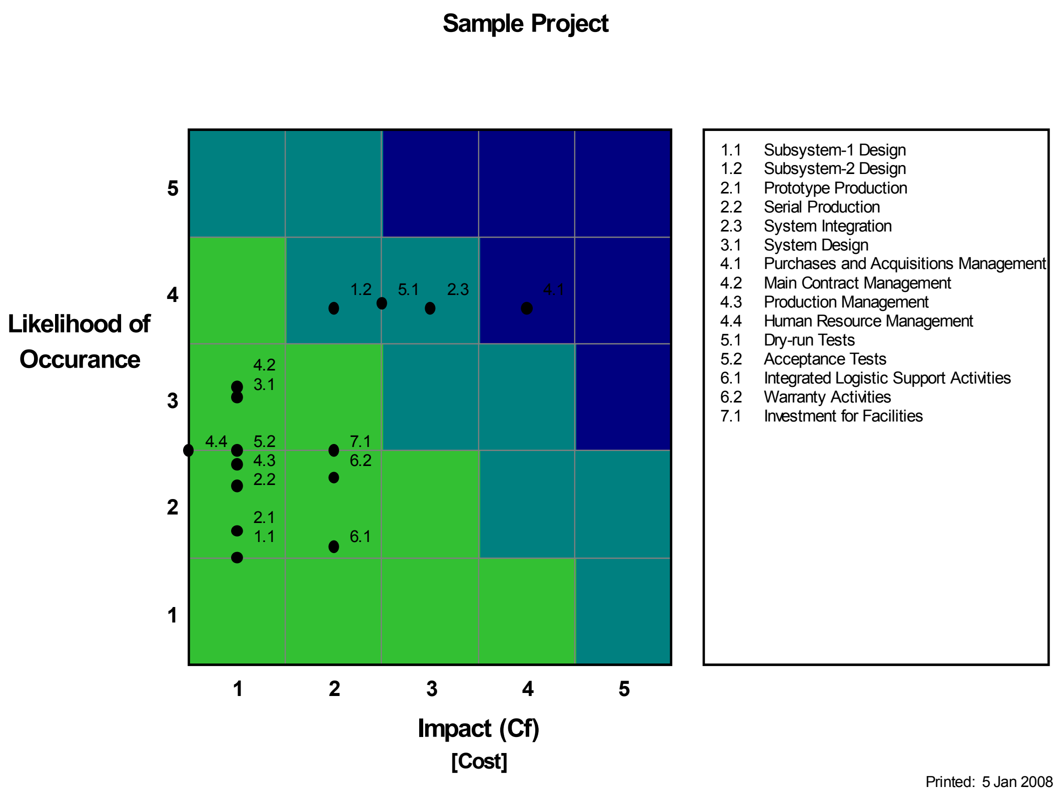


Figure 4.6 Cost Probability-Impact Matrix Output of the Sample Project

The outputs obtained from TRIMS are important determinants for the comparison of the proposed method and the current risk management practices in Company X. When the TRIMS outputs for the sample project given in Figures 4.3, 4.4, 4.5 and 4.6 are compared with the intuitively identified risks of the sample project as it is done currently, the difference in the identified risks and the determined risk levels can be seen. The only WBS element for the sample project that bears a high risk level according to the intuitive judgments of the project team is “purchases and acquisitions management”. However, the TRIMS output betrays that other activities, “design of subsystem-2”, “integration”, and “dry-run tests” bear high levels of risk. TRIMS gives more realistic and useful outputs for the judgment of the project team, as these outputs depend on analytical analysis and experiences hidden under the default question sets of the program.

The outputs of qualitative risk analysis are critical for the subsequent sub-processes of risk management in the business development phase. The results and reports obtained are used in quantitative risk analysis and in determining the responses against each risk. PMBOK 2004 and other sources in the literature suggest the implementation of quantitative risk analysis after qualitative risk analysis. However, in this study, before quantitative risk analysis, the execution of the risk response planning sub-process is suggested due to the reasons defined in Section 4.2.4.

4.2.4 Risk Response Planning

As mentioned above, the general risk management context requires the application of quantitative risk analysis after the qualitative risk analysis, before the determination of the risk response plans. Contrary to that common usage, the method in this study suggests the establishment of the risk responses against risks before the quantitative risk analysis and an iteration of this sub-process again after the quantitative analysis. The main reason for this proposition is to reduce the data that will be run in quantitative risk analysis.

As defined in the second chapter, there are three main ways to plan the responses against identified risks: avoidance, transferring, and mitigation. Since low, medium and high risk elements are assessed by the qualification sub-process, the response plans to handle the identified risks can be put forward.

In that respect, the risks are worked out with an order from low to high. Each risk must be matched with an anticipative response of avoiding, transferring, and mitigating. Each risk must first be examined for avoidance. If the project team decides that, a certain risk can be avoided and would lead to no extra cost or schedule extension for the project, this risk can be discarded for quantitative risk analysis. That is, these risks will not be used as inputs to the quantitative analysis since the effects would be negligible. The avoidance level of risks is heavily dependant on the risk taking characteristics of the firm and the features of the projects. If competition for the award of the project is harsh, project management may decide to avoid some of the risks. Since these risks will not be quantified in the quantitative risk analysis sub-process, the costs regarding them will not be included in the cost risk analysis as detailed in section 4.2.5.2. However, in this case the project team must still include these risk issues in the risk management plan and in the risk register, in order to document them and clearly put forward a plan for handling these risks in the project management phase. The second step consists of examining each risk remaining unrefuted, for the transferring option. This step needs deeper study than the previous one because the level of transfer must be determined correctly. Transferring a risk is a thin line, since while transferring the risk of one WBS element, the risk levels regarding other elements may be increased. The project team must be cautious about transferring the risks in order to hold the level of benefits higher than the losses that come up with the risk transfers. In Company X, the most common way of transferring risks is to transfer them to sub-contractors or to suppliers through contracts. In transferring risks the contracting, purchasing, and acquisitions sub-processes must be taken into consideration. The risks that are to be transferred must be included in the risk management plan as well as the risk register. The most important issue with transferring is the level of reduction in risks. The last step in risk response planning is examining the remaining risks in order to mitigate them. The conditions of mitigation are the same as transferring. The level of mitigation and the ways of mitigation must be determined precisely.

The proposed method suggests the use of the TRIMS probability impact output matrices for choosing the risk response strategies. Since these output matrices indicate the levels of risks according to performance, schedule, and cost constraints, the risk responses can be chosen by investigating the output matrices for each WBS element. These output matrices are investigated for the sample project, and the risk response plans determined for the WBS activities are given in Tables 4.2, 4.3 and 4.4 below for performance, schedule, and cost respectively. These tables include the WBS elements that bear risk, previous level of risk due to TRIMS outputs, the risk response strategy chosen, and the risk response plan descriptions. These risk response plans developed by the project team are important inputs for the application of quantitative risk analysis in the following sections of the study.

The risk levels obtained after the development of risk response plans are main inputs for the quantitative risk analysis. However, since the quantitative risk analysis deals with schedule and cost risks, the risks regarding the performance of the project must be inserted into the project schedule and the cost estimating spreadsheet. The impacts of the performance risk on the schedule and the cost spreadsheet are determined by the project team and input to the project schedule and the cost spreadsheet according to the determined levels of performance risk on the project activities as given in Table 4.2 under the “Final Risk Level” column. The modified versions of the project schedule and the cost estimating spreadsheet for the sample project including the performance risks are inserted are given in Figures 4.7 and 4.8 respectively.

When all risks are examined in terms of risk response planning and the avoidance, transferring and mitigation options are assessed, the process of quantitative risk analysis begins. The risks that are determined to be avoided are not included in the quantitative risk analysis sub-process; the ones that are determined to be transferred and mitigated are used in quantitative analysis with their assessed levels.

Table 4.2 Risk Response Plans of the Sample Project for Performance

WBS No	WBS Element	Previous Risk Level	Risk Response Strategy	Risk Response Plan	Final Risk Level
1.1	(A1) Subsystem-1 Design	Low	Mitigate	Benchmarking from previous projects and contemporary examples	Low
1.2	(A2) Subsystem-2 Design	Moderate	Mitigate	Benchmarking from previous projects and contemporary examples	Low
2.1	(B1) Prototype Production	Low	Avoid	Purchase of new production equipment	---
2.2	(B2) Serial Production	Low	Avoid	Purchase of new production equipment	---
2.3	(B3) System Integration	Low	Avoid	Experience from previous projects	---
3.1	(C1) System Design	Moderate	Mitigate	Benchmarking from previous projects and contemporary examples	
4.1	(D1) Purchases and Acquisitions Management	Moderate	Mitigate	Preparation of beneficial sub-contracts and terms and conditions	Low
4.2	(D2) Main Contract Management Activities	Low	Avoid	Mutual aggreement with the authorization body by negotiations	---
4.3	(D3) Production Management Activites	Low	Avoid	Development of efficient production plans	---
4.4	(D4) Human Resource Mangement Activites	Low	Avoid	Assigning experienced personnel	---
5.1	(E1) Dry-run Tests	Moderate	Mitigate	Experience from previous projects	---
5.2	(E2) Acceptance Tests	Low	Mitigate	Experience from previous projects and mutual aggreement with the authorization body	Low
6.1	(F2) Integrated Logistic Support Activities	Low	Avoid	Experience from previous similar products	---
6.2	(F1) Warranty Activities	Low	Avoid	Experience from previous similar products	---
7.1	(G1) Investment for Facilities	Low	Avoid	Procurement of technologically advanced equipment	---

Table 4.3 Risk Response Plans of the Sample Project for Schedule

WBS No	WBS Element	Previous Risk Level	Risk Response Strategy	Risk Response Plan	Final Risk Level
1.1	(A1) Subsystem-1 Design	Low	Avoid	Benchmarking from previous projects and contemporary examples. Assign new skilled personnel	---
1.2	(A2) Subsystem-2 Design	High	Mitigate	Benchmarking from previous projects and contemporary examples	Moderate
2.1	(B1) Prototype Production	Low	Mitigate	Adequate production planning	Low
2.2	(B2) Serial Production	Low	Mitigate	Adequate production planning	Low
2.3	(B3) System Integration	Moderate	Mitigate	Experience from previous projects, Site surveys, training for the platform	Low
3.1	(C1) System Design	Low	Mitigate	Benchmarking from previous projects and contemporary examples	---
4.1	(D1) Purchases and Acquisitions Management	Moderate	Mitigate	Preparation of beneficial sub-contracts and terms and conditions	Moderate
4.2	(D2) Main Contract Management Activities	Low	Transfer	Mutual aggreement with the authorization body by negotiations, transfer the terms and conditions of the main contract to the sub-contractors and suppliers	---
4.3	(D3) Production Management Activites	Low	Avoid	Development of efficient production plans	---
4.4	(D4) Human Resources Mangement Activites	Low	Avoid	Assigning experienced personnel	---
5.1	(E1) Dry-run Tests	Moderate	Mitigate	Experience from previous projects	---
5.2	(E2) Acceptance Tests	Low	Mitigate	Experience from previous projects and mutual aggreement with the authorization body	Low
6.1	(F2) Integrated Logistic Support Activities	Low	Transfer	Transfer the time constraints of ILS terms and conditions to the sub-contractors and suppliers	---
6.2	(F1) Warranty Activities	Low	Transfer	Transfer the time constraints of warranty terms and conditions to the sub-contractors and suppliers	---
7.1	(G1) Investment for Facilities	Low	Avoid	Procurement of technologically advanced equipment	---

Table 4.4 Risk Response Plans of the Sample Project for Cost

WBS No	WBS Element	Previous Risk Level	Risk Response Strategy	Risk Response Plan	Final Risk Level
1.1	(A1) Subsystem-1 Design	Low	Transfer	Investigate alternative source for procurement of Subsystem-1	Low
1.2	(A2) Subsystem-2 Design	Moderate	Mitigate	Benchmarking from previous projects and contemporary examples	Moderate
2.1	(B1) Prototype Production	Low	Avoid	Adequate production planning	---
2.2	(B2) Serial Production	Low	Avoid	Adequate production planning	---
2.3	(B3) System Integration	Moderate	Mitigate	Experience from previous projects, Site surveys, training for the platform, reduction in possible penalties, new personnel	Low
3.1	(C1) System Design	Low	Mitigate	Benchmarking from previous projects and contemporary examples, skilled personnel assignment	---
4.1	(D1) Purchases and Acquisitions Management	High	Mitigate	Preparation of beneficial sub-contracts and terms and conditions, scheduled control mechanisms of the sub-contractors and the suppliers	High
4.2	(D2) Main Contract Management Activities	Low	Transfer	Mutual aggreement with the authorization body by negotiations, transfer the terms and conditions of the main contract to the sub-contractors and suppliers	---
4.3	(D3) Production Management Activites	Low	Avoid	Development of efficient production plans	---
4.4	(D4) Human Resources Management Activites	Low	Mitigate	Hiring new skilled personnel	Low
5.1	(E1) Dry-run Tests	Moderate	Mitigate	Experience from previous projects, development of well established test plans	Low
5.2	(E2) Acceptance Tests	Low	Mitigate	Experience from previous projects and mutual aggreement with the authorization body	Low
6.1	(F2) Integrated Logistic Support Activities	Low	Transfer	Transfer the time constraints of ILS terms and conditions to the sub-contractors and suppliers	---
6.2	(F1) Warranty Activities	Low	Transfer	Transfer the time constraints of warranty terms and conditions to the sub-contractors and suppliers	---
7.1	(G1) Investment for Facilities	Low	Mitigate	Detailed market researches	Low

SAMPLE PROJECT SCHEDULE

ID		Task Name	Duration	Start	Finish
1		**SAMPLE PROJECT**	**165 days**	**Tue 27.11.07**	**Mon 14.07.08**
2		Signing The Contract	1 day	Mon 10.12.07	Mon 10.12.07
3		Signing of The Subcontract for Subsytem-3	1 day	Tue 27.11.07	Tue 27.11.07
4		**Design Phase**	**155 days**	**Tue 11.12.07**	**Mon 14.07.08**
5		**Subsystem-1 Design**	**25 days**	**Tue 11.12.07**	**Mon 14.01.08**
6		Design Activity-1	15 days	Tue 11.12.07	Mon 31.12.07
7		Design Activity-2	10 days	Tue 01.01.08	Mon 14.01.08
8		**Subsystem-2 Design**	**26 days**	**Tue 15.01.08**	**Tue 19.02.08**
9		Design Activity-1	13 days	Tue 15.01.08	Thu 31.01.08
10		Design Activity-2	13 days	Fri 01.02.08	Tue 19.02.08
11		**Production Phase**	**95 days**	**Thu 03.01.08**	**Wed 14.05.08**
12		Delivery of Production Equipment Investments	1 day	Thu 03.01.08	Thu 03.01.08
13		Delivery of the Raw Materials	1 day	Thu 10.01.08	Thu 10.01.08
14		Delivery of Supplies	1 day	Thu 17.01.08	Thu 17.01.08
15		Delivery of Subsystem-3	1 day	Thu 24.01.08	Thu 24.01.08
16		**Prototype Production**	**43 days**	**Fri 18.01.08**	**Tue 18.03.08**
17		Prototype Production Subsytem-1	5 days	Fri 18.01.08	Thu 24.01.08
18		Prototype Production Subsytem-2	7 days	Wed 20.02.08	Thu 28.02.08
19		Prototype Production System	10 days	Wed 05.03.08	Tue 18.03.08
20		**Serial Production**	**18 days**	**Wed 26.03.08**	**Fri 18.04.08**
21		Serial Production Subsystem-1	4 days	Wed 26.03.08	Mon 31.03.08
22		Serial Production Subsystem-1	6 days	Tue 01.04.08	Tue 08.04.08
23		Serial Production System	8 days	Wed 09.04.08	Fri 18.04.08
24		**System Integration**	**10 days**	**Thu 01.05.08**	**Wed 14.05.08**
25		System Platform Integration	10 days	Thu 01.05.08	Wed 14.05.08
26		**System Engineering**	**25 days**	**Wed 20.02.08**	**Tue 25.03.08**
27		**System Design**	**25 days**	**Wed 20.02.08**	**Tue 25.03.08**
28		System Design Activity-1	10 days	Wed 20.02.08	Tue 04.03.08
29		System Design Activity-2	5 days	Wed 19.03.08	Tue 25.03.08
30		**Project Management**	**149 days**	**Tue 11.12.07**	**Fri 04.07.08**
31		**Purchases and Acquisitions Management**	**17 days**	**Tue 11.12.07**	**Wed 02.01.08**
32		Purchase of Raw Materials	5 days	Thu 20.12.07	Wed 26.12.07
33		Purchase of Supplies	5 days	Thu 27.12.07	Wed 02.01.08
34		Sub-contract Management Activities	12 days	Tue 11.12.07	Wed 26.12.07
35		Investment Management Activities	7 days	Tue 11.12.07	Wed 19.12.07
36		Main Contract Management Activities	149 days	Tue 11.12.07	Fri 04.07.08
37		Production Management Activites	63 days	Fri 18.01.08	Tue 15.04.08
38		Human Resource Mangement Activites	109 days	Tue 11.12.07	Fri 09.05.08
39		**Test and Evaluation**	**35 days**	**Tue 01.04.08**	**Mon 19.05.08**
40		**Dry-run Tests**	**19 days**	**Tue 01.04.08**	**Fri 25.04.08**
41		**Subsystem Dry-run Test Activities**	**9 days**	**Tue 01.04.08**	**Fri 11.04.08**
42		Subsystem-1 Dry-run Test Activity	3 days	Tue 01.04.08	Thu 03.04.08
43		Subsystem-2 Dry-run Test Activity	3 days	Wed 09.04.08	Fri 11.04.08
44		System Dry-run Test Activity	5 days	Mon 21.04.08	Fri 25.04.08
45		**Acceptance Tests**	**16 days**	**Mon 28.04.08**	**Mon 19.05.08**
46		Factory Acceptance Test Activity	3 days	Mon 28.04.08	Wed 30.04.08
47		Platform Acceptance Test Activity	3 days	Thu 15.05.08	Mon 19.05.08
48		**Logistics**	**61 days**	**Mon 21.04.08**	**Mon 14.07.08**
49		**Integrated Logistic Support Activities**	**26 days**	**Mon 21.04.08**	**Mon 26.05.08**
50		Customer Training Activity	5 days	Tue 20.05.08	Mon 26.05.08
51		Customer Documents Preparation Activity	5 days	Mon 21.04.08	Fri 25.04.08
52		Warranty Activities	8 wks	Tue 20.05.08	Mon 14.07.08

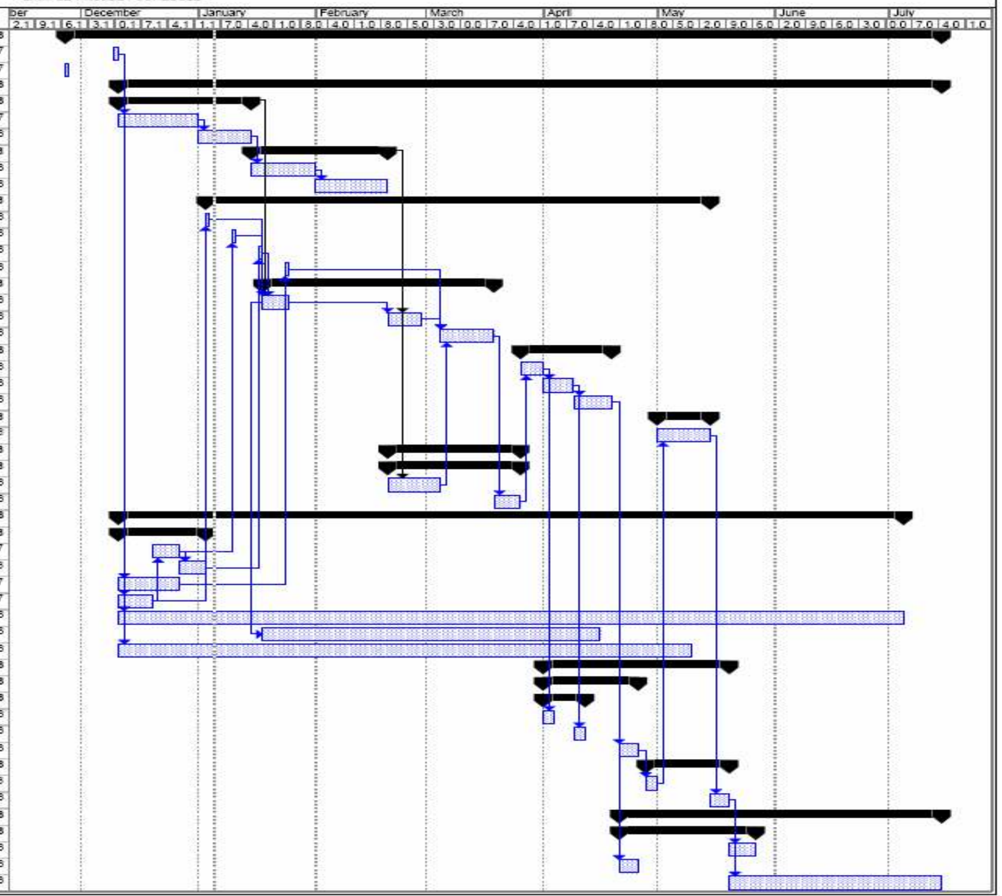


Figure 4.7 Project Schedule of the Sample Project with Performance Risks

Sample Project Cost Spreadsheet	Raw Material (€)	Supplies (TRY)	Sub-contract ($)	Total Material Cost ($)	Design Engineer 2007 (Hours)	Design Engineer 2008 (Hours)	Production Engineer (Hours)	Production Technician (Hours)	System Engineer (Hours)	Project Management Engineer-2007 (Hours)	Project Management Engineer-2008 (Hours)	Test Engineer (Hours)	Test Technician (Hours)	Logistic Support Engineer (Hours)	Logistic Support Technician (Hours)	Total Labor Cost ($)	Travelling Costs ($)	Other Costs ($)	Total Cost ($)
Design																8688			8688
Subsystem-1 Design																			
Design Activity-1					144,00											2880,00			2880,00
Design Activity-2						104,00										2288,00			2288,00
Subsystem-2 Design																			
Design Activity-1						80,00										1760,00			1760,00
Design Activity-2						80,00										1760,00			1760,00
Production				4448,63												12707,20			18655,83
Prototype Production																			
Prototype Production Subsystem-1	100,00			142,73			40,00	40,00								1452,00			1594,73
Prototype Production Subsystem-2	150,00	50,00		256,11			40,00	56,00								1680,80			1936,91
Prototype Production System		100,00	1000,00	1084,03			80,00	80,00								2904,00			3988,03
Serial Production																			
Serial Production Subsystem-1	200,00			285,46			24,00	32,00								985,60			1271,06
Serial Production Subsystem-2	300,00	100,00		512,23			40,00	48,00								1566,40			2078,63
Serial Production System		200,00	2000,00	2168,07			32,00	64,00								1619,20			3787,27
System Integration																			
System Platform Integration Activity							80,00	160,00	40,00							2499,20	1500,00		3999,20
System Engineering																2640,00			2640,00
System Design																			
System Design Activity-1									80,00							1760,00			1760,00
System Design Activity-2									40,00							880,00			880,00
Project Management																22912,96			22912,96
Purchases and Acquisitions Management																			
Purchase of Raw Materials										40,00						800,00			800,00
Purchase of Supplies										40,00						800,00			800,00
Sub-contract Management - Subsystem-3										96,00						1920,00			1920,00
Investment Management										56,00						1120,00			1120,00
Main Contract Mangement Activities										22,92	252,15					6005,85			6005,85
Production Management Activites											126,00					2772,00			2772,00
Human Resource Mangement Activites										48,44	387,56					9495,11			9495,11
Test and Evaluation																4936,80			4936,80
Dry-run Tests																			
Subsystem Dry-run Test Activity																			
Subsystem-1 Dry-run Test Activity												24,00	24,00			871,20			871,20
Subsystem-2 Dry-run Test Activity												24,00	24,00			871,20			871,20
System Dry-run Test Activity												40,00	40,00			1452,00			1452,00
Acceptance Tests																			
Factory Acceptance Test Activity												24,00	24,00			871,20			871,20
Platform Acceptance Test Activity												24,00	24,00			871,20			871,20
Logistics																8826,40			11376,40
Integrated Logistic Support Activities																			
Customer Training Activity									40,00							880,00	1000,00		1880,00
Customer Documents Preperation									40,00						8,00	994,40		50,00	1044,40
Warranty Activities														160,00	240,00	6952,00	1000,00	500,00	8452,00
Facilities and Infrastructure				4201,68															4201,68
Investment for Facilities																			
Production Equipment Investment		5000,00		4201,68															4201,68
																TOTAL COST			**90957,08**

Cost Determinant Parameters	Engineer Labor Rate 2007 ($/h)	Engineer Labor Rate 2008 ($/h)	Technician Labor Rate 2007 ($/h)	Technician Labor Rate 2008 ($/h)	Exchange Rate (€/$)	Exchange Rate (TRY/$)	Inflation Rate (2008)	General Management Overhead Rate	Value Added Tax Rate (VAT)
	20	22	13	14,3	1,43	0,84	1,1	1,05	1,18

Figure 4.8 Cost Spreadsheet of the Sample Project with Performance Risks

4.2.5 Quantitative Risk Analysis

The risk identification, qualitative risk analysis and risk response planning sub-process prepare the groundwork and necessary inputs for quantitative risk analysis, which is a critical part of the risk management method in the business development phase. The results of quantitative risk analysis are critical, since they affect the scheduling and cost estimating of the project, which are two major determinants in the proposal or in the feasibility study. The awards of the contracts by authorization bodies or the approvals of the internal development projects are dependent on schedule and cost issues.

There are several techniques for quantitative risk analysis. PMBOK (2004) suggests Monte Carlo simulation as a powerful tool. The other methods existing in the risk management area are more primitive and more subject to misuse with their high dependency on intuitive judgments (PMBOK, 2004). Nevertheless, the power of Monte Carlo simulation lies behind the effectiveness of the modeling. Constructing models that best reflect real world situations is extremely important in order to reach realistic schedule and cost estimates.

i. Monte Carlo Simulation

Monte Carlo simulation is an analysis technique that uses random numbers and probability distributions for transforming deterministic models into stochastic models (Vertex, 2007). Monte Carlo simulation is used in risk management in order to obtain probable data ranges of the determinants that characterize schedule and cost. In order to run a Monte Carlo simulation, each individual data set of the project schedule and cost estimating spreadsheet must be represented by specific probability distributions. The simulation runs with the generation of random numbers within the range of defined probability distributions. Monte Carlo simulation exposes a distribution for the output values of schedule and cost by using randomly generated numbers as inputs. These calculations are handled with iterations and the number of iterations are determined by the project team. In terms of quantitative risk analysis, the optimum number of iterations was found to be 1000, and iterations beyond this number have produced results where the outcomes do not change significantly (Grey, 1995). A critical issue in the application of Monte Carlo simulation is the probability density functions that indicate how the data is distributed within the minimum to maximum range. The probability density functions represent probability distributions in terms of integrals, and are used to summarize large number of measurements of related values. Therefore, there must be probability distributions that represent each element of schedule and cost events, which reflect the real world situation. This means that in order to determine the most applicable probability distribution for each cost and schedule element, there must be a vast amount of data gathered from past projects. There are numerous studies around the world that gather the necessary data and put forward most likely distributions for specific project activities. By the aid of these studies, risk databases have been constructed regarding the activities of specific sectors and these databases are being updated continuously. There is no data gathered or documented regarding Turkish defense industry and Company X's projects; thus, such a source cannot be used in the method proposed in this thesis. Instead, the method suggests the use of certain distributions for different types of activities and risk elements in order to run Monte Carlo simulation for the projects of Company X.

The impacts of quantified risks on the schedule must be determined first, since the results of schedule risk analysis affect the cost of the project along with other risks relevant to performance.

4.2.5.1 Schedule Risk Analysis

Since the schedule of projects is one of the three success criteria, the risks associated with schedule considerations must be analyzed. In the scheduling sub-process of the business development phase, the schedule of the project is developed, which directly reflects the work breakdown structure. Then, the risks on the WBS elements and activities are identified, qualified, and adjusted within the previously defined sub-process. At this stage, schedule risk analysis requires three point estimates for the durations of each schedule activity. The risks on these activities have already been identified and the handling options of avoidance, transferring, and mitigation are matched with these activities. The advantage of early risk response planning can be used in determining the three point estimates of the duration of the activities. The activities, which have no identified risks and which have been determined to have an avoidance option, need only one, namely the most likely estimate, and this estimate has already been determined in the scheduling sub-process. There is no need to determine three point estimates for these types of activities. The remaining activities with risk transferring and risk mitigation options require three point estimates for duration values: minimum, maximum and most likely. The next step, before the execution of the Monte Carlo simulation is the determination of the probability distributions that are applicable for the activities of the project. At this point, the results of the qualitative risk analysis obtained from TRIMS are used. Since the probability of occurrence and impact of the occurrence over the schedule are obtained for each activity within a matrix structure, the determination of the probability distribution for that activity can be based on this output matrix and the risk response plans developed according to this matrix for schedule risks. There are various probability distributions defined in the literature that are used for quantitative risk analysis applications. The most likely ones to be used are triangular, normal and beta distributions as suggested by Grey (1995). The literature suggests the use of triangular distributions for activities where exact probability density functions are not known, which is the case for Company X's projects. After the determination of the probability distributions for each task, the Monte Carlo simulation is run.

In order to run Monte Carlo simulations, there are various software programs in the market. There are stand alone, complex risk management software tools like Pertmaster of Primevera Corp. and GAIN Risk Management platform of Advanced Information Management (AIM) for this purpose. However, there are also software tools that operate as extensions to Microsoft Office tools: Microsoft Project and Microsoft Excel. The use of this type of software is advantageous for Company X, since the schedules are developed with the aid of Microsoft Project software and the cost spreadsheets are developed by the aid of Microsoft Excel software. Thus, integration of the extension packages is an advantage. The structure and the outputs of the scheduling sub-process do not need to be modified. Moreover, these extension type software packages are not very expensive. They cost a few hundred dollars for multiple user rights. In that respect, the use of a Microsoft Project extension software, @RISK for Project of Palisade Corporation is suggested in order to execute schedule risk analysis.

i. Use of @RISK for Project in Schedule Risk Analysis

@RISK for Project is one of various software packages that execute schedule risk analysis in the market. @RISK is an easy to use Microsoft Project extension with effective Graphical User Interfaces that incorporates certain add-in functions to Microsoft Project. Since the schedules are created using Microsoft Project in Company X's projects, the method proposed in this thesis suggests using @RISK as an easy extension. @RISK software is based on the execution of Monte Carlo simulation over the prepared project schedule. In order to run the program, the probability distributions for each activity must be assigned. @RISK embodies thirty-seven different predefined and configurable probability distribution functions as given in Figure 4.9. The determination of the most suitable probability function for each activity can be assessed with the aid of risk databases. Since the Turkish defense industry and Company X do not have predefined databases, the most appropriate way to execute schedule risk analysis is using triangular distribution for each activity, suggested by Grey (1995). The triangular distribution assigned to an activity of the sample project is shown in Figure 4.10. However, when the experience of project managers regarding risk management and risk issues reach a certain level, or when sufficient data is gathered for constructing a risk database, different types of probability distributions that optimize the outputs of quantitative risk analysis may be used. In order to reach such an adequate level, the risk management method proposed in this study must be applied, and the actual risk data occurring in the project management phase must be accurately documented via risk management plans, as these are two goals of this study.

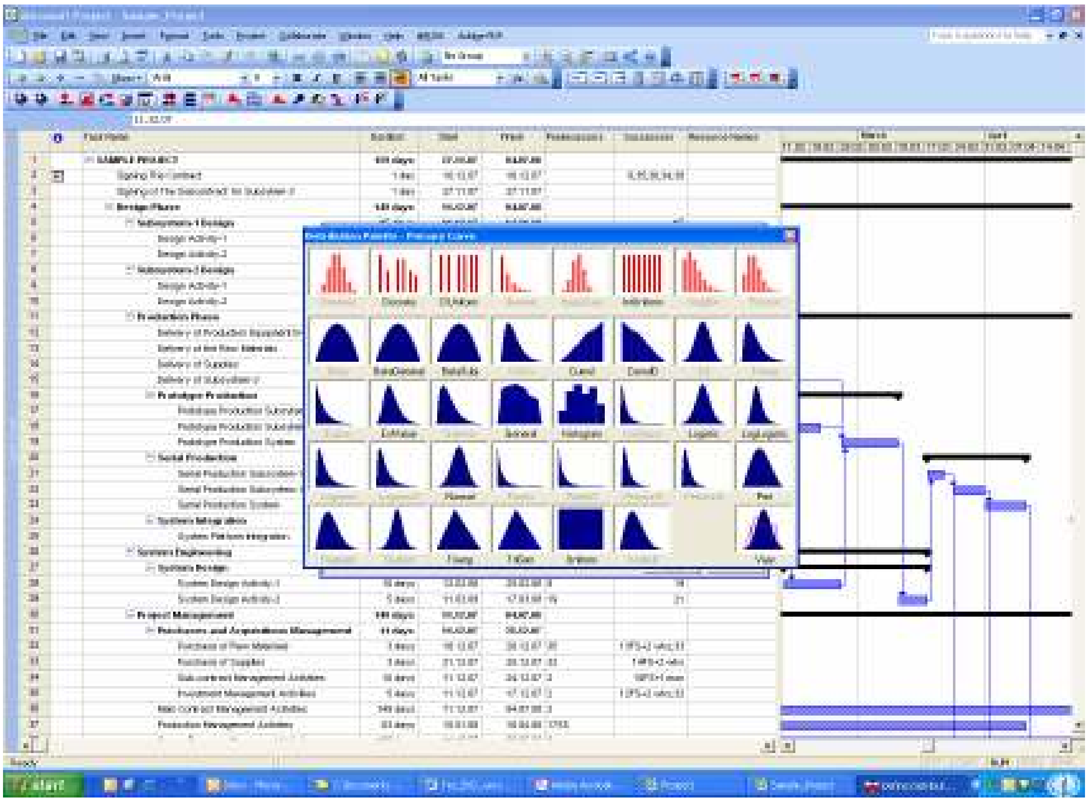


Figure 4.9 Probability Distributions of @RISK for Project

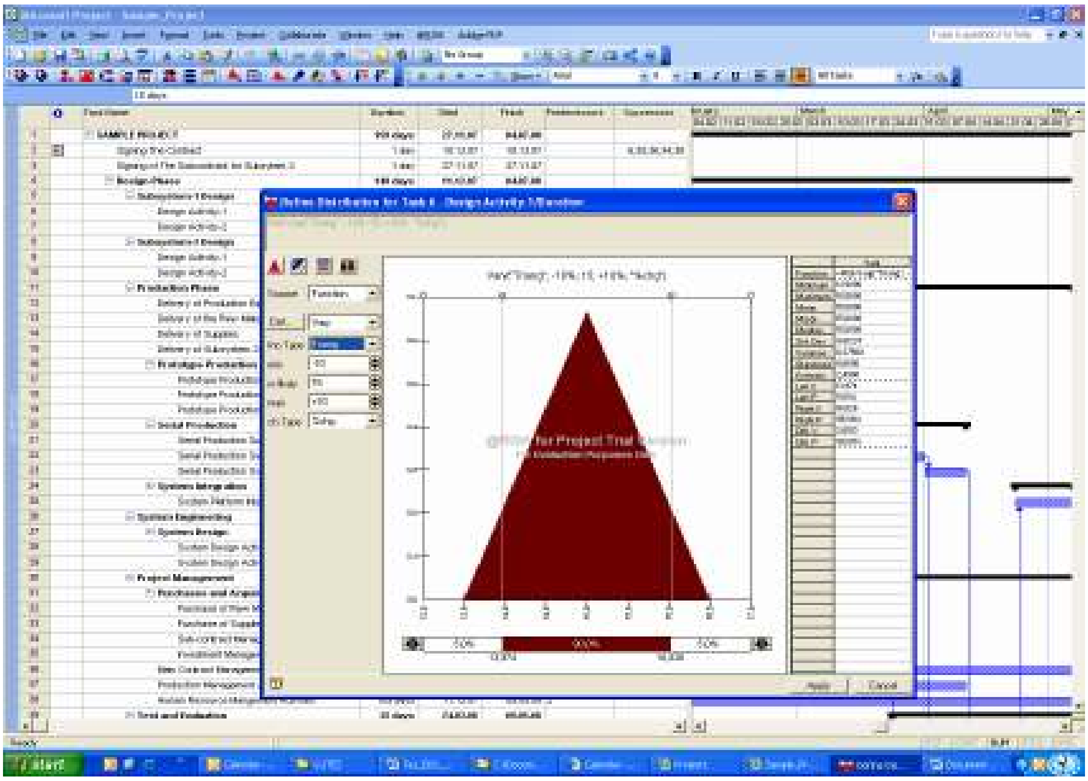


Figure 4.10 Triangular Distribution Assignment in @RISK for Project

After the determination of the probability distribution type, the confidence levels for each activity's distribution must be set. At this point, the method proposed in the thesis suggests to use the qualitative risk analyis results. The adjustments can be made according to the risk levels determined after the risk response planning sub-process given in Table 4.3. If the risk level is high, the confidence levels must be adjusted to the right hand side of the distribution to increase the probability of occurrence of higher level values, and if the risk level is low the confidence level must be adjusted to the left hand side of the distribution to increase the probability of occurrence of lower level values. The adjusted level of confidence for an activity of the sample project is shown in Figure 4.11 below, where the risk probability of occurrence and the impact of this risk are both determined to be high, that is the "Purchases and Acquisitions Management" activity. Even though the numerical values of the adjustments are not based on certain formulae, these adjustments are aimed to reflect realistic results.

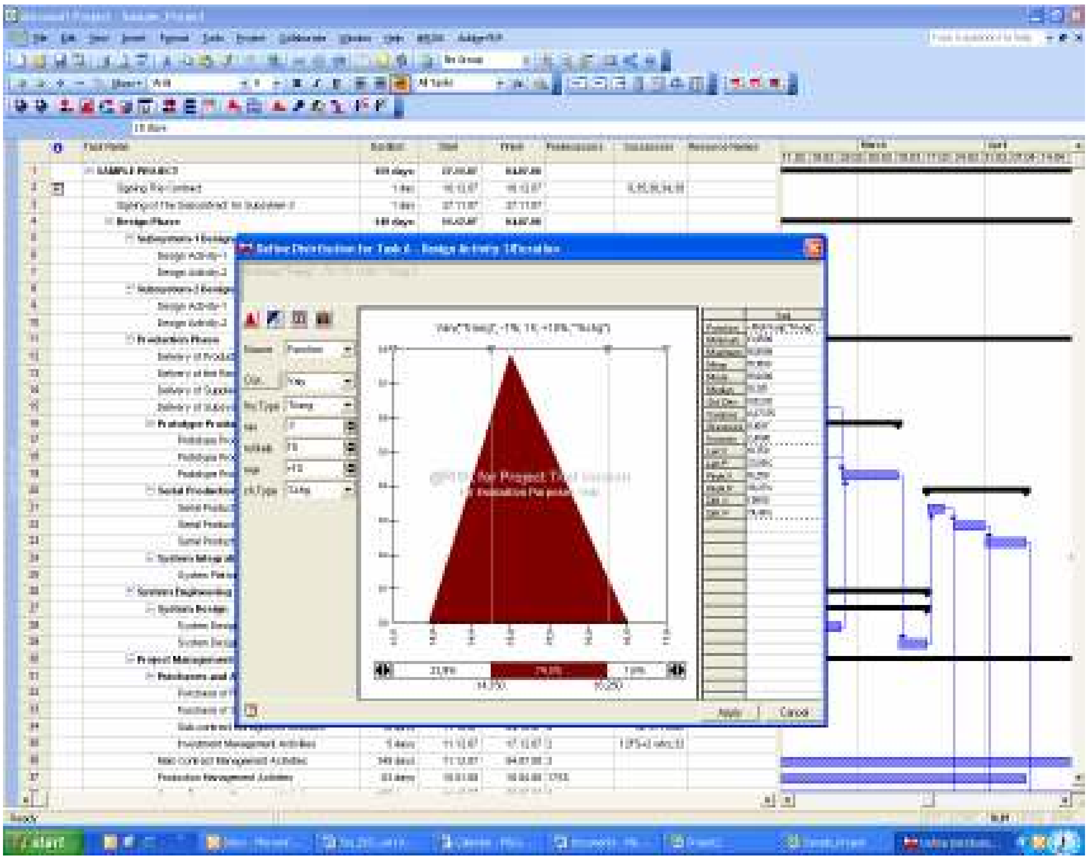


Figure 4.11 Adjusted Triangular Distribution for an Activity of the Sample Project

After the determination of the probability distributions, the correlations between the risk issues must be defined in @RISK. The correlation between activities are critical, since risk occurring in one activity may trigger the risk on another one or a negative result occurring in one activity may reduce the risk on another one. The former instance indicates a positive correlation between risks in the activities, and the latter indicates a negative correlation. The interrelations between activities are defined in @RISK by assigning weights to the correlations of the activities. The correlation coefficients are defined in a range of -1 to 0 for negative correlations, and from 0 to +1 for positive correlations. By giving weights to the interrelations of activities, the behavior of the outputs regarding these activities under the scope of risk are set. For the sample project, the "Purchases and Acquisitions" activity is positively correlated with "Prototype Production" and "Serial Production" activities. Furthermore, these activities of "Prototype Production" and "Serial Production" are also positively correlated.
After the determination of the correlations between activities, the next step in the @RISK program is defining the outputs of the program, when certain outputs are desired to be investigated separately. In the case of Company X's projects, all activities must be analyzed seperately for the risks on their scheduled durations, since the outputs of the analysis for each activity constitute the input for the cost risk analysis sub-process.

Before going into the execution of the simulation, the last step is defining the simulation settings. @RISK contains various simulation options; however, for investigating risks in the sample project, defining the number of iterations and choosing the simulation type as Monte Carlo are sufficient. Besides these options, @RISK has several other options like generating simulation logs, executing multiple simulations, using macros, and using Latin Hypercube sampling instead of Monte Carlo simulation. After all the settings are defined and the data necessary for running the simulation are entered, the simulation for the sample project is run.

@RISK produces powerful graphical and statistical results. After the execution of the simulation, the project manager (user(s)) must determine the risk confidence level over the activities, which reveals the risk taking characteristic of the project team with respect to the schedule. Since the inputs of the simulation are probability values, the outputs also have a probability distribution. This distributions show the likelihood of occurrence in a given risk confidence level. @RISK outputs minimum, mean and maximum values, standard deviation, variance, skewness, kurtosis and most importantly the activity durations depending on the chosen confidence level. With respect to the determined confidence level, @RISK outputs the durations of activities, and the probability of these activities to be completed within the given duration is the defined percentage. If the confidence level is determined as 90%, that means the activities will be completed within the output duration with 90% probability. In order to determine this confidence level, the project manager must first check the graphical output of the simulation. The output for an activity of the sample project after the Monte Carlo simulation is run on the sample project is given in Figure 4.12. This figure indicates the output durations with respect to the chosen confidence level. Choosing a confidence level near to the far right hand side of the graph, that is near 100%, means minimizing the risk levels of the schedule activities. The important consideration here is the limitations of the schedule imposed by the authorization bodies. The project manager must choose a confidence level as near to the far right hand side of the graph as the schedule limitations permit. That means the schedule risks that may be faced in the project management phase are minimized with that level of confidence. After the confidence level based on the restrictions and the features of the project, the activity durations are output for this confidence level, ready to be used in the cost risk analysis sub-process.

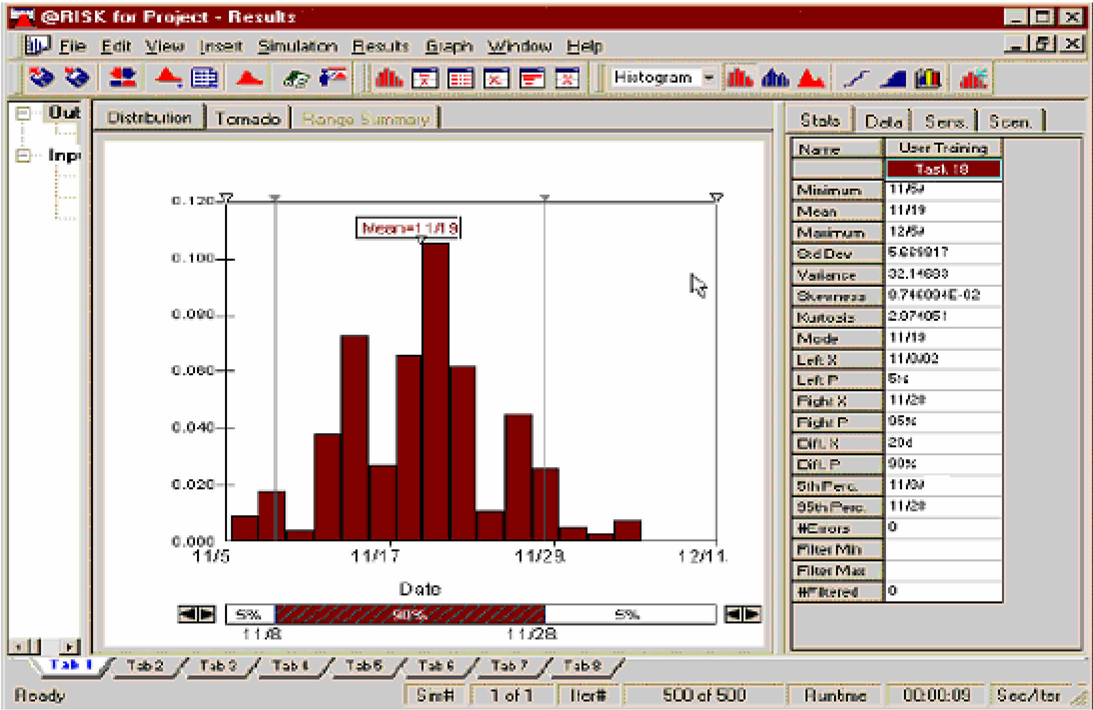


Figure 4.12 @RISK Output for an Activity of the Sample Project

The final version of the project schedule for the sample project after the Monte Carlo simulation is run on @RISK for Project is given in Figure 4.13. For the construction of this final project schedule, the confidence levels for all activities determined to have risk after the risk response planning are adjusted to 90%. That means, the activities of the sample project that are determined to bear risks are expected to be completed within the given schedule in Figure 4.13 with 90% confidence.

SAMPLE PROJECT SCHEDULE

ID		Task Name	Duration	Start	Finish
1		**SAMPLE PROJECT**	**170 days**	**Tue 27.11.07**	**Mon 21.07.08**
2		Signing The Contract	1 day	Mon 10.12.07	Mon 10.12.07
3		Signing of The Subcontract for Subsytem-3	1 day	Tue 27.11.07	Tue 27.11.07
4		**Design Phase**	**160 days**	**Tue 11.12.07**	**Mon 21.07.08**
5		**Subsystem-1 Design**	**25 days**	**Tue 11.12.07**	**Mon 14.01.08**
6		Design Activity-1	15 days	Tue 11.12.07	Mon 31.12.07
7		Design Activity-2	10 days	Tue 01.01.08	Mon 14.01.08
8		**Subsystem-2 Design**	**26 days**	**Tue 15.01.08**	**Tue 19.02.08**
9		Design Activity-1	13 days	Tue 15.01.08	Thu 31.01.08
10		Design Activity-2	13 days	Fri 01.02.08	Tue 19.02.08
11		**Production Phase**	**98 days**	**Fri 04.01.08**	**Tue 20.05.08**
12		Delivery of Production Equipment Investments	1 day	Fri 04.01.08	Fri 04.01.08
13		Delivery of the Raw Materials	1 day	Mon 14.01.08	Mon 14.01.08
14		Delivery of Supplies	1 day	Tue 22.01.08	Tue 22.01.08
15		Delivery of Subsystem-3	1 day	Fri 25.01.08	Fri 25.01.08
16		**Prototype Production**	**41 days**	**Wed 23.01.08**	**Wed 19.03.08**
17		Prototype Production Subsytem-1	6 days	Wed 23.01.08	Wed 30.01.08
18		Prototype Production Subsytem-2	8 days	Wed 20.02.08	Fri 29.02.08
19		Prototype Production System	11 days	Wed 05.03.08	Wed 19.03.08
20		**Serial Production**	**18 days**	**Thu 27.03.08**	**Mon 21.04.08**
21		Serial Production Subsystem-1	4 days	Thu 27.03.08	Tue 01.04.08
22		Serial Production Subsystem-1	6 days	Wed 02.04.08	Wed 09.04.08
23		Serial Production System	8 days	Thu 10.04.08	Mon 21.04.08
24		**System Integration**	**12 days**	**Mon 05.05.08**	**Tue 20.05.08**
25		System Platform Integration	12 days	Mon 05.05.08	Tue 20.05.08
26		**System Engineering**	**26 days**	**Wed 20.02.08**	**Wed 26.03.08**
27		**System Design**	**26 days**	**Wed 20.02.08**	**Wed 26.03.08**
28		System Design Activity-1	10 days	Wed 20.02.08	Tue 04.03.08
29		System Design Activity-2	5 days	Thu 20.03.08	Wed 26.03.08
30		**Project Management**	**149 days**	**Tue 11.12.07**	**Fri 04.07.08**
31		**Purchases and Acquisitions Management**	**20 days**	**Tue 11.12.07**	**Mon 07.01.08**
32		Purchase of Raw Materials	6 days	Fri 21.12.07	Fri 28.12.07
33		Purchase of Supplies	6 days	Mon 31.12.07	Mon 07.01.08
34		Sub-contract Management Activities	13 days	Tue 11.12.07	Thu 27.12.07
35		Investment Management Activities	8 days	Tue 11.12.07	Thu 20.12.07
36		Main Contract Management Activities	149 days	Tue 11.12.07	Fri 04.07.08
37		Production Management Activites	63 days	Wed 23.01.08	Fri 18.04.08
38		Human Resource Mangement Activites	109 days	Tue 11.12.07	Fri 09.05.08
39		**Test and Evaluation**	**39 days**	**Wed 02.04.08**	**Mon 26.05.08**
40		**Dry-run Tests**	**19 days**	**Wed 02.04.08**	**Mon 28.04.08**
41		**Subsystem Dry-run Test Activities**	**9 days**	**Wed 02.04.08**	**Mon 14.04.08**
42		Subsystem-1 Dry-run Test Activity	3 days	Wed 02.04.08	Fri 04.04.08
43		Subsystem-2 Dry-run Test Activity	3 days	Thu 10.04.08	Mon 14.04.08
44		System Dry-run Test Activity	5 days	Tue 22.04.08	Mon 28.04.08
45		**Acceptance Tests**	**20 days**	**Tue 29.04.08**	**Mon 26.05.08**
46		Factory Acceptance Test Activity	4 days	Tue 29.04.08	Fri 02.05.08
47		Platform Acceptance Test Activity	4 days	Wed 21.05.08	Mon 26.05.08
48		**Logistics**	**65 days**	**Tue 22.04.08**	**Mon 21.07.08**
49		**Integrated Logistic Support Activities**	**30 days**	**Tue 22.04.08**	**Mon 02.06.08**
50		Customer Training Activity	5 days	Tue 27.05.08	Mon 02.06.08
51		Customer Documents Preparation Activity	5 days	Tue 22.04.08	Mon 28.04.08
52		Warranty Activities	6 wks	Tue 27.05.08	Mon 21.07.08

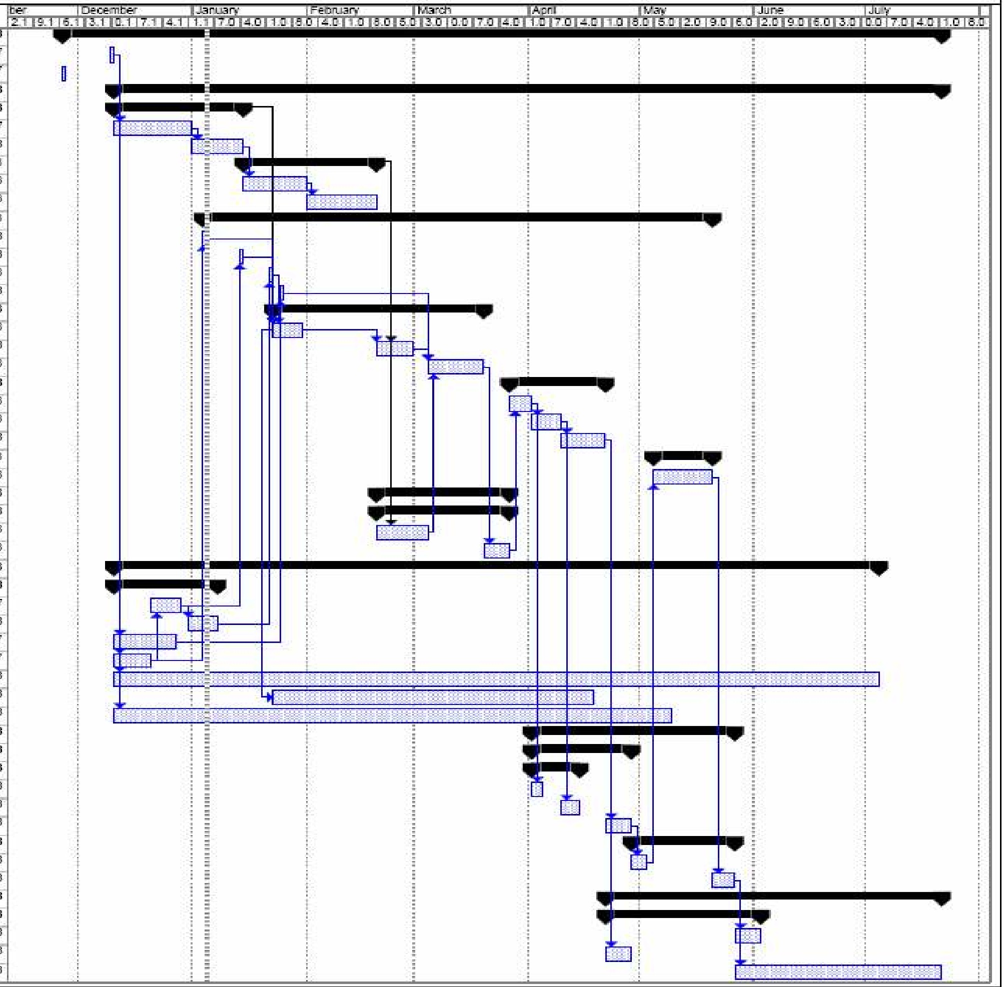


Figure 4.13 Final Project Schedule after Schedule Risk Analysis

When compared to the current intuitive risk management practices of Company X concerning the schedule risks of the project, the use @RISK for Project and Monte Carlo simulation give important outputs to the project manager and the project team. The project schedule, where the possible risks are analyzed shows the possible results of these risks with 90% confidence.

The outputs of the schedule risk analysis must be inserted into the cost estimating spreadsheet of the sample project. The durations given in Figure 4.13 regarding the schedule of the sample project are input to the cost spreadsheet before the execution of the cost risk analysis detailed in the following section of the study. The cost estimating spreadsheet of the sample project with the modified durations of the activities bearing risk is given in Figure 4.14.

Sample Project Cost Spreadsheet	Raw Material (€)	Supplies (TRY)	Sub-contract ($)	Total Material Cost ($)	Design Engineer 2007 (Hours)	Design Engineer 2008 (Hours)	Production Engineer (Hours)	Production Technician (Hours)	System Engineer (Hours)	Project Management Engineer-2007 (Hours)	Project Management Engineer-2008 (Hours)	Test Engineer (Hours)	Test Technician (Hours)	Logistic Support Engineer (Hours)	Logistic Support Technician (Hours)	Total Labor Cost ($)	Travelling Costs ($)	Other Costs ($)	Total Cost ($)
Design																9744			9744
Subsystem-1 Design																			
Design Activity-1					144,00											2880,00			2880,00
Design Activity-2						104,00										2288,00			2288,00
Subsystem-2 Design																			
Design Activity-1						104,00										2288,00			2288,00
Design Activity-2						104,00										2288,00			2288,00
Production				4448,63												14159,20			20107,83
Prototype Production																			
Prototype Production Subsystem-1	100,00			142,73			48,00	48,00								1742,40			1885,13
Prototype Production Subsystem-2	150,00	50,00		256,11			48,00	64,00								1971,20			2227,31
Prototype Production System		100,00	1000,00	1084,03			80,00	80,00								2904,00			3988,03
Serial Production																			
Serial Production Subsystem-1	200,00			285,46			32,00	40,00								1276,00			1561,46
Serial Production Subsystem-2	300,00	100,00		512,23			40,00	48,00								1566,40			2078,63
Serial Production System		200,00	2000,00	2168,07			40,00	72,00								1909,60			4077,67
System Integration																			
System Platform Integration Activity							80,00	160,00	40,00							2789,60	1500,00		4289,60
System Engineering																2640,00			2640,00
System Design																			
System Design Activity-1									80,00							1760,00			1760,00
System Design Activity-2									40,00							880,00			880,00
Project Management																23552,96			23552,96
Purchases and Acquisitions Management																			
Purchase of Raw Materials										48,00						960,00			960,00
Purchase of Supplies										48,00						960,00			960,00
Sub-contract Management - Subsystem-3										104,00						2080,00			2080,00
Investment Management										64,00						1280,00			1280,00
Main Contract Mangement Activities										22,92	252,15					6005,85			6005,85
Production Management Activites											126,00					2772,00			2772,00
Human Resource Mangement Activites										48,44	387,56					9495,11			9495,11
Test and Evaluation																5227,20			5227,20
Dry-run Tests																			
Subsystem Dry-run Test Activity																			
Subsystem-1 Dry-run Test Activity												24,00	24,00			871,20			871,20
Subsystem-2 Dry-run Test Activity												24,00	24,00			871,20			871,20
System Dry-run Test Activity												40,00	40,00			1452,00			1452,00
Acceptance Tests																			
Factory Acceptance Test Activity												32,00	32,00			1161,60			1161,60
Platform Acceptance Test Activity												24,00	24,00			871,20			871,20
Logistics																8826,40			11376,40
Integrated Logistic Support Activities																			
Customer Training Activity									40,00							880,00	1000,00		1880,00
Customer Documents Preperation									40,00						8,00	994,40		50,00	1044,40
Warranty Activities														160,00	240,00	6952,00	1000,00	500,00	8452,00
Facilities and Infrastructure				4201,68															4201,68
Investment for Facilities																			
Production Equipment Investment		5000,00		4201,68															4201,68
																TOTAL COST			85217,24

Cost Determinant Parameters	Engineer Labor Rate 2007 ($/h)	Engineer Labor Rate 2008 ($/h)	Technician Labor Rate 2007 ($/h)	Technician Labor Rate 2008 ($/h)	Exchange Rate (€/$)	Exchange Rate (TRY/$)	Inflation Rate (2008)	General Management Overhead Rate	Value Added Tax Rate (VAT)
	20	22	13	14,3	1,43	0,84	1,1	1,05	1,18

Figure 4.14 Cost Spreadsheet of the Sample Project after Schedule Risk Analysis

4.2.5.2 Cost Risk Analysis

The determination of the cost budgets is one of the most critical tasks of the project team in the business development phase. Cost estimating is the major source of the price of a project, and price is a main concern for the authorization bodies in awarding the contracts. On the other hand, cost budgets are also most important determinants for senior management when approving development projects. Even though cost estimation is such an important part of the business development phase, the current method of handling risks regarding costs in Company X's projects is a simple process. As stated in previous chapters, in order to compensate for the effects of risks, an intuitive risk mark-up is used as given in Figure 3.3. For the sample project, the intuitively determined risk mark-up is 5%, that corresponds to 4406 US Dollars on the overall cost of the project. The following part of the study suggests a cost risk analysis in order to put forward the effects of the risks on the cost of the projects. The cost risk analysis in this method highly resembles the schedule risk analysis in terms of application.

The major components of cost in Company X's projects are labor costs that arise from the man-hours spent during the project management phase, supply costs (including raw materials) that arise from the purchases, the sub-contract costs that arise from the acquisition of supplies and/or services from sub-contractors, and traveling costs. Besides these major costs, there are various minor cost items like transportation costs, documenting costs of manuals and project documents, training costs (training of staff - not training the user or the customer) and consumables costs (office material costs, materials that are sold in bulk amounts like bolts, nuts and washers). Each cost element that is determined by the project team and input to the cost estimating spreadsheet is directly related to one or more of the WBS activities. Therefore, in cost estimating spreadsheets the WBS activities are the subject rows where the relevant costs are gathered as indicated in Figure 3.3 for the sample project. Thus, risks regarding these costs are present for each WBS activity. These risks are identified, qualified and responses for avoiding, transferring, or mitigating them are determined within previous sub-processes. Besides, the schedule risks are quantified within the schedule risk analysis sub-process and input to the cost estimating spreadsheet. All the preliminary data is in the hands of the project team for cost risk analysis. With these acquired data, the risks regarding cost are quantified with the aid of Monte Carlo simulation executed on the cost spreadsheet. The process is much the same as the schedule risk analysis. In the case of cost risk analysis, the use of @RISK as an extension software package running on Microsoft Excel is recommended in this study.

i. Use of @RISK for Excel in Cost Risk Analysis

For the execution of the Monte Carlo simulation on the cost estimating spreadsheet, the probability distributions have to be determined regarding each cost element of the project. As in the case for schedule risks, databases for the Turkish defense industry and Company X's projects cost elements are not available. Thus, the initial distributions for cost elements must be defined by the project team, based on the results obtained from TRIMS with respect to the probability of occurrence and impact matrices, and with respect to the risk response plans developed for each WBS element as given in Table 4.4 for the sample project. The cost elements regarding the WBS activities are, as stated above, labor costs, supply costs, sub-contract costs, traveling costs, transportation costs, documenting costs, training costs and consumables costs. Each of these costs bear a risk and the probability and impact matrices regarding them are determined during the qualitative risk analysis sub-process. The probability distributions for the costs elements other than the labor costs must be determined first. The determination of probability distributions for labor costs is unnecessary, since the analysis on the labor hours is already performed in the schedule risk analysis. Labor costs are obtained by multiplying the duration outputs of the schedule risk analysis with the relevant labor rates as given in Figure 4.14.

For probability distributions in environments where no appropriate past data exists, the use of the normal distribution is suggested in the literature (Grey, 1995; Palisade, 2007). Since this is the case for the Company X's projects, in order to analyze the risks regarding WBS cost elements, the normal distribution is used.

Other than the probability distributions regarding WBS cost elements, the probability distributions characterizing other parameters must be determined. These parameters are the exchange rates that mostly affect the supply and sub-contract costs, changing inflation rates through consecutive years of the project management phase that affect all the cost elements of the project. Labor rates changing through consecutive years during the project management phase also affect the activity costs as well as the general management overhead costs that affect labor rates, and purchasing and acquisitions costs. These parameters are estimated by the financial departments of Company X to be used in the cost estimating sub-process. The financial units suggest estimates regarding these parameters. The data gathered for these parameters can be used for determining the related probability distributions. The probability distribution of the activities and the parameters used for the sample project is the normal distribution and is input to @RISK for Excel.

After the determination of the probability distributions for each cost element and for each parameter that affect the cost budget of the project, the correlations between the cost elements and parameters are determined, the outputs are defined and the simulation options are set before running the Monte Carlo simulation. These steps are performed as in the schedule risk analysis sub-process. Risks over any cost element or parameter can be correlated with any other cost element or parameter. As an instance, labor rates are directly related to the inflation rate, therefore, these two parameters are positively correlated. The correlations are determined and input to the program in a -1 to +1 scale. The correlations between these parameters and the activities of the sample project are input to the program.

Then, the required outputs must be defined. For the projects of Company X, the outputs are the total cost figure of the project and the individual costs of the WBS elements. The last thing to do before running the simulation is to set the simulation options. @RISK for Excel serves the same options list as @RISK for Project, and the settings for cost risk analysis simulation are the same as the schedule risk analysis simulation options. The number of iterations are set to 1000 and the simulation type is set to Monte Carlo simulation.

After the simulation run, the outputs are analyzed by the project manager in order to adjust the confidence levels regarding each output and the overall total cost. @RISK for Excel supports various graphical and statistical analysis tools for the investigation of outputs as @RISK for Project. The graphical output for the total cost of the sample project after the simulation is given in Figure 4.15 below.

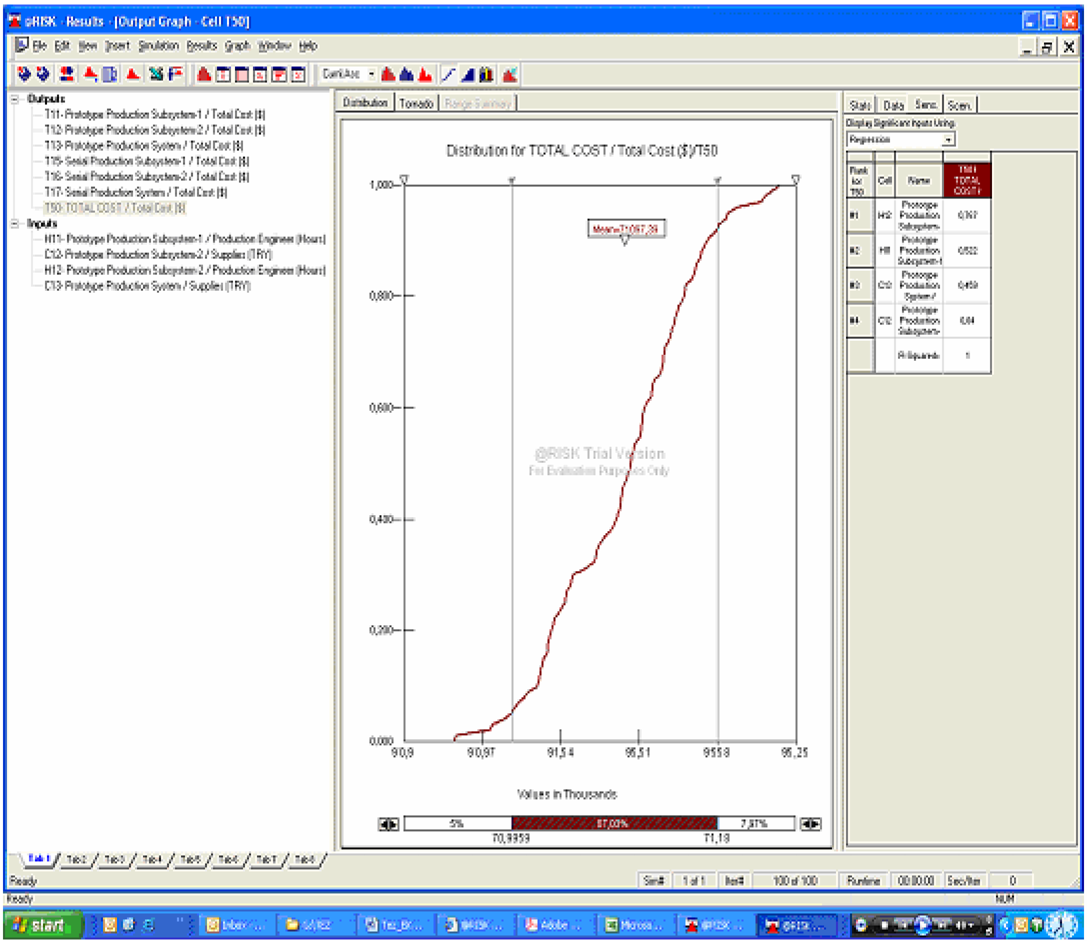


Figure 4.15 Graphical @RISK for Excel Output for the Total Cost of the Sample Project

Besides the graphical outputs, the project team may see the statistical output values in a detailed statistics window. The detailed statistical view of the results for the sample project is given in Figure 4.16 below.

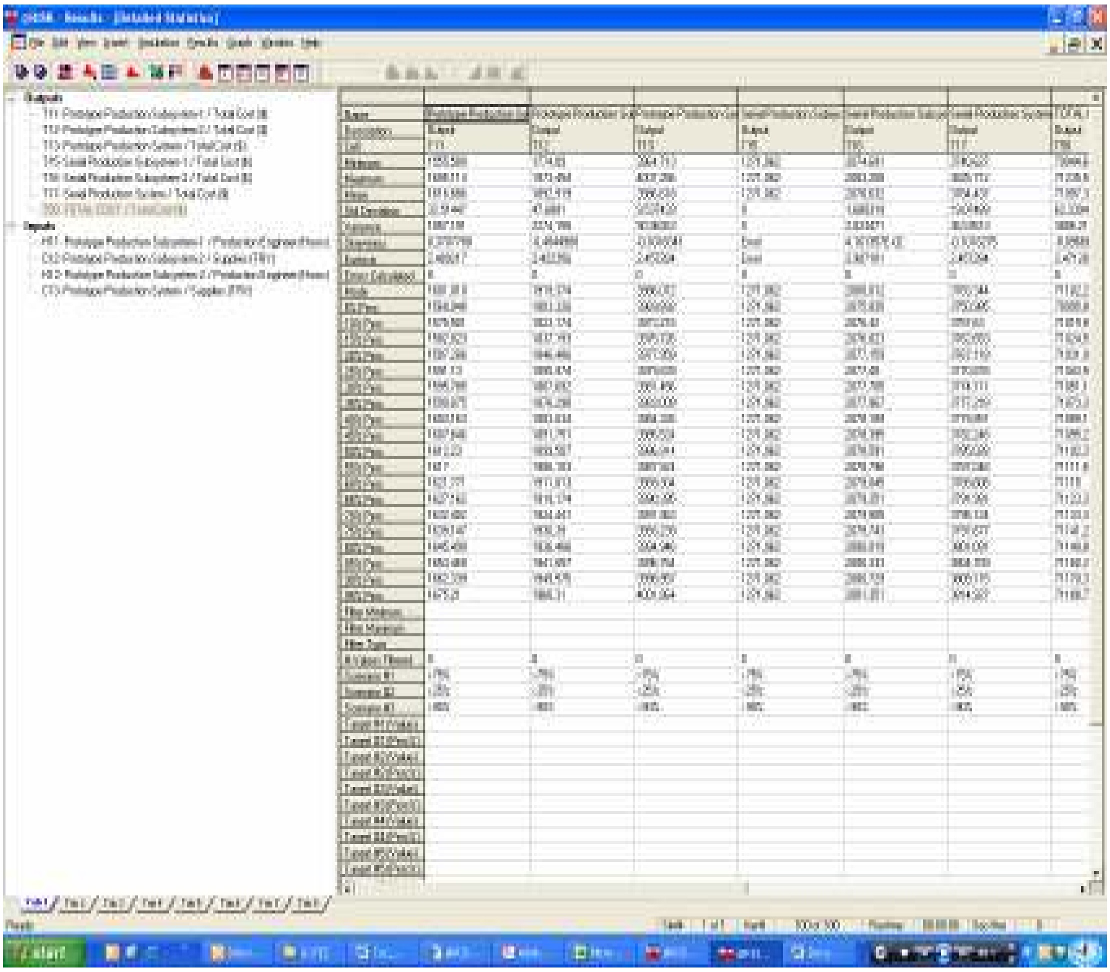


Figure 4.16 Statistical @RISK for Excel Output for the Sample Project

Cost risk analysis ends up with the determination of the risk confidence levels for the cost outputs of the project. The obtained results constitute the basis for the price of the project. As shown in Figure 4.15, the confidence levels of each cost element of the project and for the overall cost are set at 90% as in the schedule risk analysis. This confidence level indicates that the costs of the project will remain under the obtained figure of 96154 US Dollars with the risks of the project compensated with 90% confidence level.

When the results of the cost risk analysis are compared with the results of the current intuitive risk mark-up approach, the cost figures are different. With the 5% risk mark-up, the overall cost of the sample project is estimated as 92528 US Dollars. However, after evaluation of the proposed method, the overall cost figure is found to be 96154 US Dollars that correspond to a 9% increase in the overall cost of the project over the net estimated cost without risk considerations. This result indicates that the intuitive risk mark-up of 5% underestimates the cost of the sample project and this would cause a profit loss for Company X.

The cost risk analysis is the last step of quantitative risk analysis. Upon the completion of this step, the project team must insert the results obtained from the qualitative and quantitative risk analysis sub-processes into the risk register (Table 4.1) and into the risk management plan. The completed risk register for the sample project is given in Table 4.5. The related sections of the risk management plan must also be completed with the analysis results in order to construct the document structure given in Figure 4.1.

The risk management method proposed in this thesis ends with the construction of the entire risk management plan except the compliancy part that must be filled during the project management phase. Furthermore, the prior sub-processes evaluated before the risk management sub-processes must be revisited by the project team under the scope of the results obtained from the risk management method. After the revision of the business development phase sub-processes, the proposal, or the feasibility report is ready to be submitted to the authorization body, including the risk issues, their probabilities of occurrences, and their impacts on the project.

Table 4.5 Risk Register for the Sample Project

No	Risk Definition	Risk Source (Stakeholder)	Related Success Criteria	Related WBS No	Responsible Personnel	Risk Response	Expected date of Occurence	Risk Level	Impact on Schedule	Impact on Cost	Compliancy
1	(A1) Subsystem-1 Design	Company X	Performance Cost	1.1	A	Mitigate Transfer	January 08	Low	5 days	$696	
2	(A2) Subsystem-2 Design	Company X	Performance Schedule Cost	1.2	A	Mitigate Mitigate Mitigate	February 08	Moderate	5 days	$1.274	
3	(B1) Prototype Production	Subcontractor, Company X	Schedule	2.1	B	Mitigate	March 08	Low	2 days	$156	
4	(B2) Serial Production	Subcontractor, Company X	Schedule	2.2	B	Mitigate	March-April 08	Low	3 days	$248	
5	(B3) System Integration	Authorization Body,Company X	Schedule Cost	2.3	C	Mitigate Mitigate	May 08	Moderate	5 days	$496	
6	(C1) System Design	Company X	Performance	3.1	D	Mitigate	February-March 08	Low	5 days	$372	
7	(D1) Purchases and Acquisitions Management	Subcontractor and Suppliers	Performance Schedule Cost	4.1	E, F	Mitigate Mitigate Mitigate	December 07	High	10 days	$2.436	
8	(D2) Main Contract Management Activities	Authorization Body	Performance Cost	4.2	E, G	Avoid Transfer	December 07- July 08	Low	2 days	$312	
9	(D3) Production Management Activites	Company X	Performance Schedule	4.3	E, H	Avoid Avoid	January-April 08	Low	1 day	$144	
10	(D4) Human Resources Management Activites	Company X	Performance Cost	4.4	E	Avoid Mitigate	January-June 08	Low	1 day	$144	
11	(E1) Dry-run Tests	Company X	Performance Schedule Cost	5.1	C	Mitigate Avoid Mitigate	March-April 08	Low	5 days	$288	
12	(E2) Acceptance Tests	Authorization Body, Company X	Performance Schedule Cost	5.2	E, C	Mitigate Mitigate Mitigate	May 08	Moderate	3 days	$986	
13	(F2) Integrated Logistic Support Activities	Authorization Body, Company X	Performance Schedule Cost	6.1	I	Avoid Transfer Transfer	May-June 08	Low	2 days	$192	
14	(F1) Warranty Activities	Authorization Body, Company X	Cost	6.2	I	Transfer	June-July 08	Low	2 days	$192	
15	(G1) Investment for Facilities	Suppliers	Cost	7.1	E, J	Mitigate	January 08	Low	1 day	$96	

When the proposed method is compared with the current risk management practices of Company X for the sample project, considerably different results are obtained. For the risk identification phase, as shown in Figures 4.3, 4.4, 4.5 and 4.6, the identification of the risks through TRIMS results with the determination of more activities with risk along with their respective risk levels. The qualification for the levels of risk with TRIMS, results in more realistic risk levels than those determined intuitively by the project team. For risk response planning, the use of TRIMS output matrices puts a more reliable and easy to understand picture of the risks of the project that leads to more applicable risk response plans. Furthermore, a major difference between the current approach and the proposed method is in relation to quantitative risk analysis. The current practices ignore the schedule risks and the effect of the identified risks on the project schedule. However, the proposed method puts forward the impacts of the risks with exact durations on the schedule. This also leads to a better estimation of the costs of the project. For cost risk analysis, the use of Monte Carlo simulation exposed the difference between the intuitive risk compensation and the analysis results. The lesson learned from the differences between the cost estimating practices of the two methods shows that if the cost estimates of the current method are used, the overall cost of the project is underestimated. That means that a proposal submitted with the cost estimates of the current method would lead to a profit loss for Company X.

The application of the proposed risk management method through the business development phase depends on some conditions. In order for the method to be applicable for Company X, the adaptation of the method to the organization is critical. Besides the organizational adaptation, the return on investment for the method must be satisfactory. The benefits that the method proposes must compensate the investments. These investments include the training of the personnel about risk management and the software infrastructure that must be constructed. These conditions are discussed in the following sections of this chapter.

4.3 Risk Management and the Organization

In order to perform risk management practices and thus, carry out the proposed risk management method, the first prerequisite is the assimilation of the risk management concept by the firm. This may require even an organizational change; hiring risk management specialists and forming a risk management team that will perform the risk management activities for all projects of the firm. However, it is not a suitable and feasible way of adapting risk management concepts into Company X, since this increases the costs considerably. Rather than setting up a separate unit, getting the whole staff involved in risk management is a better approach. The staff members who work in the project team must be trained about risk management. The overall awareness of the project teams about risk management increases the effectiveness of the application of the proposed risk management method. Therefore, the first step in the application of risk management concepts in the firm is ensuring the involvement of all staff. This approach also decreases the effort of the project managers in handling risk and makes the identification of risks easier and less prone to errors. Moreover, senior management support is necessary for effective risk management.

In order to draw the attention of senior management to the risk management issue, senior management must be convinced about the benefits of risk management practices. This condition is detailed in the next section of the study.

4.4 Return on Investment and Use of Risk Management Software Packages in Company X

The earnings of firms from the application of risk management practices must exceed the amount of investments in terms of software purchases and necessary trainings. Since Company X has been omitting risk management practices even though other project management practices have been extensively used, the method must not incur large costs and must be satisfactory in terms of increasing the earned value. Therefore, a major consideration in the proposed method has been to keep the associated costs to a minimum. The proposed method avoids the use of expensive risk management software packages available in the market. There are various risk management tools in the market that provide software solutions for all the risk management sub-processes of identification, qualification, quantification and risk response planning. Pertmaster of Primavera Corporation, and GAIN for Risk Management of AIM Software Company are examples of such integrated software packages. Costs of using these software packages are much higher than the add-in software packages proposed in this study. Moreover, there must be well-trained personnel who are capable of using these software tools adequately. The training costs regarding these software packages are also much higher than the general risk management training proposed in the study. Along with the high prices, these software packages are also not well suited to the specific features of the firm's projects. They have inherited features and modules applicable to defense industry projects, however, these modules require considerable amount of past data, which is available neither for the Turkish defense industry sector nor for Company X. These powerful tools are good at handling project risks in environments where past projects are well documented and the inputs and outcomes are recorded.

The method proposed in this study suggests the use of freeware and add-ins. The TRIMS software is a freeware (open to public use) used in the method for risk identification and risk qualification. @RISK for Project suggested for schedule risk analysis and @RISK for Excel suggested for cost risk analysis are much cheaper software packages than the integrated packages of Primavera or AIM. These proposed tools are easy to use and easy to implement to the firm's projects. They are simple tools, however powerful and useful. These tools are also free from the unnecessary applications and data regarding other sectors, they are configurable and flexible, and were created specific to defense industry projects. The advantage of the suggested software tools over the integrated software packages is their direct applicability to the existing business development phase sub-processes of Company X. The integrated tools are stand alone packages that require the development of specific input data, other than the results of the sub-processes in business development phase of the firm's projects. However, the suggested add-ins are integrated into the sub-processes of the business development phase, and they directly use the outputs of the prior sub-processes. Therefore, the use of these add-ins as suggested in the thesis is more advantageous than the use of integrated risk management software for Company X's projects.

CHAPTER V

CONCLUSION

5.1 Discussion

The research problem is based on the lack of risk management practices in Company X, which is an electronics company executing defense projects in Turkish and foreign defense industry markets. The changing market conditions in terms of competitiveness, the increasing complexity of projects with new research and development missions, and the desire of the firm to play important roles in foreign projects necessitate risk management practices in Company X.

The thesis presents a risk management method for the business development phase of the projects of Company X that aims to overcome the shortcomings of current project management practices during this phase. The method offers the integration of risk management sub-processes on top of the existing processes of the business development phase. The necessary inputs are obtained from the existing sub-processes of WBS creating, schedule development, cost estimating and budgeting, and contracting planning and require no additional inputs.

The proposed risk management method is based on the management concepts, application tools, and techniques in the literature. Two features of the method stand out. The first one is that the risk response planning sub-process occurs before the quantitative risk analysis sub-process. This alteration in the sequence of processes reduces the size and complexity of the work.

The second feature of the method is the construction of the risk management plan. The format of the plan and the steps described for filling out the sections in the plan constitute the core of the proposed methodology.

Unlike prescribed practices in the literature, the format includes two new sections: the results and compliancy sections. The results section illustrates the fact that the risk management plan is a live document that is updated after the completion of the sub-processes described in the method. Thus, the iterative nature of the risk management concept is embedded in the method. The compliancy section that is to be completed during the project management phase, aims to constitute a record of the comparison between the risks foreseen in the business development phase and those that actually occur during the project management phase. Thus, the compliancy section constitutes the basis for the development of a risk database specific to the firm's projects. Such a database is necessary for identifying the most likely risks and for the proper assessment of probability distributions in the quantitative analysis sub-process.

The TRIMS software suggested for risk identification and qualitative risk analysis sub-processes is a freeware that supports the risk management method with its powerful visual and statistical outputs. Besides TRIMS, @RISK for Project and @RISK for Excel software add-ins suggested for the application of schedule and cost risk analysis respectively during quantitative risk analysis are easy to use and do not require special skills and more knowledge other than basic risk management concepts. They are compatible with the existing project management practices in the industry and do not require extra work for the determination of specific inputs. Moreover, they are not highly priced and thus are more likely to be approved by top management to support the organization-wide risk management practices proposed in this method.

There are some prerequisite conditions for the application of the method. The acceptance within the firm, especially the senior management support for risk management practices is important. Convincing senior management for the realization of necessary investments like purchase of the software packages, and training the personnel about risk management is a key determinant. Each part of a project may bear risks and the overall awareness of whole organization about risk issues is crucial. Beyond the awareness and the involvement of the firm, awareness

on the part of other stakeholders like the sub-contractors and the authorization bodies will increase the effectiveness of the proposed method.
The proposed method is illustrated with its implementation for a sample project in Company X. The sample project is first used to describe the current risk management practices of the firm, and subsequently to present the application of the proposed method. The outputs of the two methods are compared and discussed. The differences between these methods and the advantages of the proposed method are highlighted through the description of the related risk management sub-processes.

Consequently, the proposed method aims to support Company X to achieve more competitive proposals and feasibility studies with the conception and easily achievable analysis of the risks that may occur in terms of performance, schedule, and cost objectives. The use of the proposed risk management method within the business development phase of the firm's projects intends to increase the competitiveness and the profitability of the firm in the domestic market, as well as in the foreign defense industry markets. Furthermore, the method aims to lead to the construction of the crucial risk databases that would increase the effectiveness of risk management in future projects.

5.2 Recommendations for Future Research

The proposed method concentrates only on the business development phase of projects, but not on the project management phase. The risk management practices in the project management phase must also be studied for the firm's projects. A risk management method that is applicable to the project management phase can be constructed within the same perspective of the proposed method. By the development of such a method, the entire risk management framework can be established. Thus, an overall risk management method that is applicable throughout the lifecycle of projects can be obtained.

Furthermore, the development of a method for risk management in the project management phase would increase the applicability of the method especially in view of the compliancy part of the proposed risk management plan. Thus, the results of the business development phase can be evaluated and refined with the application of a risk management method for the project management phase.

5.3 Further Enhancements of the Method

An important enhancement to the method would be its integration with existing ERP systems (like SAP) in firms. Since these ERP systems are extensively used in the defense industry, the integration of the method would ease the use of the risk management practices in terms of direct data input, as well as its effectiveness in terms of widened scope within the firm.

Another enhancement to the method can be the development of an integrated software that covers all the tools of the method in one package instead of using separate programs like TRIMS and @RISK. This can be extended to cover all the sub-processes of the business development phase. Therefore, with the aid of such a software an integrated management tool for the business development phase would be achieved.

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