Faculty of Business

MSc in Project Management

PROJECT CRISIS MANAGEMENT TECHNIQUES TO OVERCOME THE PROBLEMS OF SCHEDULE DELAYS AND COST OVERRUNS

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Declaration:

I, Mohammad Halloum, Hereby Declare That This Study Has Been Solely Written By Myself, And that All Materials Not My Own Have Been Identified Duly.

Abstract:

The government authorities responsible for the infrastructure in Abu Dhabi/UAE are suffering from the repetitive problems of cost overruns and schedule delays of their development projects. This study shows that more than 93% of the projects reviewed were accomplished with cost enhancements averaging almost 8.7% more than their original budget. Moreover, more than 90% of the projects were executed with schedule delays averaging 8.3% more than their planned duration. Thus, on average, 6.44 million dirhams are being added to the budget of every project during execution, as well as a whole month of delay.

So, this research aimed to resolve these problems by utilizing the concepts of project crisis management. An extensive literature review was conducted to study the causes of project crisis and the techniques that have been proven to overcome and mitigate the problems of cost overruns and schedule delays. The techniques of project planning and initiation along with methods of project monitoring and control were also investigated.

Qualitative and quantitative research methods were used to collect real-life data about the development projects. The qualitative data research aimed to highlight the main drawbacks of the current practices utilized by the government authorities. The quantitative research aimed to determine the main factors for cost overruns and schedule delays. It was found that time enhancement and cost enhancement are correlated with multiple variables including scope identification, rules and responsibilities assignment, initial estimation, project control, technical aspects, and contingency planning. These variables were found to explain 88% of the variation in cost enhancement in the studied projects, and 84% of the variation in time enhancement.

Based on the data analysis, several recommendations, which are essential to fulfill the gaps in the authorities' practices, are proposed in order to increase adherence to project budgets and schedules. The proposed recommendations include incorporating the techniques of lifecycle cost estimation, alternative evaluation, time and cost control, resources monitoring, activities acceleration, and schedule crashing into the project management process. Together, these recommendations form a comprehensive package of proven techniques to overcome the problems of schedule delays and cost overruns in the concerned development projects.

Dedications:

To my great parents,

Ata Halloum and Nuzha Taha

To my beloved brothers and sisters,

Omar, Amjad, Samar and Marah Halloum

I dedicated this study as a small recompense.

Acknowledgments:

I would like to take this opportunity to convey my gratitude to all those who had a part in the completion of this research study.

I would like, in particular, to express my warm thanks and deep appreciation to Dr. Arun Bajracharya, the mentor and the advisor of this dissertation, for the valuable time he devoted to discussing this study and providing insightful guidance along the way. For his tangible contribution to my intellectual development on the subject matter, I owe him an enormous debt. I would also like to offer my thanks to all professors, doctors, and staff of the British University in Dubai.

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And... now and always, Thanks to God.

Table of Contents:

List of Figures:

List of Tables:

1.0 Introduction

1.1 Research Background and Introduction:

Projects, in practice, are often accomplished at costs far higher than initially estimated and with schedules far longer than originally planned. Inadequacies and insufficiencies in the application of project management concepts lead to crises in terms of schedule delays and cost overruns. Yet a growing body of research shows that with proper project management, potential crises can either be averted or mitigated, thereby saving significant amounts of time and money for the associated companies. Through the use of proven crisis management techniques, those entities involved with managing projects can overcome the problems of schedule delays and cost overruns resulting from project crises. "The objectives of both project management and the project are different and the control of time, cost and progress, which are often the project management objectives, should not be confused with measuring project success" (Munns and Bjeirmi, 1996, p.83).

Project management was recognized as "an efficient tool to handle novel or complex activities" (Avots, 1969, p.77) since it was developed as a studied science. Furthermore, project management has been developing to become a distinguished organization structure for organizations that are specialized in managing projects. Back in 1969, Avots had suggested that it is more efficient than traditional methods of management, such as the practice of functional divisions in a formal hierarchical organisation, for handling projects. Anderson and Merna (2003) claimed that project failures or poor performances are "often originated in poor management particularly at the front-end rather than poor downstream execution" (Anderson and Merna, 2003, p.388). Conversely, it has become commonly known that the successful implementation of project management techniques contributes to a successful project (Avtos, 1969; Duncan and Gorsha, 1983; Lackman, 1987; Wit, 1988; Munns and Bjeirmi, 1996).

In today's highly competitive business environment, project management's capability to schedule activities and control progress within strict cost, time, and performance guidelines is becoming increasingly important (Siemens, 1971). According to Chen (2007), this is happening in order to gain competitive priorities such as on-time delivery, on-budget commissioning as well as customization. Consequently, companies should carefully plan for their future projects and have clear estimates of the total life cycle cost in order to allocate the desirable budget.

Additionally, the precise project's schedule has to be cautiously prepared and highly detailed to adequately control the overall stages of the project. According to Kramer and Hwang (1991, p.53), "a project schedule greatly influences the ultimate success or frailure of the project".

However, it is well known that projects rarely run according to plans and estimates. As frequently noted by researchers, delays and over costing are common phenomena in the construction industry worldwide (Chan et al., 1997; Frimpong et al., 2003; Koushki et al., 2005; Arditi et al., 2006; Abdul-Rahman et al, 2008). Due to several internal and external reasons, projects fall behind original schedules and run above the allocated budgets. "In engineering and construction projects, plans and cost estimates are usually drawn to ensure that the work is carried out to the desired quality, in the allowed time, and within budget. However, we often hear about projects with delays and where the costs tend to be higher than depicted by budget" (Karlsen and Lereim, 2005, p.24). This problem of cost overruns and schedule delays is commonly facing the projects managed by the government authorities. This particular problem is being tackled as a crisis in the project lifecycle that might result in cancelling the project after initial execution or in finishing the project without delivering its goals and objectives.

Delay and cost overrun of governmental and mega projects are not merely a 'leakage' in the construction industry (Aibinu and Odeyinka, 2006), they are also a catastrophe to the construction industry and to the nation (Abdul-Rahman et al, 2008). At the macro level, delay and cost overrun lead to a negative rate of national economic growth (Arditi et al., 1985; Lo et al, 2006), contribute to financial loss (Mezher and Tawil, 1998) and hold back the development of the industry (Odeh and Battaineh, 2002). At the micro level, a project with time and cost overruns can lead to dispute, arbitration, litigation, and total abandonment (Sambasivan and Yau, 2007). In addition, it can result in loss of productivity, acceleration, and contract termination (Arditi and Pattanakitchamroon, 2006). In general, the final quality will be reduced (Hong and Proverbs, 2003), and the developers' financial and sales commitments will be reduced (Benson, 2006). Thus, the completion of a construction project on time and on budget is highly conceived as a major criterion of project success (Rwelamila and Hall, 1995) especially in the case of developing countries (Abdul-Rahman et al, 2008).

One of the main reasons for project cost and time crises is insufficient project initiation and identification processes (Ward, 1999). The Millennium Dome in London, England was a valid example for a project crisis due to improper project identification problems (National Audit

Office, 2002). “The dome has cost the government £21m over the past year while it stood empty” (Guardian, 2001). Furthermore, cost overrun and time enhancement problems occur because of wrong initial estimations and lack of proper monitoring during execution. “An obvious aspect of uncertainty in any project concerns estimates of potential variability in relation to performance measures like cost, duration, or quality related to particular planned activities” (Atkinson et al, 2006, p.688). An example of cost and time crises in this regard is the Big Dig project in Boston, U.S.A (CNN, 2006) that ended up with about 1000% in extra costs and delayed for many years (Boston Globe, 2008).

Another reason for project cost and time crises is the involvement of multiple parties and stakeholders in a mismanaged situation (Loosemore, 1998). A recent example of a project that led to huge cost crises is the disastrous Deepwater Horizon Oil Rig project of British Petroleum Company. The Oil Rig's explosion "was the result of multiple equipment errors and human error involving many companies”, BP chief Tony Hayward said (CNN, 2010). In addition, some project crises occur due to unforeseen technical difficulties. Lack of technical experience (Abdul-Rahman et al., 2006) and inadequate contractor’s experience (Sambasivan and Yau, 2007) constitute the major delay factors in project crises (Abdul-Rahman et al, 2008). A well known example of a project in this regard is the Sydney Opera House in Australia (Braithwaite, 2007). Due to the ignorance of possible technical problems since the original design required advanced technology that was not available, the project was finally completed in 1973. Its total cost amounted to $102 million, 15 times the original estimated budget (Shenhar and Dvir, 2008).

Today, project management techniques are being investigated and developed that can be implemented and used to better understand the project lifecycle’s uncertainties, to minimize the opportunities of their occurrence and finally to mitigate their results if they occur. “Crises in projects are inevitable. Yet, the destructive consequences of many crises can be reduced through the effective use of planning tools from emergency management” (Mallak et al, 1991, p.430). Over the last 3 decades, crisis management as a theoretical study field has evolved from the relatively long tradition of research into practiced management processes (Shrivastava, 1994). Actually, throughout a crisis, ‘configurations’, ‘interests’, ‘values’, ‘perceptions’, ‘bargaining’ and ‘decision-making progressions’ come into sharp focus (Rosenthal and Kouzmin, 1993). Moreover, because a large number of forces interact during a crisis, crisis management “provides an excellent context for the integration of theory” (Loosemore, 1998, p.139).

Aiming to facilitate the success of projects, the concept of crises, project crises and project crises management have been extensively studied and introduced in this contribution. This is, first of all, for project managers and personnel to understand the characteristics of crises that may interrupt projects. Then, this study is focused on the project's budgets and durations in order to assist in understanding the main reasons that lead to cost overruns and schedule delays. Finally, the extensive study of project crises has been followed by the study of project Crisis management. This is to enable project personnel to understand the dynamic and continuous process. This process includes both proactive and reactive actions with the aim of identifying the crisis, planning a response to the crisis, confronting the crisis, and resolving the crisis. "Crisis management process constitutes three main periods that are before, during and after the crisis" (Ocal, Oral and Erdis, 2006, p.1499).

Currently, the construction industry plays a major role in the development of many countries. Infrastructure and construction projects are becoming one of the most important economic growing sectors in the United Arab Emirates (UAE) with 10% growth in 2005. Accordingly, this field has an effective influence in UAE economic growth; for instance, in 2005 it represented 8% of the growth domestic product (GDP) and 11% of the non oil GDP (Human Rights Watch, 2009). The Abu Dhabi 2030 vision plan has opened new complete infrastructure and construction markets for governments, developers and investors. This vision includes the city of Abu Dhabi, Al Ain and the Western Region (Al Gharbia), where many large scale projects will be constructed such as Al Raha Beach Complex, Reem Island and Abu Dhabi Sewage Tunnel – the world's deepest and longest sewage tunnel.

The case of Abu Dhabi city has been the focus in this dissertation. Specifically, the government infrastructure authorities have been considered as the study scope. The 'development infrastructure projects' have been intensively studied, investigated and analysed in this study. It is typical for these kinds of projects to be accomplished with an higher costs and delays in the schedule than the original estimations in the project plans. Thus, qualitative analyses followed by statistical quantitative analysis have been carried out to study the development projects that are executed by the infrastructure government authorities in Abu Dhabi. These analyses aimed to determine the main motives that affect the concerned projects and lead to cost overruns and schedule delays. Additionally, the analysis highlighted the main drawbacks in the existing practises in the project management procedures of the government authorities, in order to help modifying the processes and procedures to overcome the frequent problem of money and time enhancements.

Finally, recommendations have been proposed based on the literature review and the data analysis. The recommendations provide practical techniques needed to prepare for the problems of cost overruns and schedule delays and to mitigate them once they have occurred. The proposed recommendations include incorporating the techniques of lifecycle cost estimation, alternative evaluation, time and cost control, resources monitoring, activities acceleration, and schedule crashing into the processes of project management within the concerned authorities. Finally, some of the proposed techniques to be utilized have been implemented on some real project cases.

1.2 Research Problem

This research investigates the frequent problems of cost overruns and schedule delays for projects initiated by Abu Dhabi government authorities. Both problems are making the process of executing the governmental infrastructure projects inefficient, and causing the projects to be accomplished with extra costs beyond the allocated budget and lots of delays further to the planned duration. In here, the study focuses on the infrastructure development projects being executed through the main five authorities responsible for the infrastructure of Abu Dhabi, the capital of the United Arab Emirates.

For any construction project, three main define success at a project's conclusion: cost, time and quality. So, for a project to be defined as a success, it should be appropriately accomplished achieving its desired deliverability within the required time, within the allocated budget, and with the required quality. It should be mentioned here that the United Arab Emirates in 2010 has been ranked sixth in the world regarding the quality of its infrastructure (WAM, 2010). That ranking was according to a report issued by the World Economic Forum, which is an independent, international organization incorporated as a Swiss not-for-profit foundation.

Of the three main constrains of the construction projects, quality should not be achieved at the expense of the other two essential variables of time and money. However, the infrastructure projects in Abu Dhabi frequently face the problems of cost overruns and schedule delays during execution. Those two problems can be defined at a certain point as project crises. So, this particular study focuses on identifying the main reasons that lead to those two problems in particular. Additionally, the current project management practises are investigated in order to highlight the major drawbacks that need to be improved. Finally, some project crises management techniques are extensively studied and selected techniques that would assist in mitigating the problems and minimizing their impacts are proposed.

1.3 Aim and Objectives

The aim of this particular dissertation is to study the principles of projects crisis and to examine several techniques that can be used in the planning, controlling and mitigation stages to overcome the problems of schedule delays and cost overruns. Then, a combination of techniques is proposed to accelerate schedules and optimize budgets.

The objectives of this paper are to:

- Examine the concepts of project crisis in general in regards to budget delays and schedule overruns.
- Investigate the main drawbacks of project management practices and examine statistically the main project uncertainties that lead to budget overruns and schedule delays in the projects within the study scope.
- Explore better planning, estimation, monitoring and control practices and estimation techniques, including risk assessment and contingency management.
- Study the methods that can be used to accelerate activities, and link them with schedule crashing principles to propose a complete strategy for project cost/duration optimization, taking into consideration rewards and penalties.
- Illustrate some of the proposed techniques on real life project cases.

1.4 Research Scope

This particular research aims to deal with the ‘infrastructure development projects’ in Abu Dhabi, the capital of the UAE. These projects are being executed to improve and develop the infrastructure of the existing areas of the city and to develop the infrastructure of new areas stated for construction. It should be highlighted that those concerned projects are usually being executed by the main government authorities who are responsible for the infrastructure in Abu Dhabi. These government authorities contribute all together in the execution of those development projects.

In the data collection stage of this study, the focus will be on the infrastructure government authorities that are responsible of the infrastructure projects in Abu Dhabi. The said authorities are as follows:

- Abu Dhabi Municipality (ADM): the authority responsible for the task of providing comprehensive services to the public and ensuring proper planning of the developing city of Abu Dhabi, with regularized road networks, maintenance services, lighting works, launching the Agriculture Development Plan in the Emirate and establishing public markets in various areas.
- Abu Dhabi Water and Electricity Authority (ADWEA): the government authority responsible for planning, development, operation, and maintenance of the water and electricity infrastructure in Abu Dhabi. As well, it is the monopolistic authority licensed to supply power and water to citizens in the Emirate of Abu Dhabi.
- Abu Dhabi Sewage Systems Company (ADSSC): the government authority responsible for planning, development, operation, and maintenance of the sewage systems in the city of Abu Dhabi. ADSSC’s operating license stipulates protecting the environment, public health and customer interests by regulating the activities of wastewater collection and treatment and the safe and sustainable disposal of end products.
- Etisalat: a semi-governmental authority responsible for the development of the communication network in the city. It is a comprehensive telecommunications provider for mobile and fixed-line voice and data services to individuals,

enterprises and international telecommunications companies, ISPs, content providers and mobile operators.

- Town Planning Department: the organization responsible for managing the processes of the detailed urban planning development.

Thus, in this study the infrastructure projects of water pipelines, power and electricity networks, communication cables, road projects and sewage networks will be included. For the sake of accessibility of data, the research is limited to projects accomplished in the years from 2007 to 2009.

It should be noted that this study will only tackle the infrastructure part of the development projects. It will not be concerned with any other construction activities that relate to the superstructure development of the projects.

2.0 Literature Review:

2.1 Introduction to Crisis:

A crisis is "a situation faced by an individual, group or organisation which they are unable to cope with by the use of normal routine procedures and in which stress is created by sudden change" (Booth, 1993, p.56). In any field, a crisis is an unexpected event in an organisation's life, for which there are no contingency plans in place, which threatens high priority goals and demands a time-pressured response (Shrivastava, 1994). Crises may be allied with disasters, but not necessarily. Crisis, according to Hallgren and Wilson (2008), is any incident that poses a threat to an organization's security or has an adverse impact on its financial situation, relationships, or reputation in the marketplace.

Moreover, Heath (1998) described crisis as a period of sudden change during which a totally new system is formed that contains not only risk, threat, uncertainty, accident, conflict, and instability but opportunity as well. Ocal, Oral and Erdis (2006) mentioned that crisis can be either abrupt or cumulative. They described 'abrupt crisis' as an unexpected impact of internal and external disturbances that is generally more specific, but less predictable than a 'cumulative crisis'. In contrast, cumulative crisis is foreseen although it may occurs suddenly.

The crisis occurrences can be seen, to a certain extent, as an examination of the response capacity of the concerned organization. Thus, when they occur, crises highlight weaknesses in the organizations which would normally remain hidden (Loosemore, 1998). Hermann (1963, p. 64) defined a crisis with 'negative behaviours' as a "stimulus to which certain kinds of behaviour like anxiety or panic are possible responses". However, Loosemore (1998) pointed to a whole range of behaviours which can be both helpful and destructive. At one extreme, a crisis can result in more integration and innovation within an organization. On the other, it can lead to destructive and compromising behaviours.

2.2 Crisis Management:

Crisis management as a theoretical study field has evolved over the last 'three decades' from the relatively long tradition of research into disaster management (Shrivastava, 1994). Driving forces for the evolution of crisis management research into its own field were "first provided by international political instability, then by rapid technological advances and more recently, by an increasingly hostile business environment" (Loosemore, 1998, p.139). Because crises are unique laboratories of human life processes which lie at the very core of management, crisis management's value in other contexts is already becoming obvious though its research is in its infancy (Rosenthal and Kouzmin, 1993). In actuality, throughout a crisis, configurations, interests, values, perceptions, bargaining and decision-making progressions come into sharp focus. Moreover, because a large number of forces interact during a crisis, crisis management "provides an excellent context for the integration of theory" (Loosemore, 1998, p.139). According to Ocal, Oral and Erdis (2006, p.1499),

> Crisis management is a dynamic and continuous process that includes both proactive and reactive actions with the aim of identifying the crisis, planning a response to the crisis, confronting the crisis, and resolving the crisis. Crisis management process constitutes three main periods that are before, during and after the crisis.

In their crisis management process, Ocal, Oral and Erdis (2006) proceeded to mention three main stages to manage the crisis as follows:

1- Management before the crisis. Crisis management before the crisis focuses on two main issues. The first is "issue analysis" which is the recognition of the possibility of any crisis occurring as well as the recognition of any potential causes of crisis. According to Kash and Darling (1998), many organizations fail to take steps to proactively plan for crisis because they fail to recognize the possibility of any crisis occurring. Secondly, an 'Early Warning System' is required. An early warning system provides the organization a continuous review of current performance with respect to the plans. Any changes that may result in a crisis are then recognized. Moreover, threats and opportunities stemming from the potential crisis can then be assessed if the crisis can not be prevented. Such a warning system will enable the organization to act before the crisis. As Maynard (1993) mentioned, for organizations that prepare proactive crisis plans, decisions during crisis are more balanced and crises are of shorter duration.

2- Management during the crisis. Management during the crisis is facilitated by a plan that guides both the management and the employees on what should be done in order to get the crisis under control with the least loss. Decisions during crisis are usually made under pressure, uncertainty and little time. Therefore, use of teamwork and decision-making techniques are essential to reach objective decisions (Ocal, Oral and Erdis, 2006). Moreover, the management should focus on increasing productivity and raising motivation both of which are needed to mitigate the organizational loss because of the crises.

3- Management after the crisis. Activities after the crisis should analyze the current situation. New directions taken by the organization should be decided by analyzing the impact of the crisis on the organization. Feedback on managerial, financial and organizational performance should be used to adopt the missions and policies of the organization (Ocal, Oral and Erdis, 2006). Consequently, strategic repositioning along with a series of changes in the structure, systems, and processes need to be undertaken in order to overcome the impact of severe crises (Hwang and Lichtenthal, 2000).

Similarly and in greater detail, Jaques (2007) conceptualized crisis management as a continuous discipline based on 'clusters and non-linear elements' that forms a relational model shown in Figure 2.1. The model's non-linear structure emphasizes that the elements should be looked at as 'clusters' of interrelated and integrated disciplines rather than 'steps' to be undertaken in a sequential manner. The clusters of his model are as follows:

1. Crisis preparedness
    a. Planning processes: Includes putting planning in place, assigning roles and responsibilities, and establishing process ownership.
    b. Systems and manuals: Includes crisis management infrastructure, equipment, resources, and documentation.
    c. Training and simulations: Includes programs familiarization, testing, and live simulations.
2. Crisis prevention
    a. Early warning: Includes processes that evaluate the current performances.
    b. Issue and risk management: Includes identification and prioritization of risks to develop and implement strategies.
    c. Emergency response: Includes infrastructure, documentation, and training.

3. Crisis incident management
    a. Crisis recognition: Includes objective assessment.
    b. Systems activations/response: Includes the activation process.
    c. Crisis management: Includes strategy selection and implementation, damage mitigation, stakeholder management, and media response.
4. Post-crisis management
    a. Recovery and resumption: Includes operational recovery and financial retention.
    b. Post-crisis issue impacts: Includes coronial inquests, judicial inquiries, prosecution, litigation, reputational damage, and media scrutiny.
    c. Evaluation and modification: Includes root cause analysis and management assessment.

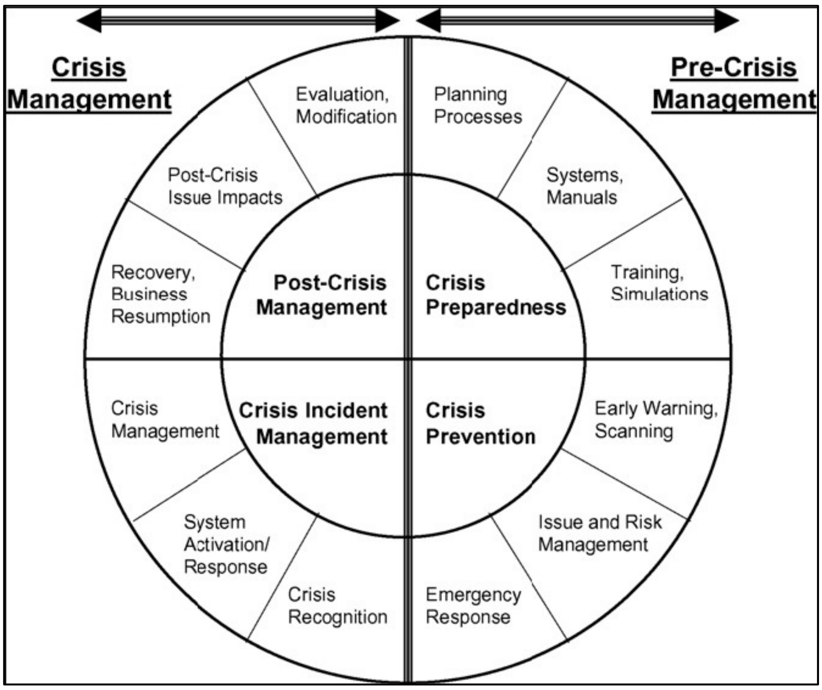

Figure 2.1: Crisis Management Rationale Model. (Jaques, 2007, p.150)

In this particular study, the literature review will focus on the project crises of budget overruns and schedule delays. In this regard, extensive research will be conducted to determine the roots of such crises. Additionally, the crisis management phases of project planning, project control and crisis mitigation will be extensively studied in order to merge them as a one technique package.

2.3 Project Crisis Reasons:

The aim of this section of the dissertation literature review is to cover all reasons that lead to a potential crisis in a certain project. It should be mentioned that no particular studies in the literature were found that focus on reasons behind project crisis in the UAE. Therefore, the recognized crises reasons in other contexts, which are studied and mentioned in the literature, would be identified regardless of the nature of the project field in which it was researched or the geographic location with which it was associated with. Then those causes would be analysed through linking them particularly to the scope of this study and the field of project being tackled. Through the qualitative study approach, all identified causes would be categorized into groups which would be analysed statistically throughout the quantitative study approach later.

One of the main reasons for project cost and time crises is the insufficient project initiation and identification processes (Ward, 1999). The Millennium Dome was and still is a valid example for a project crises due to improper project identification problems. The Millennium Dome is a project, consists of a large dome-shaped building, originally used to house the Millennium Experience, a major exhibition celebrating the beginning of the third millennium (National Audit Office, 2002). Still, the project and exhibition were the subject of considerable political controversy as it failed to attract the number of visitors anticipated, leading to recurring financial problems (BBC, 2001). By the end of the millennium exhibition, the dome was left empty because the purpose of the project was not set clearly. “The dome has cost the government £21m over the past year while it stood empty” (Guardian, 2001).

Other reasons for cost overrun and time enhancement problems are the wrong initial estimations and lack of proper monitoring during execution. “An obvious aspect of uncertainty in any project concerns estimates of potential variability in relation to performance measures like cost, duration, or quality related to particular planned activities” (Atkinson, Crawford, and Ward, 2006, p.689). An example of cost and time crises for this regard is the Big Dig project that incurred about 1000% extra costs with many years of delay. The Big Dig, the unofficial name of the Central Artery/Tunnel Project (CA/T), is a megaproject in Boston that rerouted the Central Artery, the chief highway through the heart of the city, into a 3.5 mile (5.6 km) tunnel. The project also included the construction of the Ted Williams Tunnel, the Leonard P. Zakim Bunker Hill Memorial Bridge over the Charles River, and the Rose Kennedy Greenway (LeBlanc, 2007). By the end of the project, The Big Dig was the most expensive highway project in the

U.S. at its completion time (CNN, 2006). Even though the project was initially estimated in 1985 at $2.8 billion (Johnson, 2006), the total costs were raised up to $22 billion according to the Boston Globe (2008).

Another reason for project cost and time crises is the involvement of multiple parties and stakeholders in a mismanaged situation (Loosemore, 1998). A recent example of a project that led to huge cost crisis is the Deepwater Horizon project of British Petroleum Company. The Deepwater Horizon project is a semi-submersible mobile off shore drilling unit. It consisted of a massive floating, dynamically positioned drilling rig that could operate in waters up to 8,000 feet (2,400 m) deep and drill down to 30,000 feet (9,100 m) (Robertson and Krauss, 2010). The project was 9 years old when it turned into the largest accidental marine oil spill in the history of the petroleum industry (USA Today, 2010). As a sequence of the disaster, BP has accepted responsibility for the cleanup and has set aside a $20 billion escrow fund to pay for damages. BP chief Tony Hayward said the disaster "was the result of multiple equipment errors and human error involving many companies" (CNN, 2010).

In addition, some project crises occur due to unforeseen technical difficulties. Lack of technical experience (Abdul-Rahman et al., 2006) and inadequate contractor's experience (Sambasivan and Yau, 2007) constitute the major delay factors in project crises (Abdul-Rahman et al, 2008). A well known example of a project in this regard is the Sydney Opera House. The Sydney Opera House is a multi-venue performing arts centre in Sydney, Australia (Braithwaite, 2007). The construction was estimated to take about five years at a cost of $7 million (Arup and Jenkins, 1968). The project was delayed until 1973, due to the ignorance of the possible technical problems since the original design required advanced technology that were not available. Its total cost amounted to $102 million, almost 15 times the estimated budget (Shenhar and Dvir, 2008).

Loosemore (1998) identified three main managerial causes of crises in construction projects and called them 'the three ironies'. He stated that crises are less likely to occur at a time when effective communication is important, at a time when mutual sensitivity between project members is important, and at a time when collective responsibility and teamwork are important. Effective communication is essential in bringing efficiency because it stabilizes the significant social, financial and technical changes that occur within project lifecycle are demanded by a crisis. Loosemore (1998) gave two explanations for the emergence for this 'irony', information being a source of power in resolving conflicting interests and the amount of information created during a crisis.

Additionally, while the project is being executed, selfish tendencies of individuals emerge because of the different aim perspectives of different parties. This in return tends to generate conflicts of interests between project participants with responsibility for the protection of different project objectives. Above all, collective responsibility identification and effective teamwork characterization are crucial to minimize project crises. This is because each crisis demands an injection of extra resources that need to be determined and supplied (Loosemore, 1998). Moreover, teamwork is needed to be influenced in order to eliminate polarization of a certain party among others.

In the same regard, Atkinson, Crawford, and Ward (2006) categorized the reasons behind project crises into three key areas of uncertainties: uncertainties associated with estimating, uncertainties associated with project parties, and uncertainties associated with stages of the project life cycle. Accordingly, they claimed that good project management practises that minimize crises can be thought of as effective project uncertainties management. Uncertainties management includes clarifying all of what can be done, deciding on what to be done, and ensuring that it gets done as decided.

The process of planning is considered to be one of the major stages in the project management cycle that generate project uncertainties. "An obvious aspect of uncertainty in any project concerns estimates of potential variability in relation to performance measures like cost, duration, or quality related to particular planned activities" (Atkinson, Crawford, and Ward, 2006, p.691). The sources of uncertainties concerning estimates include one or more of the followings:

- Lack of clear specification of the requirements
- Novelty or lack of past experiences of the particular project in progress
- Complexity in terms of the amount of controlling factors.
- Inadequate analysis of the processes engaged with the project.
- Emerging conditions unknowable at the early stages of the project.

In addition, especially in large projects, key performance issues are often related to conflicts introduced by the existence of multiple parties. Thus, according to Ward (1999), uncertainties arise from several factors associated with project parties, including the following:

- Vagueness regarding the level of performance that will be achieved.
- Differences in objectives and motivations of different parties.
- The extent to which different objectives are allied to each others.
- The different abilities of parties involved.
- The availability of parties at all stages of the concerned project and their interest of other parties' scope.

Finally, Atkinson, Crawford, and Ward (2006) stated that the third motive for crises is the uncertainties associated with different stages in the project lifecycle. In their study, they identified several uncertainties that have been categorized based on the stage they occur in during the project lifecycle. In this regard, all kind of uncertainties associated with project conception, design, planning, resource allocation, execution, delivery, and finally commissioning are clarified (Ward and Chapman, 1995). Atkinson, Crawford, and Ward (2006) in their analysis proposed that all uncertainties associated with each project phase are fundamental to be examined and the implications of their interaction to be identified. In here, they concentrated on the design and planning stages because they argued that these stages would result in insufficient execution if they were not done effectively and if all specifications were not well defined.

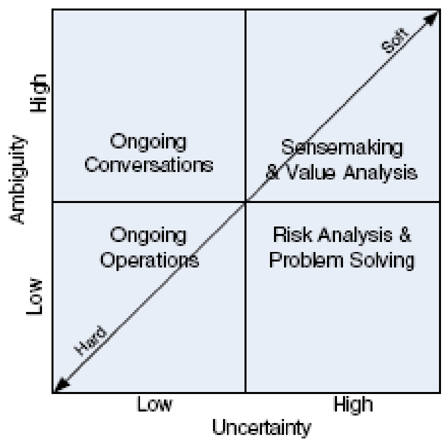

Figure 2.2: Uncertainties – Ambiguity relationship. (Thiry, 2002, p.224)

Furthermore to Atkinson et al (2006) analysis, Thiry (2002) made a clear distinction between projects' uncertainties and ambiguities as shown in Figure 2.2. According to Thiry (2002), uncertainty is defined as the lack of information due to the dissimilarity between the required information and the already possessed information. On the other hand, ambiguity is the lack of understanding linked to confusion because of the existence of multiple and conflicting interpretations. In this regard, reasons behind project crises are divided into the lack of objective information and the answering of specific questions on one hand, and the lack of sense-making and the situation on the other.

In Pearson and Rodinelli's (1998) study of project crises in European firms, they focused on the environmental liabilities and the potential for project crises. They stated that environmental liabilities have slowed the execution of private projects for many state-owned enterprises in Central Europe. Subsequently, investors have become more sensitive to the financial costs and potential damage to their reputations from crises caused by poor environmental performance (Pearson and Rodinelli, 1998).

In addition, Ocal, Oral and Erdis (2006) studied the projects of the top 120 construction companies in Turkey. In their study, they focused on testing the environmental and organizational factors of project crises. Their analysis showed that government policies and unstable market conditions were the most effecting environmental causes that lead to crises. Lack of financial support, inadequacy of human resources and inadequate organizational structure were, on the other hand, the most important Organizational causes for project crises (Ocal, Oral and Erdis, 2006).

The planning process of any project should never be subjectively expedited aiming to start the execution early. "Situations varied, but from start to finish the project plan would be normally finished in two weeks" (Hallgren an d Wilson, 2008, p.833). It should be noted that an essential chapter in project plan is risk management where all potential risks should be highlighted as well as the potential to avoid them. According to Hallgren and Wilson (2008, p.833), "[risk management] is implemented in order to avoid cost and time overruns. It includes maximising the results of positive events and minimising the consequences of negative events". In their study, Hallgren and Wilson (2008) identified 15 sources of crises where nine of them dealt with contract disputes of different forms where four in concern with clients, three with sub-contractors and two with suppliers. However, it should be mentioned that the top crises source on

Hallgren and Wilson (2008) list is the under-estimation of time and cost at the planning stage of the project.

Above all, Kursave (2003) claimed that the project schedule should always be updated even when the execution stage starts. That is because there are certain factors that influence the project plans to be delayed including the following:

- Incorrect estimates of activity durations.
- Unforeseen weather conditions or site hazards.
- Unpredictable delays in material deliveries.
- Added or reduced quantities of work.
- Strikes or other labor trouble.
- Unexpected site conditions.

2.4 Project Planning:

Management of complex projects that consist of a large numbers of interrelated activities poses problems involved in planning, scheduling, and control, (Kelley, 1961; Lamberson and Hocking, 1970; Liu, 2003) especially when the project activities have to be performed in a specified technological sequence (Falk and Horowitz, 1972; Robinson, 1975). Liu (2003) insisted on the great assistance of the program evaluation and review technique (PERT) and the critical path method (CPM). He stated that with the help of those methods, “the project manager can schedule project activities at appropriate times to conform with proper job sequences so that the project is completed as soon as possible” (Liu, 2003, p.162). Closely associated with the philosophies of PERT and CPM is the problem of resource utilization to reduce total project duration (Berman, 19634). Determining how to optimally allocate further resources to the project in an effort to reduce the duration of the entire project is also a challenge to the project manager (Gould, 2005).

In today’s highly competitive business environment, project management’s capability to schedule activities and control progress within strict cost, time, and performance guidelines is becoming increasingly important (Siemens, 1971). “Time and cost estimates are the building blocks of project planning and management. Estimates are used to ascertain project feasibility and to develop and maintain detailed schedules and plans” (Adeli and Karim, 2001, p.101). According to Chen (2007), this will result in gaining competitive priorities such as on-time delivery, on-budget commissioning as well as customization. In most of the cases, projects can be really complicated and challenging to be managed. According to Goyal (1975), critical path method (CPM) has been proved to be a reliable tool in managing projects in an efficient manner to meet this challenge. However, in many situations, the project must be completed in a time which is less than the critical path duration, under budget constraints. That multi-constrained challenge was treated by several algorithms such as project crashing (Feltz, 1970).

Further in the discussion, the literature review of project planning will focus on risk analysis, project life cycle cost estimation and value management, as well as time planning and network scheduling.

2.4.1 Time / Cost / Resources Trade-Offs:

In general, the duration of any activity of a project can be controlled and shortened by the allocation of more resources to the activity (Liu, 2003). However, the project time/cost trade-off problem represents a particular class of project resource allocation problems. The key question is, "Which activities in a project should be modified in duration in order to shorten the total project duration by a specified amount at a minimal additional direct cost?" (Phillips and Dessouky, 1977, p.393). In this situation, the project manager is concerned with the allocation of additional resources which will permit a faster completion of project activities. Thus an earlier project completion time would be the result. In this particular research, the resources are not considered explicitly, but the associate composite costs of utilizing them are recognized only. Activity's cost functions are defined over a range of durations bounded by the normal and crash durations. The normal duration for an activity represents activity completion time when the normal level of resources is assigned. The crash duration represents the shortest possible activity completion time that requires the use of the maximal resources (Moore, Taylor, Clayton and Lee, 1978).

In the same concern, the project management time/resource trade-off analysis addresses the issue as to “which activity or activities in a project should be allocated additional resources in order to reduce the total project duration by a required amount of time at a minimal level of additional resource expenditure?” (Phillips, 1996, p.697). A project is defined as a set of activities that must be completed in a predetermined progression. According to Fulkerson (1961, p.169), in any project, “the concern is duration time and resource level for completing the project in an expected time interval or for completing the project in less time than the expected or normal time”. This reduced completion time interval can be attained only by incurring supplementary direct costs due to the allocation of supplemental resources (Phillips, 1996).

2.4.2 Risk Analysis:

All projects are exposed to many kinds of risks from the first initiation to delivery and implementation that can be result in project crises as stated previously. The sources of risk can be divided into internal and external factors. Internal factors include project technical complexities, internal management policies, routines and procedures, organizational and personnel competences, management skills, and the organizational internal culture. External sources on the other hand include inflations, market fluctuations, weather conditions, government policies, technology development, other involved organizations and stakeholders. Consequently of all, significant attention should been given to all kinds of risks in order to ensure comprehensive identification and objective assessment of project risks to provide a clear understanding of the extent of risk exposure faced by a project. Those practises would initially give an attention and assessment of the crises reasons in order to minimize their occurrences.

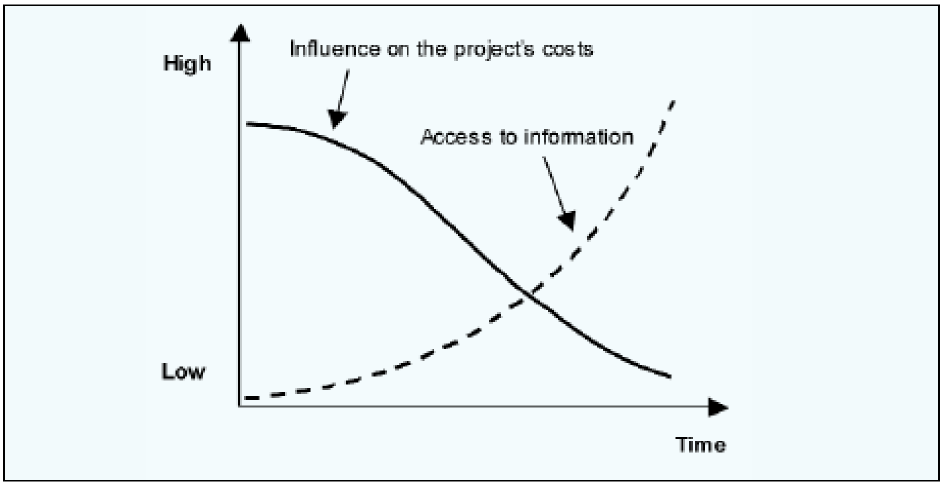

Figure 2.3: The information / influence gap. (Karlsen and Lereim ,2005, p.24)

In projects and particularly in construction projects, time plans and cost estimates are generally practised to make sure that the desired work is carried out to the required quality, in the allowed time, and within budget. Nevertheless, projects are often accomplished with delays in the plans and extra costs higher than allocated budgets (Robin, Richard and Winterfeldt, 2002). This is a frequent occurrence due to a certain margin of risk is inherent in all projects. The reason behind that is because project managers commonly face an information and influence dilemma in the early phases of the project. It is well known that the possibility to influence and change the project is highest in the early stage of the project while the conceptual decisions have not yet been made or taken effect. However, the ability to access information is limited at the same time, as shown in Figure 2.3. As per Dong and Hartman (2000), it is hard to achieve accurate estimations about what the final cost and schedule will be. That is because relatively little precise information is obtainable about the main cost and schedule drivers.

Consequently, risks are a major cause of projects' problems, disputes, disruptions, delays and cost overruns (Dong and Hartman, 2000). As a result, risk management is important to account for the cost and time impacts of risks may occur. According to Karlsen and Lereim (2005, p.24), "it is therefore of utmost importance to establish a standard and practice for deriving a consistent set of cost estimation, including uncertainty and the use of risk reserves figures as the basis for the project budget and master control estimate". As well, according to Williams (1999), it is essential to consider the delays of activities, especially the critical ones that largely affect the overall duration of the project, as part of the risk analysis. In this regard, both cost and time contingencies of risks will be tackled.

Since each of these risk sources can be a reason that leads to a crisis, project personnel should give considerable attention to them. That is in order to ensure that broad identifications and intention assessments of project risks are made, providing a clear understanding of the extent of risk exposure the project is facing. The starting point of the risk analysis is risk identification. According to Karlsen and Lereim (2005, p.25), it should be practised

> to identify all the risk items that could affect the project in terms of performance, cost, or schedule. This step is of paramount importance in the frame of risk management. It does not matter how good the risk assessment is, if you have not identified the key risks that might affect the project.

Then, the second stage of the risk analysis is to assess and quantify the effects of each risk source on the project. The purpose of this step is to verify the magnitude of all risks individually and to rank them with respect to cost and time impacts. To accomplish this purpose, it is essential to determine the occurrence probability and the consequence severity of each risk identified in the previous phase (Abrahamson, 1984). This risk analysis process should be practised hand in hand with the process of cost and time estimations. Consequently, through performing risk analysis, project management will be able to get an early warning of potential cost and time deviations. Finally, the harmful impacts of all associated risks can be assessed and then evaluated to determine risk reserves (Karlsen and Lereim, 2005).

In regards to cost estimation, in most situations, they are estimated as point estimates. Point estimates are defined as "a single value estimate based on the most likely values of the cost elements" (Karlsen and Lereim, 2005, p.25). However, as Picken and Mak (2001), the single estimates should not accurately indicate the possible value of the cost estimates. As well, they do not indicate the possible range of values an estimate assumes. That would mean that the estimates are dangerous at the time they do not include the risks of the previously identified projects' crisis reasons. Consequently, as it is well known, an essential part of the cost estimation practises is the process of risk analysis. However, as claimed by Karlsen and Lereim (2005, p.25), "although project risk management has been practiced for almost 20 years, most of the methods, techniques and its application are more recent phenomena".

Many techniques and approaches have been proposed in literature for the estimation of risk reserves. The most traditional method of considering risks is to add a percentage figure to the most likely estimate of final cost estimation as shown in Figure 2.4. The percentage added usually normally ranges between five and ten percent. The purpose of this approach is to make sure that the estimated budget is sufficient to include any cost deviation caused by risks. However, as David and Mak claimed (2001), this approach is weak at the time it is based on subjective estimation. Another weakness of this approach is that the percentage added cost is still result the of a single figure prediction of cost, which is the same problem as that of the cost estimation (Karlsen and Lereim, 2005).

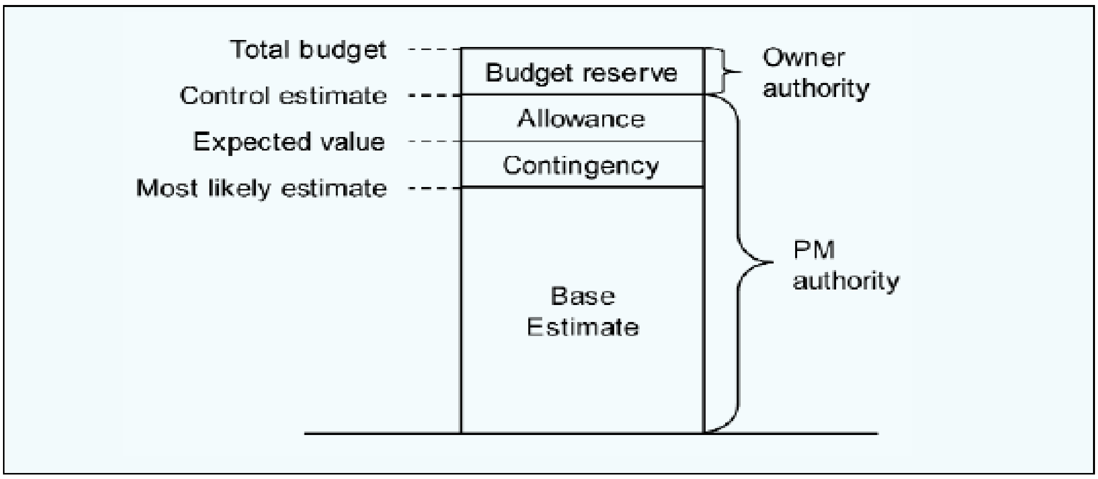

Figure 2.4: Percentage added value for contingency. (Karlsen and Lereim ,2005, p.27)

Another approach for risk estimation that is similar to the above discussed method is where a contingency percentage is added to each cost item in the work breakdown structure. Although this method is more detailed, “it still has many of the same weaknesses” (Karlsen and Lereim, 2005, p.26). Another approach used to include risks in the cost is following the program evaluation and review technique (PERT) estimation procedure based on a set of three-point estimates (Yeo, 1990). These three estimates are adopted through the previous actual costs of the same activity in completed projects. These are the lowest probable value (L), the most likely value (M) and the highest probable value (H) of the cost elements for each work package in the work breakdown structure (WBS) as shown in Figure 2.5. A weakness with the risk estimation through the PERT procedure is that it assumes that all costs are independent random variables, but in practise, costs are often correlated with each other. The problem with this assumption is that it tends to underestimate the variance associated with the total project cost (Moselhi, 1997).

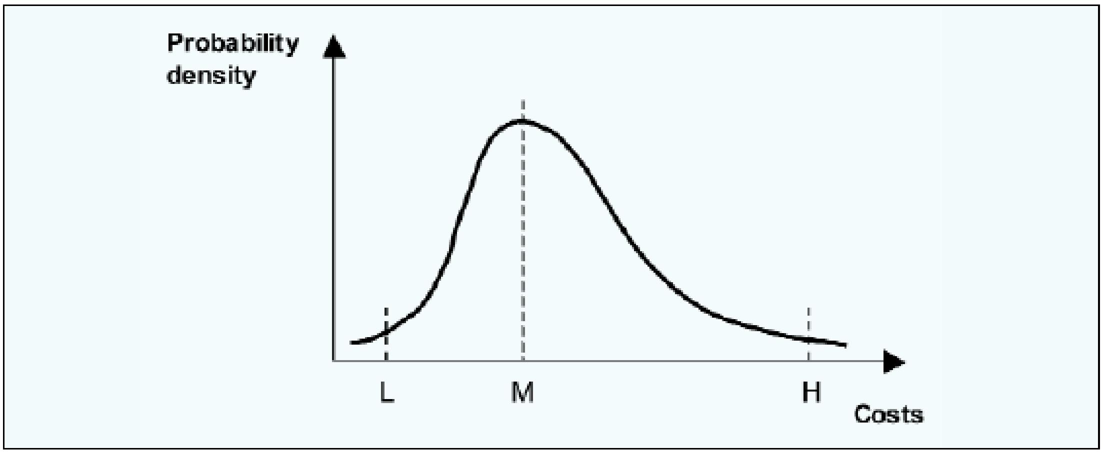

Figure 2.5: Risk estimation through PERT. (Karlsen and Lereim ,2005, p.26)

As an alternative to the PERT approach, “a straightforward method of obtaining information about the distribution of total project cost is through the use of Monte Carlo simulation” (Karlsen and Lereim, 2005, p.26). This is an approach where associated risk costs are simulated as illustrated in Figure 2.6. The model adopts the principles of cost breakdown structure (CBS) where each of the cost items is estimated as a single point estimate. All the identified and quantified risks are included in the model to ascertain where the risks will have impact on the costs. As shown in Figure 2.6, some risks may only have an impact on a certain work package while others may influence the total project. Each risk item is range defined by the

PERT procedure. Similarly, the impacts of risks on cost items can either be measured in percentage added or in amount of cost added.

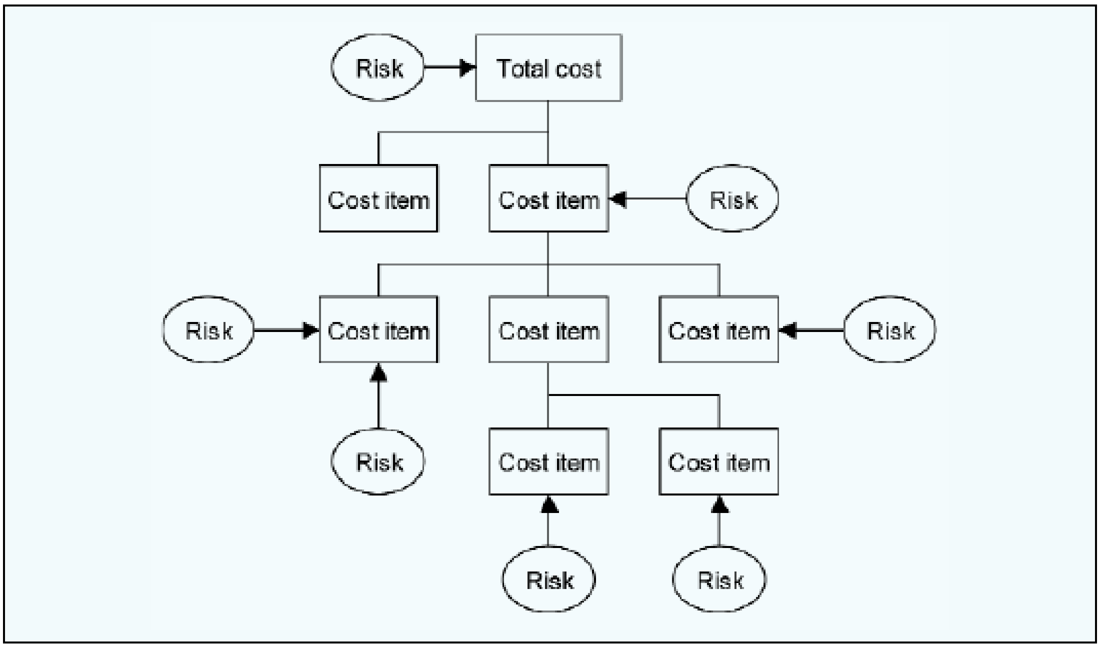

Figure 2.6: Monte Carlo Simulation Model. (Karlsen and Lereim ,2005, p.27)

Furthermore risks, on the other hand, need to be associated with project duration estimation and time planning. Williams (1999) stated that there are two main scenarios for allocating contingency to account for the risks in the project plan. Those scenarios are as follows:

- In case the activity has a lot of variability and is likely to be on the critical path, it should be given a larger share of the contingency as overruns in this case have a disproportionably large impact on the overall duration of the project.
- In case the activity has a lot of float, extending it does not affect the overall project duration.

In his proposed approach, Williams (1999) used the concept of activity criticality index which is defined by Dodin and Elmaghraby (1985) as the probability that the activity lies on the critical path. However, Williams expanded the definition and principled the activity with a high criticality index to be the activity that causes high risk to the project overall plan, and thus requires attention more than other activities.

Because a number of networks with different characteristics can be shown to give the same criticality indices for activities, Bowers (1995) proposed the ‘cruciality index’. Cruciality index was defined as the correlation between the activity duration and the total duration of the project. It was claimed that the length of an activity with respect to the project length is presumably an extent of the activity uncertainty in the project. According to Williams (1999, p.443), this index has now been used for studies of many major projects, “to identify problem areas that the standard criticality analysis would not have picked up”.

Furthermore, Williams (1999) went on to assume that the activity duration variances that contribute most to the variance of individual path durations cause most of the uncertainties in the path duration and therefore project duration. This concept was called ‘activity covariance’. The following is the algorithm proposed to be adopted once a network has been simulated:

1- Calculate the standard length of all the activities through selecting the mean value of the PERT approach.
2- Stimulate the expected duration of the project.
3- Calculate the ‘covariance’ of the duration for all the activities.
4- Add the contingency level to the activities according to the covariance index, then re-simulate the project network duration.

As it has been shown, it is recommended that all projects should be initially analysed to identify all risks and all crisis reasons that can impact the associated projects. Then, using the two recommended approaches of allocating risks in time and cost estimations would enable the project personnel especially the estimators to better allocate contingencies for the identified risks.

In general, the availability of precise and concurrent data is not enough to mitigate crises in project management. However, good implementation of risk analysis is essential to assist in better planning and properly preparing for crises in projects as well as to take further steps to reduce the crisis occurrences and their impacts.

2.4.3 Project Lifecycle Cost and Value Management:

According to Weustink et al (2000), cost estimation is defined as foreseeing the costs that are related to all of the project activities before they have been executed. However, in frequent cases, many cost overruns are the results of hidden costs that the initial budget did not allow for. As a sequence, all costs that are directly and indirectly associated with the project should be accounted for starting from the conceptual decision up to the demolition stage. Still, the problem is how the project personnel can estimate the budget for costs that they can not see or predict. However, following an accurate and reliable cost estimation model is a key to cost prediction and cost reduction (Weustink et al, 2000). Moreover, the whole project lifecycle costs and benefits from initial project conceptualisation through operation and disposal of the project have to be decided from the early stages of the project with the involvement of all stakeholders. An owner should be concerned with a project from the cradle to the grave. That is because construction costs represent only one portion of the overall life cycle costs (Hendrickson, 1998). Therefore, in order to minimise the cost overruns, an accurate estimate of the overall lifecycle cost should be done at the first place with the involvement of the stakeholders.

According to Stamelos and Angelis (2001), an essential activity in the initial project phases is the estimation of the necessary project development cost as well as time. The main approaches for the development of cost estimation are based on three principles which are expert judgement, estimation by analogy and algorithmic cost estimation. Expert judgement is principled on the bases of the accumulated experience of a team of experts. Estimation by analogy is based on the compression of the project under consideration with few similar historical projects. Finally, algorithmic cost estimation applies one of the cost models that use one or more mathematical formulas that have been derived through statistical data analysis (Shepperd and Schofield, 1997).

As it is widely recognized and well practised, the detailed cost estimation is a forecast of the final project cost broken down into cost packages associated with the work packages (Morris and Pinto, 2004). However, according to Morris and Pinto (2004), every project estimate carries a certain amount of uncertainties. Still, as will be shown later in this study, the estimate shall serve as a baseline for the cost control during execution. "A fair estimate will have an equal probability of overrun and undertaken" (Morris and Pinto, 2004, p.16). In this particular study, the basic principles of cost estimation will not be intensively researched because at this time they are well researched and commonly practised. Instead, this study will focus on the principles of the further techniques and tools available in the literature that will improve the existing cost estimation practises to better forecast the projects costs in order to minimize the overruns during execution.

Projects in general and particularly construction projects pass through several distinct phases. As Adeli and Karim (2001, p.47) stated, "these phases form a cycle of operations from project conception to project termination and disposal". As part of Value Management and particularly Value Engineering, "total life cycle costs of proposals are considered" (Norton and McElligott, 1995, p.11). Life Cycle Cost (LCC) was first applied in the 1960's when the United States' Department of Defence stimulated the enhancement of its cost predictions for equipment to improve Defence systems, such as an aircraft or a special land vehicle (Sherif and Kolarik, 1981). Later, LCC moved from defence systems to industrial and consumer product areas, "where each user controls only a portion of the actual life cycle of the system" (Utne, 2009, p.336).

In real life cases, organisations in both the private and public sectors make determinations of project costs simply on the basis of initial purchase and construction costs (Woodward, 1997). Nevertheless, estimating the total Life Cycle Costs (LCC) encompasses all the initial costs of design and construction as well as the net present value of costs in use such as the operations and maintenance costs. It also includes the net present value of costs for the occasional replacement of elements during the life of the project as well as the disposal and termination costs (Norton and McElligott, 1995). Woodward (1997, p.336) stated:

> LCC seeks to optimise the cost of acquiring, owning and operating physical assets over their useful lives by attempting to identify and quantify all the significant costs involved in that life, using the present value technique. LCC is concerned with quantifying different options so as to ensure the adoption of the optimum asset configuration. It enables total LCC, and the trade-off between cost elements during the asset life phases, to be studied to ensure optimum selection.

Furthermore, Frangopol (1998) set an application of the Life Cycle Cost analysis to include the management of natural hazards for infrastructure systems, which is the core of this study scope. The proposed approach is extended further to the "the traditional life cycle cost to include both the cost of seismic upgrading prior to a disaster and the expected repair costs from damage in disasters" (Frangopol, 1998, p.60). In addition, Chang and Shinozuka (1996) included in the life cycle cost the 'economic costs' imposed on users from lifeline service distribution of the infrastructure systems. They have claimed that particularly in the case of water systems, users cost's or losses can hugely outweigh the costs of physical repair to the system, by as much as 10 times (Chang and Shinozuka, 1996).

The identified objectives of LCC are as follows (Wiibbenhorst, 1986; Woodward, 1997; Utne, 2009):

- To enable different available options to be more effectively evaluated.
- To consider the impact of all associated costs rather than only initial costs.
- To assist in the effective management of completed projects.
- To facilitate a preference among other competing alternatives.
- To assist in a proper communication and cooperation between planners, producers and users.

These objectives of the LCC approach can be obtained through the identification of all present and future costs and benefits then reducing them to their present value. The present value of all costs can be calculated through the utilization of the discounting techniques through which the economic worth of project options can be evaluated. In order to achieve those objectives the following elements of LCC should be identified (Woodward, 1997):

- Initial capital costs
- Life of the project as well as the asset
- The discount rate of cost through the life of the asset
- Operating and maintenance costs
- Disposal cost
- Information and feedback
- Uncertainty and sensitivity analysis

So, clients should begin the financial planning for a project at the same time as the technical design phase starts. However, the financial estimation usually occurs when all the features of the project are already determined. "The most successful projects are ones in which the financial planning is a key part of the project strategy from the start and the aim of the project is to minimize the whole-life cost" (Morris and Pinto, 2004, p.49). However, the ability to develop an ambitious and yet realistic budget is, as well known, heavily dependent on the ability to obtain basic information about the project (Khorsrowshahi and Kakat, 1996). Still, adopting the financial planning results in the early design stages of the project will enable the technical designers to better consider the available options and will open their eyes to further requirements the designs should consider. “It is therefore useful to engage the financiers as early as possible, so options are not selected that have to be rejected” (Morris and Pinto, 2004, p.49). This, according to Khorsrowshahi and Kakat (1996, p.375), “enables implementation of deterministic as well as holistic assessment of a trade-off between the objectives of the organisation and its limited resources”. Consequently, this will make the project processes maintain the Value Engineering practices which focus on improving the value in the design and construction stages of the project (Kelly et al, 2004).

In addition, it should be mentioned that further cost amounts should be reserved in addition to the estimated cost. Morris and Pinto (2004, p.50) believed that “any estimate will carry a contingency”. So, this reserved amount of money should be added in order to cover any contingency might occur because of the project uncertainties identified earlier. As shown previously, with proper risk analysis and contingency management practises “the uncertainty of the cost item can be estimated” (Morris and Pinto, 2004, p.50). So as Stamelos and Angelis (2001) conceptualized, the approach of cost estimation adopted by project managers and decision makers should take account of not only tangible cost items but also other unclear factors.

2.4.4 Project Scheduling and Network Analysis:

Schedule Planning is one of the essential stages of a project's life cycle that should be done appropriately at the early stages in order to finalize the project properly. Project schedule planning is the process of selecting the methods and the sequence of work to be used in the project. Planning starts with the assembly of all information necessary to produce a schedule and must be completed before a schedule can be developed. Liu (2003) insisted on the great assistance of the program evaluation and review technique (PERT) and the critical path method (CPM). He stated that with the help of these methods, "the project manager can schedule project activities at appropriate times to conform with proper job sequences so that the project is completed as soon as possible" (Liu, 2003, p.162).

In this regard, network analysis has caught the interest of mathematicians, academicians, research analysts, and practitioners since its inception and development (Moore, Taylor, Clayton and Lee 1978). The most common name associated with network analysis, which is highly depended on, is the critical path method. Siemens (1971, p.354) stated that, "one of the most salient features of CPM is the attempt to optimize the total project cost by shortening appropriate project activities". CPM focused on optimizing the total costs for various possible project completion dates. However, no systematic procedure was initially proposed to effectively achieve this goal of cost optimization. According to Kramer and Hwang (1991, p.54), "a project schedule should be developed to reflect the objective of the organization. Major project scheduling objectives are to minimize project duration, minimize the cost of the project, or to use project resources at a controlled rate".

Today, just as it was in the 1960's, "critical path analysis is commonly considered to be a technique for planning and scheduling of projects" (Crowston and Thompson, 1967, p.407). Still, the critical path method "has become one of the tools that are most useful if practiced and applied in planning and control of the realization of complex projects" (Chanas and Zielinski, 2001, p.542). Chen (2007, p.444) summarised the critical path method and stated that "The CPM is a network-based method designed to assist in the planning, scheduling, and control of the project. Its objective is to construct the time scheduling for the project. Two basic results provided by CPM are the total duration time needed to complete the project and the critical path". Yet, the principles of project scheduling and the concept of critical path method will not be an intense focus of this study since they are well known and extensively practised. Instead the missing concepts in the practical project management practises within the study scope will be researched and introduced in this part of the study. Mainly, the concepts of fuzzy activities in scheduling, resource allocation and scheduling, as well as cost optimization and net present value maximization will be the focal titles to concentrate on. Those will improve the normally practised process of critical path method for project scheduling in order to better plan the project and minimize the probabilities of crisis occurrences.

Kursave (2003, p.8) stated that "a schedule is a time-phased plan for accomplishing the tasks that make up a project. It is based on specified logical relationships between the tasks and on estimated task durations". In addition, Kolisch and Padman (2001) indicated that the main objective of project scheduling is to minimize the project duration. Elmaghraby and Herroelen (1990) claimed that the vast majority of project scheduling methodologies that are represented in the literature have been developed with the main objective of minimizing the project duration. Alternatively, project scheduling should consider other projects constraints such as maximizing the net present value of the project (Elmaghraby and Herroelen, 1990). Furthermore, Drexl (1991) highlighted that project management frequently faces a recurring problem that involves the allocation of the scarce resources required in the project. Thus, project scheduling should consider both the availability of resources as well as their assignment in the associated project tasks further to the tasks durations estimation (Drexl, 1991).

Consequently, Kolisch and Padman (2001) have intensively studied the project scheduling concept and claimed that the project schedule should integrate minimizing the project duration, net present value maximization, quality maximization, and cost minimization considering resources availability. In this regard, net present value can be maintained through calculating the cost of activities and generating a cost-critical path as well as the time-critical path. Kolisch and Padman (2001) stated that the idea of integrating the net present value maximization of cash flows with the project scheduling concepts was originally presented by Russell (1970). Russell (1970) analysis considered cash outflows related to the expenses for initiating activities and cash inflows for completing sets of activities. Russell (1970) maintained that the cost-critical path is different than the time-critical path. Thus, the cost-critical path must be generated when financial objectives are needed to be considered (Kolisch and Padman, 2001). Elmaghraby and Herroelen (1990) as well used the same concepts of Russell's model to develop a simplified tool that gives the optimal schedule while considering the net present value of the project. The most advantageous plan is to schedule activities with positive cash flows as early as possible and activities with negative cash flows as late as possible.

Besides the cost optimization matter, in many frequent real life situations, projects can be complicated and challenging to manage from the time perspective as well. Though the critical path method has been proved to be a useful tool in managing projects and an efficient approach to overcome project challenges, it is only reliably applicable when the project activity times are deterministic and known. However, there are many cases in practise where the activity times may not be presented in a precise manner and the accuracy required can not be satisfied (Chen, 2007; Chanas and Zielinski, 2001). So, in order to be able to deal quantitatively with imprecise data, the program evaluation and review technique (PERT) based on the probability theory was suggested to be employed. The PERT method has been developed "with the formulation of the not unique estimations of the activity times, and the conception of the random variable with the beta distribution has been used to model the activity times" (Chanas and Zielinski, 2001, p.195). However, there are critiques of this approach in time estimation and network scheduling because in the PERT analysis many simplifying assumptions should be taken. Subsequently, the use of the beta distribution or its variants may not be able to provide an appropriate distribution when the activity time is highly skewed (Chen, 2007).

So, another proposed approach to the network project analysis is what is called the fuzzy PERT method or the fuzzy CPM. "An alternative way to deal with imprecise data is to employ the concept of fuzziness" (Chen, 2007, p.443). This approach has been developed to suggest using fuzzy numbers in the process of modelling the activity times (Chanas and Zielinski, 2001). Through adopting this approach, the vague activity times can be represented by fuzzy sets of numbers. Consequently, the main advantage of project scheduling based on activities estimated through the fuzzy numbers concept is that it does not require previous predictable regularities as well as subsequent frequency distributions. This approach can also deal with imprecise input information containing feelings and emotions quantified based on the decision-makers' subjective judgment (Shipley et al, 1997).

In regard to the fuzzy approach of project scheduling, several studies have investigated the use of this particular approach in situations where some activity times in a certain project are only known approximately. In these situations, activities are more suitably represented by fuzzy sets rather than crisp numbers.

As a result, computing the intervals of possible values of the activities' latest starting times and floats with inexact durations represented by fuzzy or interval numbers is an approach aligned with the CPM (Dubois et al, 2003). This approach is conceptualized based on formulas for the forward and the backward project duration estimation. However, in the case of fuzzy concept, the activity times are replaced with the fuzzy times. Yet, as noted by Zielinski (2005), the backward exercise using the fuzzy activity times fails to compute the sets of all possible values of the activities latest starting times and floats. As a result new 'polynomial algorithms' were developed for determining the intervals of the latest starting times of the network in general (Zielinski, 2005). These algorithms overcame the drawbacks of the proposed heuristics for computing the sets of possible values of the latest starting times and floats of activities by Dubois et al (2003). Moreover, Chanas and Zielinski (2002) generalized the criticality principle and allied it with the project scheduling concept with fuzzy activity times, in order to calculate the degree of possible criticality and some results are provided. However, in practical scenarios the critical path will be varied as activity durations are varied in an interval of fuzzy times. As well, Chen (2007, p.443) proposed a further approach that describes the total project duration through the "membership function which completely conserves all the fuzziness of activity times, and the critical paths under different possibility levels can also be obtained".

Furthermore, modern project management is concerned with integrating the resource availability, allocation, and distribution within the scheduling processes. According to Christofides et al (1987, p.262), scheduling a project under resource constraints,

> consists of determining a set of starting times for the activities of the project in such a way that the precedence constraints between them and the resource constraints, limiting the total amount of available resources at each time of the schedule, are satisfied and the total completion time is minimized.

Slowinski (1980) and Weglarz (1981) defined two kinds of resources in projects as renewable and non-renewable. Whilst the renewable resources have a limited period availability, the non-renewable resources are limited for the entire project. However in practice, "resources are often doubly constrained" (Weglarz, 1981, p.1040) which means that resources are usually constrained by both total usage and total consumption. Therefore, practically, through the project scheduling process, both the renewable resources and non-renewable resources should be considered (Slowinski, 1980). Yet, the objective is to find an algorithm for the network and a start time for each activity such that the schedule is minimal and feasible with respect to the resource constraints (Hartmann, 2001).

In the scheduling of resource-constrained projects, "non-preemptive activities requiring renewable resources and subject to precedence constraints have to be scheduled to minimize the [project duration]. The activities have to be not interrupted during their processing" (Damaka et al, 2009, p.2654). In resource modelling, the process starts with the resource allocation, where all resources required have to be assigned to the projects activities. Then, the scheduling of the activities is adopted usually through the normal scheduling techniques such as the critical path method. Next, a resource graph should be developed for each particular resource separately where the amount of the resource needed for each activity is illustrated per time. Then, the resource aggregation is practised, where the amount of each resource can be obtained at a certain period of time through the summation of the activities occurring at that time (Lorenzoni et al, 2006). It is now necessary to compare resource requirements with resource availability, which is called the resource levelling stage. Finally, whenever a certain resource exceeds the available amount at a certain time, resource smoothing is adopted, in which the activity network logic must be changed accordingly. Subsequently, as Damak et al (2009) illustrated, through the trial and error iterations, the optimum project schedule can be obtained with respect to the constrained resources required.

Furthermore, as Kursave (2003) argued, it is very unlikely that the actual duration of a certain activity will be exactly as estimated. Practically, it is unlikely that the actual execution sequence of the activities will be performed exactly as planned in the logic network and according to budgets. There are also frequently additions or deletions to the project scope of work that will influence the dates of starting and completing the activities as well as the associated costs. Consequently, the "reliance on the original project schedule throughout the duration of a project after additional information has become available is very much like using a road map that you purchased in an antique bookstore" (Kursave, 2003, p.8). Thus, as it will be shown afterwards, the performance should be always monitored during the execution of the project. Afterwards, the execution status should be always compared with the original plans and then the schedule should be updated accordingly.

2.5 Project Control and Monitoring during Execution:

As discussed previously, it is very unlikely that the actual duration of a certain activity will be exactly as estimated (Kursave, 2003). Also, it is unlikely that the actual execution sequence of the activities will be performed exactly as planned in the logic network and according to budgets. Furthermore, there are frequently additions or deletions to the project scope of work that will influence the dates of starting and completing the activities as well as the associated costs. Consequently, the original project schedule throughout the duration of a project can not be relied on, after additional information has become available. Thus, as it will be shown in this part of the study, the performance should be always monitored during the execution of project. Then, the execution status should always be compared with the original plans and then the schedule and budget should be updated accordingly.

"Time and cost are two important planning and control variables in a project. They are interdependent" (Morris and Pinto, 2004, p.51) which means that they are related to each other, and each is a dependent variable of the other. So, the capabilities to control the project progress within strict cost, time, and performance guidelines as per the planned schedules are essential in the competitive business environment (Siemens, 1971). Project control guarantees the project accomplishes what it is supposed to deliver (Gardiner, 2005) through taking the appropriate action whenever possible to assure the alignment with the stakeholders' and clients' expectations. Project control is an essential key to success in projects. Project planning and control is necessarily required because "we often hear about projects with delays and where the costs tend to be higher than depicted by budgets" (Karlsen and Lereim, 2005, p.24). Project control techniques are principles in order to assist the project manager to "schedule project activities at appropriate times to conform with proper job sequences so that the project is completed as soon as possible" (Liu, 2003, p.163). According to Gardiner (2005), projects that are especially associated with high risks and complexities should have a well-designed control system. Thus, project crises can be predicted early so the associated harmful impacts can be minimized at the end of the day.

2.5.1 Earned Value Management:

Earned Value Management (EVM) is a system that incorporates the organized components of the project's schedule, budget estimate and scope of work into a process by which the project's forecasted costs at the end of the project can be more reliably determined. The earned value for a project can be defined as the total sum of the budgets for those elements that are complete plus the partial budget amounts corresponding to the physically complete portion of work in progress. In simple words, EVM as a technique enables us to measure the schedule and budget variances at any time while executing the project. Therefore, the current status of the project can be represented as a compression with the original plans and estimates. It also enables us to better forecast the total cost and duration at the completion of the project according to the current performance. According to Gupta (2008, p.13), "[EVM] measures project progress in an objective manner, combining the measurements of technical performance, schedule performance, and cost performance within a single integrated method. EVM provides an early warning of performance problems". Furthermore, many projects face the problem of 'scope creep' which is defined as deviating from the original identified need of the project after its initiation. Subsequently, EVM is utilized to enhance the project scope definition, prevent the scope creep, enhance project monitoring, and keep the parties involved in the project focused on the project progress.

Industrial engineers were the first to apply the "earned value" concept to measure performance on the factory floor in the 1800's. Then the U.S. government applied the same concept to many military and industrial projects in the 1960s (Chen, 2008). While pursuing its minuteman missile development program, the U.S. government continued to develop and refine many of the project management techniques that are still in use today (Kuehn, 2007). Nevertheless, the earned value remains one of the most effective cost management tools available for performance monitoring and evaluation (Fleming and Koppelman, 1994). That is because the traditional cost management tools use a two-variable method to relate the actual cost to the planned cost. While the actual performance efficiency is not as accurate as the initial assumption used in the project planning phase, the actual cost acquired can not be a proper reflection of the actual accomplishment (Fleming and Koppelman, 2002). Consequently, a third variable which is called 'the earned value' is required to measure the actual accomplishments. Figure 2.7 illustrates the traditional tools and the earned value technique variance contrast.

According to Chen (2008), the earned value system reduces subjectivity, and provides a more objective measurement with respect to the planned performance. Earned value applications have satisfied the basic concept of establishing and maintaining a plan through measuring the actual accomplishment, which is one of the most fundamental management principles (Chen, 2008).

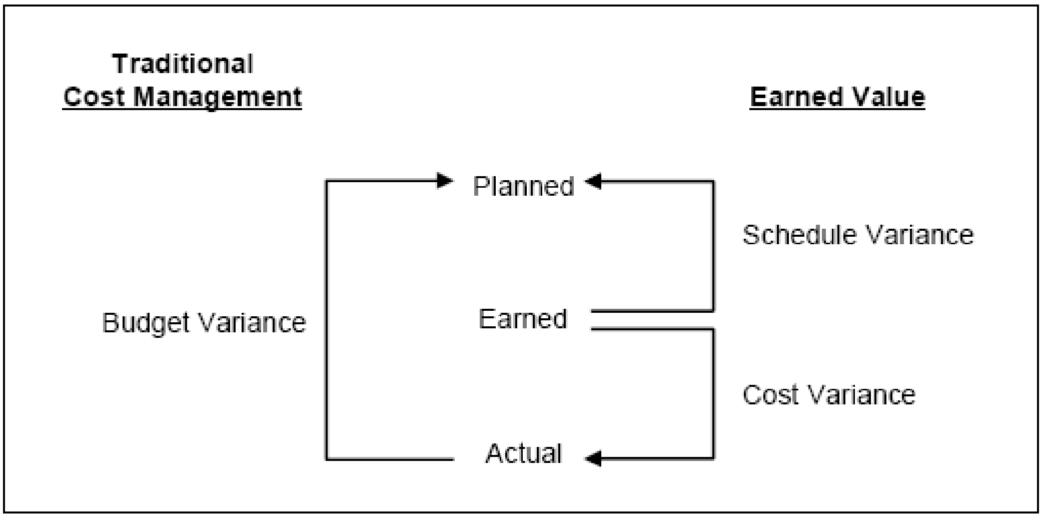

Figure 2.7: Traditional Cost Management versus Earned Value. (Chen, 2008, p.2)

In addition, Kuehn (2007) claimed that in project management, it is not being exactly on the planned baseline that is essential. Instead, it is the ability to steer the project back toward the planned baseline. That is because projects are always facing uncertainties as identified previously, and then "as uncertainties multiply, plans go awry" (Gupta, 2008, p.13). So, Kuehn (2007) suggested that using the tools and applications of earned value management allows the identification of the performance creep away of the project baseline in order to keep the project successful. Furthermore, Warhoe (2004) mentioned that after utilizing the earned value management as a system, costs are no longer being forecasted during the execution of the project through subtracting the actual costs at any point in time from the budgeted cost. That is because EVM is a system that integrates all the main components of the project's schedule, budget, and scope of work and incorporates them into a process that more reliably determine the project's forecasted cost at the end of execution.

Above all, Fleming and Koppelman (2002, p.1) stated that "the basic utility of earned value is to contain the cost risks associated with projects". They argued that utilizing the earned value application would give early indications about the project's problems, which in return will give a better chance to mitigate those problems (Fleming and Koppelman, 2002). It is also worth mentioning that earned value management is a tool that can be used on all projects, large or small, cost type or fixed price, and on all fields of projects. "[E]arned value management is a technique that can be applied to the management of all capital projects in any industry and employing any contracting approach" (Fleming and Koppelman, 2002, p.33). Moreover, the utilization of the earned value technique will not consume extra resources at the time of use because much of the basic earned value data is already available on most of the projects. However, as Fleming and Koppelman (2002) recommended, specific process should be obtained for using the earned value management in order to mitigate project risks.

Earned value is conceptualized to focus on the relationship between acquired actual costs and the actual work performed on the project in a given duration. It relates the performance carried on with what was spent in order to complete it (Vargas, 2005). In other words, the earned value management is the evaluation between what was actually spent and what was budgeted in the original project plan. It is principled on the fact that as each project activity is being performed, the budgeted cost for the activity "starts to constitute the earned value of the project" (Vargas, 2005). To understand its concept, the three dimensions of the earned value management should be understood. These three dimensions are as following (Fleming and Koppelman, 2002):

- The planned value (PV): combines the authorized work, along with the authorized budget, within the authorized time-frame, which in total forms the project baseline. The planned value is frequently called the budget cost of work scheduled (BCWS).
- The earned value (EV): combines the authorized work which has been completed, as well as the original budget for this work. The earned value is frequently called the budget cost of work performed (BCWP).
- The actual costs (AC): combines the authorized work which has been completed, as well as the actual cost needed to complete this work. The actual costs value is frequently called the actual cost of work performed (ACWP).

Through the utilization of these earned value dimensions, "any project can accurately monitor and measure the performance of projects against a firm baseline" (Fleming and Koppelman, 2002, p.34). Measurement followed by evaluation should take place at regular intervals during the execution of the project in order to determine the three dimensions. This practise will provide a wealth of reliable data that reflects the true status of projects.

Chen (2008) had conceptualized prerequisites during the project planning stage that will establish a solid foundation for a credible implementation of the earned value management. These prerequisites are as following:

- Convert the scope of work into a work breakdown structure (WBS).
- Each WBS element becomes a work package that describes a measurable product, action or service.
- Develop a time-phased schedule of values associated with WBS.
- Assign responsibility for each work package.
- Determine the appropriate progress measurement duration.
- Establish a consistent practice to collect actual costs (money or work hour).
- Set a threshold level of performance variance to trigger corrective action.

After satisfying those prerequisites, the earned value management starts as a continuous project monitor and control process. According to Chen (2008), it should begin with a consistent tracking of the three basic variables (PV, EV, and AC) as shown in Figure 2.8. After determining the three variables, the analyses are performed in order to determine real performance status of the project with respect to time and cost. It should be noted that before starting the analysis, the three variables (PV, EV, and AC) should be converted into the same unit of either money or work hours ($ or WH).

Then the variance which is used to "determine the magnitude of deviation for a given project" (Chen, 2008, p.3) is calculated for both time and cost. Time and cost variance can be calculated by using the following equations:

$$SV\ (Schedule\ Variance) = Earned – Planned = EV – PV$$

$$CV\ (Cost\ Variance) = Earned – Actual = EV – AC$$

A positive SV indicates the work is accomplished more favourably than the original plan. On the other hand, a negative SV indicates a schedule delay. Similarly, a positive CV indicates the work is accomplished more efficiently than the estimated efficiency in the plan. On the other hand, a negative CV indicates a cost overrun. On this regard, Chen (2008, p.3) stated that, Both schedule and cost variances are meaningful to a given project since they reflect the deviation magnitude applicable to that project only. They are not suitable for comparing against the performance of another project.

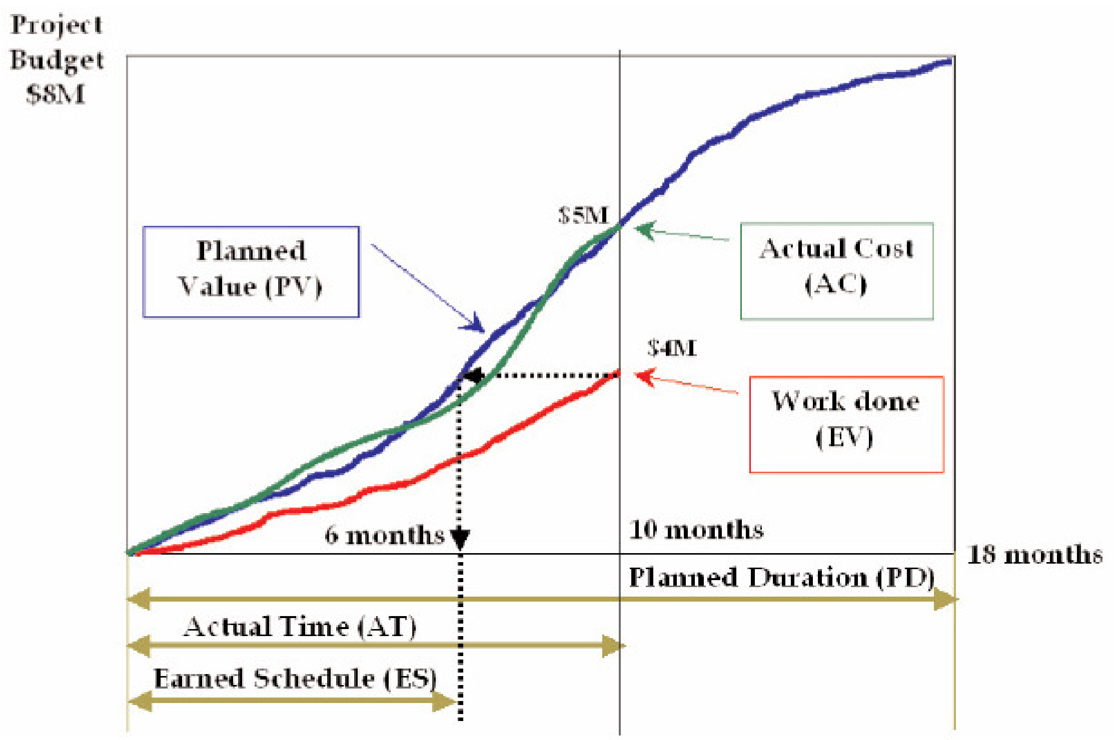

Figure 2.8: The Earned Value Variables. (Stratton, 2007, p.2)

Earned value management, as well, gives valuable cost and time efficiency indicators (Stratton, 2007). Through the utilizing of the same three basic variables of the earned value management, performance indexes for schedule and cost can be calculated, as shown in Figure 2.8. Those indexes indicate how the true progress of the project with respect to the favourable planned progress. The schedule performance index and cost performance index can be calculated using the following equations:

SPI (Schedule Performance Index) = Earned / Planned = EV/PV

CPI (Cost performance Index) = Earned / Actual = EV/AC

A ratio over 1 indicates favourable progress. ASPI of 0.9 indicates that the project is gaining 90% of value for every work hour performed. Additionally, a CPI of 0.9 indicates that the project is receiving $0.9 of value for every $1 spent.

2.5.2 Human Performance Index:

After evaluating the technical performance with respect to time and money using EVM, it is still essential to evaluate the human performance. A new index, called human performance index (HPI), was developed and will be adopted in the research in order to “allow the team to do evaluation for project professionalism” (Vargas, 2005, p.22). This index consists of the relationship between the CPI and SPI, allowing the evaluation of the schedule and budget of the activities executed by the resources simultaneously. According to Vargas, it is important to evaluate the HPI along with the EVM, not only to evaluate the individual work outcome, but also the whole team’s work. “It’s in the team work in which the resource is an integral part of the project as a whole” (Vargas, 2005, p.22).

The project human resources area is one of the knowledge areas that managers and project teams should carefully consider. As reported in the PMBOK Guide (2000), human resources project management includes the required processes to make the most effective and efficient utilization of the human resources involved with the project. The guide includes all project stakeholders: sponsors, customers, individual contributors and other related parties. The processes mainly include the following (PMI, 2000):

- Organizational planning, which is to identify, document and assign project roles, responsibilities, and the reporting relationships.
- Staff acquisition, which consists of ensuring that the required human resources are designed as per required by the project scope.
- Team development, which includes developing individual and group skills in order to increase the project performance.

In this regard, team development, as outlined, involves the enhancement of the capability of the involved parties to contribute individually, as well as the enhancement of each person’s ability to work in a team. Individual growth (managerial and technical) is the foundation required to develop the team. This becomes crucial to the success of projects and becomes a key for the organization to accomplish its goals.

As Fitz-Enz (2002) stated, each organization and each project is led by a combination of strengths that represent the internal and external factors. These factors make “the organization unique, describing collectively how and why the organizational processes influence performance improvement” Vargas (2005, p.21). The internal factors are those determined by an organization and its project goals. On the other hand, the external objectives are those determined by the external environments in which the organization and the projects are inserted.

Because of the previously determined projects' problems and crises' reasons, it is essential to have an impartial and objective tool to evaluate the resources performance process that also allows improvements in individual skills, team behaviours, and individual and team competencies.

Because of the performance problems identified previously, it is essential to have an impartial and objective performance evaluation process to be combined with the cost and time evaluation processes. Such a performance evaluation process will enable the resources to be monitored and controlled and will bring improvements in individual skills, team behaviour, and individual and team competencies.

As mentioned previously, this tool would allow the formation of the HPI index that evaluates the accomplishments of the schedule and budget of the project's activities executed from the resources perspective.

The formula to calculate this index is as following (Vargas, 2005)

$$HPI = \%_C \; x \; CPI + (1-\%_C) \; x \; SPI$$

Where CPI = Cost performance index

SPI = Schedule performance index

$\%_C$ = Project complete physical percentage

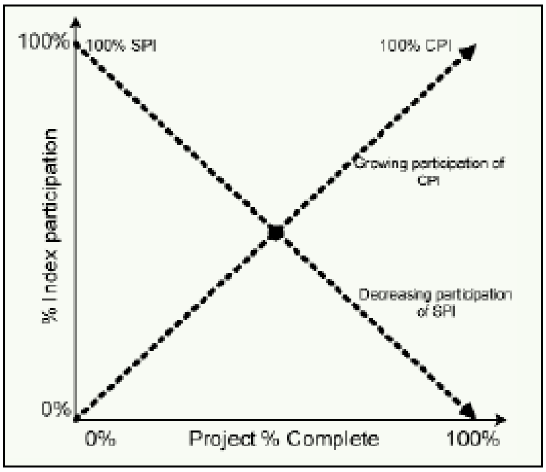

Figure 2.9: Participation of HPI according to project completion percentage. (Vargas, 2005, p.22)

Figure 2.9 shows the participation of the cost and schedule indexes in the HPI composition along the project according to the percentage of completion. It should be noted that as Vergas (2005) proposed, it is required to evaluate the HPI not only of the individual work outcome, but also of the teamwork. "It's in the team work in which the resource is an integral part of the project as a whole" (Vargas, 2005, p.22). The HPI of the whole project should also be evaluated in order to be able to evaluate the final HPI that is the weighted average of these three indexes (individual, team, and project) as shown in the following equations:

$$HPI_{Individual} = \%_c \times CPI_{Individual} + (1 - \%_c) \times SPI_{Individual}$$

$$HPI_{Team} = \%_c \times CPI_{Team} + (1 - \%_c) \times SPI_{Team}$$

$$HPI_{Project} = \%_c \times CPI_{Project} + (1 - \%_c) \times SPI_{Project}$$

$$HPI_{Final} = (HPI_{Individual} \times Weight_{Individual} + HPI_{Team} \times Weight_{Team} + HPI_{Project} \times Weight_{Project}) / (Weight_{Individual} + Weight_{Team} + Weight_{Project})$$

Where: $CPI_{Individual}$ = Cost performance index of the work packages where the evaluated resource is involved

$SPI_{Individual}$ = Scheduled performance index of the work packages where the evaluated resource is involved

CPI_{Team} = Cost performance index of the team work packages of which the evaluated resource is participant

SPI_{Team} = Schedule performance index of the team work packages of which the evaluated resource is participant

$CPI_{Project}$ = Cost performance index of the project

$SPI_{Project}$ = Schedule performance index of the project

$Weight_{Individual}$ = Contribution of resource HPI in the HPI Final

$Weight_{Team}$ = Contribution of team HPI in the HPI Final

$Weight_{Project}$ = Contribution of project HPI in the HPI Final

$\%_C$ = Project complete physical percentage

Furthermore, Vargas (2005) suggested that HPI_{Final} can be evaluated using a variety of strategies perspectives. It can be viewed starting from a strong concentration on individual outcomes up to a balanced focus among the individual, team and project. A model of weight composition for different focuses is shown in Figure 2.10.

	$Weight_{Individual}$	$Weight_{Team}$	$Weight_{Project}$
Individual Focus	60	20	20
Team Focus	20	60	20
Project Focus	20	20	60
Balanced Focus	40	30	30

Figure 2.10: Proposal of weight distribution for HPI resource composition. (Vargas, 2005, p.23)

It is important to highlight that the resource, team and project HPI´s should not be obtained directly from CPI and SPI´s work packages. Instead, they should be obtained from the summation of the BCWS, BCWP and ACWP's resource activities and later from applying the following equations (Vargas, 2005):

$$CPI = BCWP/ACWP$$

$$SPI = BCWP/BCWS$$

As a result of this exercise, the project manager can conduct an evaluation of the human resources and teams through a more direct mathematical model than the subjective evaluation. Along with the EVM practises shown previously, the project manager can evaluate the time, money and resources of the project in order to be able to predict the future of the project and minimize the probability of crisis occurrences. Furthermore, the project manager can utilize the principle of bonuses and reward policies in order to motivate the personnel involved in the project looking for better results. Hence, such policies should "be directly connected to the indexes causing a more transparent mechanism of the distribution of project outcomes" (Vagas, 2005, p.25).

2.5.3 Schedule Updating and Monitoring:

Further to the processes of proper planning and estimation of the project, it should be noted that continuous monitoring the original plans is essential. As per Kursave (2003, p.8),

> Just as project planning and scheduling are necessary to ensure that a project is properly and logically organized, it should also be equally necessary to properly monitor the project progress to ensure that all changes are incorporated into the original plan and that the completion date has not been jeopardized.

Without the proper status monitoring of the project schedule, the project's completion date and the status of any succeeding projects are uncertain. Yet, as mentioned previously, the predecessor to project schedule monitoring is that a project has to be properly planned out in a network logic format with interdependent relationships between work activities as well as to be properly time estimated including the details of each activity. Then it is up to the project personnel, especially the project manager, to determine the time interval and methodology to evaluate the project's progress (Kursave, 2003). After that, project schedule updating comes as a sequence to keep the planned schedule of the project matching with the current performances.

Project monitoring and updating should not be too time-consuming. However, it can be as complex as needed (Mueller, 1986). Since projects especially construction ones, are subject to many uncertain factors concerning project conditions, resources, and people, the reasonableness of a schedule monitoring update must be examined (Chao and Chien, 2010). A simple update would involve assessing the progress made on the activities performed since the update was last made. Such an update frequently involves dates that work activities were started and completed along with the work percentages of the activities that are currently under execution. At the other extreme, a project manager is able to monitor detailed project data such as quantities completed or resources expended to get an accurate percentage of the work completed for each of the project activities (Kursave, 2003).

Kursave (2003) identified three main reasons for monitoring and updating project schedules. The first reason is to reflect the current project status so it can be presented to all parties involved in the project, at the time they have essential interest in knowing the completion status. This is needed so each party can match the periodic progress payments on a project with the specific percentage completed. Another reason is to provide the parties involved with the capacity to make informed decisions when needed and to plan future events related to the tracked project. Another reason is to assess the work procedures and performances so any delays can be determined to minimize the associated causes. Consequently, this frequent practice may justify time extensions and relieve the parties from damages and claims (Willis, 1986).

According to Chao and Chien (2010), the critical path method, discussed earlier in this study, can also be used as the basis for monitoring project progress. The monitoring can be done by tracking the activity progress on the original schedule developed in the planning stage. This process would keep the project activities' network up to date which would allow the management office to be familiarized with all the updates. The object of updating the network, as Kursave (2003, p.8) stated, is "to introduce the project status, as well as any logic revisions into a new computation of the completion date". Project updating can be done through giving zero duration to all completed activities. In the same regard, activities still in progress are assigned the time durations required to complete them. Finally, "activities are removed, added, or assigned new activity numbers to recognize any logic revisions" (Kursave, 2003, p.8).

When the current data has been obtained in the network, a new computation should be made to integrate the new data with the previous existed data. Then, the new modified network should be validated and checked against scheduling errors in order to be able to analyze the outcomes and use them efficiently. It should be noted that the critical path and float might have changed so they should be reviewed (Willis, 1986).

There is no single correct rule for determining the update intervals; it depends on the individual case situation (Chao and Chien, 2010). However, Kursave (2003) suggested that there are three possible approaches that can be adopted in relation to project updating. In fact, these approaches are just common sense approaches and are highly dependent upon the project manager and the project situation. The first suggested approach is not to have any schedule updates throughout the execution of the project. This approach is adopted from the common belief that the original schedule is what should be used to measure performance and should never be changed. It might be true that the original schedule should be used to measure current performance (Kursave, 2003). Yet, without the schedule being frequently updated, the real current progress as well as the completion date according to the current performance can not be known. This approach of thinking is not recommended. Especially with the available software applications in the market, there is no reason to let a project schedule be left untouched. It can be updated frequently and original plan can still be used as a reference.

The second approach to project updating suggested by Kursave (2003) is to update the project plan schedule only when needed. “The intention here is that no updates are being planned; however, if the project falls behind schedule, then an update will be performed to evaluate progress” (Kursave, 2003, p.9). In real project situations, this claimed approach is definitely better than the previous approach of no update at all. Yet, this approach’s drawback is that the update is only considered when the project falls considerably behind the original plan. At that time, recovery of the project would be very difficult if not impossible.

The last and final approach suggested by Kursave (2003) involves ‘pre-determined’ intervallic updates. This approach is better than the previous ones because the updates are planned from the start of the project. Such planned updates will give a more accurate picture of how work progressed. Additionally, they can be considered as a record of the actual performance of the project execution.

As shown previously, there are many factors that can cause the original estimate to be inaccurate. So schedule updates can be executed by reviewing and revising the project schedule periodically, and then replacing the original planned dates with actual dates resulting in an accurate and up-to-date schedule.

2.5.4 Forecasting Budget and Time at Completion:

Earned value management does not end at the determination of performance indices analyzing the existing status of the project. According to Chen (2008, p.4), “projects sometimes fail to take the full advantage of the valuable insight revealed by these indices to forecast the final project costs”. Performance indices are simple and effective metrics that can be used to forecast the time and cost estimations at the completion of project. This can be done through using the current performance status to predict the needed time and money required to complete the remaining work. Afterward, the estimation at completion (EAC) is compared accordingly with the allocated budget at project completion to assess the project risk and develop a risk mitigation plan, if needed. Furthermore, as Yonezawa (2005) mentioned, a possible range of EAC is more realistic to lead the project personnel to manage project risk. Consequently, earned value management should be a practical approach to estimate EAC including future risk analysis based on the current performance indices.

The objective of the earned value management system, as a cost control system, is determining the forecasted final cost of the project in a reliable manner (Warhoe, 2004). As shown previously, one of earned value management’s great strengths is that it relies less on subjective progress measurement practices than the other cost control approaches do. Subsequently, this advantage is further used to measure the forecasted estimations at completion of the project. There are two forecasted completion estimates that are obtainable throughout the life of the project through the earned value practices. The first forecasted estimate is the estimated cost at completion (EAC), which is the total contract cost or time estimate at the end of the project, including all the modifications. Likewise, the other forecasted estimate is the Estimate to Complete (ETC), which is the total estimated cost needed in order to finish the remaining scope works. It should be noted that “this approach takes into account the performance of the project” (Warhoe, 2004, p.9) which makes it more reliable and realistic for the project personnel.

The earned value management approach to predict the total project cost or time at the end of the project, if the performance is kept consistent, can be calculated using the following equation (Kuehn, 2007):

$$EAC = BAC / CPI \qquad or$$

$$EAC = AC + \{(BAC-EV)/(CPI*SPI)\}$$

Subsequently, the amount of money or effort that will be needed to complete the project, if nothing changed, is as per the following equation (Kuehn, 2007):

$$ETC = EAC\text{-}AC$$

It should be noted that using the Earned Value approach to forecast the future money and time needed to accomplish the project results in a reliable estimate. The data obtained can be helpful and essential when this approach takes into consideration the current performance of the project (Warhoe, 2004). However, it should be kept in mind that all this forecasting analysis is predicting the future of the project assuming that performance will stay consistent in the project (Kuehn, 2007).

2.6 Crisis Mitigation:

As it was shown, it is very unlikely that the actual duration and cost of a certain activity will be exactly as estimated and planned (Kursave, 2003). As well, in practical real cases it is unlikely that the actual execution sequence of the activities will be performed exactly as planned in the logic network and according to budgets. In addition, there are frequently additions or deletions to the project scope of work that will influence the dates of starting and completing the activities as well as the associated costs. Thus, the "reliance on the original project schedule throughout the duration of a project after additional information has become available is very much like using a road map that you purchased in an antique bookstore" (Kursave, 2003, p.8). Thus, the project control techniques discussed previously were introduced in order to always monitor the actual performance during the execution of the project.

However, there is still a chance for crisis to occur or to be predicted. As stated earlier, a crisis is a situation the project faces which can not be coped with by the use of normal routine procedures and in which stress is created by sudden change (Booth, 1998). Crises can still occur because there is still subjectivity in the planning and the estimation procedures. Moreover, cries may occur due to the impact of the project uncertainties shown and discussed intensively before. Thus, the project management must continue further to mitigate the impacts of crises once they occur. According to Ocal et al (2006), crisis management is not nearly a systematic process. Yet, it is also a continuous process that includes the reactive actions with the aim of responding to the crisis, confronting the crisis, and resolving the crisis.

Management during the crisis therefore is a plan that guides both the management and the personnel on what should be done in order to get the crisis under control with the least loss (Jaques, 2007). It is well known that decisions during crises are usually made under pressure, uncertainty and little time (Ocal, Oral and Erdis, 2006). Consequently, confident theoretical and practical techniques were introduced as parts of project crisis mitigation management. Therefore, in this part of the study, the management techniques, which were introduced in the literature to mitigate the crises when they occur, will be studied. Those principles and techniques are proposed in order to be used as a subsequent step to get the project status back on track as well as to minimize the impacts of the occurred crises.

2.6.1 Activities Acceleration:

Activity Acceleration is a term used to "describe the process of accelerating an activity or multiple activities to shorten the overall duration of a project" (Gould, 2005, p.19). By adding additional people or equipment or by working additional hours, an activity's duration can be shortened, and if it is a critical activity, the whole project will be shortened too. There are many reasons for accelerating activities. Below are some of the reasons Gould (2005) identified:

- An activity may need to be accomplished by a specific date for contractual reasons.
- Some activities can be completed more economically during a certain time of the year or at a certain period of the project duration.
- The cost of accelerating an activity that will shorten the project duration may be less than the overhead cost of running the project for the original duration.

Above all, activities acceleration, as a concept, is introduced in this study in order to be utilized as a tool to shorten the duration of the not completed activities. Thus, the project duration will be shortened in the case of crisis occurrences to facilitate minimizing the associated harmful impacts. As per Hassanein and Moslehi (2005), accelerating schedules is practised to meet targeted completion dates when they are unable to be met through the same level of functionality provided by the original plans.

Schedule acceleration through activities acceleration was classified by Mohan (2008) as directed acceleration and constructive acceleration. Directed acceleration is defined as the situation when the owner directs the contractor either to perform the original scope of work within reduced time duration, or to perform an increased scope of work within the original time duration. On the hand, constructive acceleration is defined as the situation when the contractor is forced to complete the project within the original duration (Mohan, 2008).

As Gould (2005, p19) said, "[w]hen an activity is crashed, the direct costs increase". Those costs are the costs of the materials, labour, and equipment directly associated with the installation or construction of the project. Crashing activities cause the direct cost of the project to increase because of inefficiencies that arise when the work is accelerated to a faster than normal rate. On the other hand, as Feltz (1970) mentioned, an accelerated project can earn additional bonus money, prevent the payment of fines or liquidated damages to the owner. It can also save the company additional indirect cost of overheads.

Acceleration of an activity can, in theory, be achieved in endless number of ways that can be categorized as following (Mohan, 2008; Hassanein and Meselhi, 2005; Kanda and Rao, 1984; Swink, 2003):

- Improving the productivity of existing resources
- Changing the working method or/and reducing the work content.
- Reducing lead time for material delivery
- Increasing the quantity of the productive resources.

Improving the productivity of existing resources can be achieved by implementing the planning practises that were discussed earlier. It is also necessary to improve the organization in order to remove barriers to productivity that can cause disruption and interference to activity. Furthermore, enhancing the motivation of the workforce can be effective in this case (Kanda and Rao, 1984). An example of this method is re-sequencing the activities. Through re-sequencing activities, contractors can easily accelerate the schedule (Mohan, 2008). As shown previously, project schedules will have logical links that are driven by either physical constraints or resource constraints. Some of the logical links may also be driven by contractor means and methods. So, efforts can be made in order to re-arrange the logical links of the schedule.

However, practically, it can be argued that this can not be possible, as the project management either should have been doing this already or has little influence in the overall project execution. As well, after the producing of the critical path method and practising it commonly in software applications, the ability to make changes within the network of activities is very minimal (Mohan, 2008). Still, theoretically, it is always argued that significant improvements in productivity are almost always possible through leadership enhancement, teamwork improvement, and aims and objectives integration (Swink, 2003). Unfortunately, it is not usually possible to rely on improving productivity to achieve activity acceleration quickly enough to satisfy the usual need for a fast response to the unacceptable situation that might be faced once crisis occur.

In the same scenario, changing the working method can not be reliable when crises occur. That is because each company would effectively focus on either using the most advanced methodology available or maximizing it in order to afford accomplishing the project in the first place. Moreover, reducing work content is impossible at the time; all clients require the task to be accomplished as required and agreed upon (Hassanein and Meselhi, 2005). This can be adopted, in practise, if a certain portion of the project is needed to be accomplished at a certain time. So the client may accept minimizing the scope of work in order for the contractor to be able to hand over the urgently required portion.

According to Mohan (2008, p.3), “if the critical path for a project passes through the procurement activities, shortening the material lead-time will result in an accelerated schedule”. This can be adopted through either paying for the reduced lead-time or by selecting a different vendor who offers a shorter lead-time. Another practical method of reducing material delivery time is by increasing the number of scheduled delivery activities by dividing them into smaller sets of packages. So the material is delivered separately which allows the activities to proceed in parallel (Yau and Ritchie, 1990). However, this method is argued to be inefficient because planners most frequently practise it while generating the original plan at the first place (Mohan, 2008).

Consequently, the most effective approach to be adopted in order to accelerate project activities is to increase the quantity of productive resources. By adopting the resource index shown previously, the most productive resources can be determined. Then those critical productive resources can be effectively enhanced by using the following:

1- Extending the working hours of existing resources through overtime.
2- Adding to the number of personnel employed, during normal working hours.
3- Utilizing a multiple shifts system.

So, utilizing the outcome results of earned value analysis and resource indexes practises studied previously as control tools, the critical resources and delayed activities can be clarified. Subsequently, through using the proposed approaches for increasing the quantities of productive resources, activities can be effectively accelerated.

1- Extending the working hours:

Working overtime is a frequently used method for acceleration activities. However, it would be wrong to assume that the productivity levels of the normal eight-hour day, which is commonly practised, can be maintained during overtime hours. It was argued that every hour worked in excess of 40 hours per week would result in a loss of productivity of approximately

1% per extra hour, for the whole working week (Horner and Talhouni, 1996). This loss of productivity is because of the following reasons (Mohan, 2008; Oglesby et al, 1989):

- Fatigue and boredom.
- Tidying up the workplace.
- Reluctance to begin a new task.

Over all, this particular method would be costly generally due to several reasons. Firstly, the loss of productivity means that the paid working hour because less valuable in term of what it can achieve (Mohan, 2008). Additionally, working extra hours as a method has been shown to cause more production errors and work place accidents (Turner, 1993). Above all, in practise, the extra working hours commonly have a higher rate of pay. Furthermore, repetitive overtime working hours will lead to higher absenteeism among the labourers (Feltz, 1970).

As illustrated, this method can be very costly. However, it can be seen as desirable when the acceleration is urgently required because of the failure to meet the target completion date. Consequently, meeting the deadlines becomes a reward for the project at the end of the day.

2- Adding to the number of personnel employed, during normal working hours:

Another method for accelerating certain activities is adding human resources while the project is being executed. This should be a sequence after practicing the human performance index in order to figure out which particular personnel to be added. The addition of personnel, as per Mohan (2008, p.3), “is often the first response to a direction to accelerate, though this may not be the most economical”. The additional personnel will increase the progress rate of the project activities up to a certain limit. However, there are significant side effects of utilizing this approach; most importantly, it can add to the cost of acceleration, if it is carried out beyond the optimum efficient level. This is because of several reasons (Hassanein and Moselhi, 2005; Oglesby, 1989; Horner and Talhouni, 1996):

- Congestion on a physical activity
- Increased losses because of operatives have to experience task learning familiarisation
- Poor balance of skills
- Additional recruitment and induction costs

- More supervision costs

In addition, it should be noted that the assignment of resources for an activity at a level below the optimum level can also reduce the productivity. That is because there will be insufficient balance of knowledge and skills required for proper execution of the activity (Turner, 1993).

3- Utilizing a multiple shifts system:

Another approach for adding resources in order to accelerate activities is to introduce a multiple shifts system. This approach has been commonly utilized particularly in production when the process requires a high investment in plants and equipment that should be operated continuously and consistently to give the maximum return on the initial investment (Oglesby et al, 1989). However, in construction projects, certain issues should be considered before adopting multiple shifts system as an activities acceleration approach.

Firstly, productivity will normally be lower for shift works, particularly the late night shifts. Furthermore, it should be noted that shift work will have to be paid, and normally at a higher rate (Hassanein and Moslehi, 2005). In addition, the multiple shifts system will lead to inconsistent work outcomes at times when the skills of labourers do not match when they are working on shifts basis to execute a shared task (Swink, 2003)

2.6.2 Schedule Crashing:

Since the cost of shortening any activity is typically not the same for each activity in the project, then the concern is which activities to shorten in order to meet the required completion scheduled date (Siemens, 1971; Feltz, 1970). In addition, there is evidently a limited ways by which an activity can be shortened. Therefore, a systematic approach is required to implement the shortening of the project duration (Lamberson and Hocking, 1970) in accordance with minimizing the additional costs incurred due to compressing the project duration by a specific amount (Robinson, 1975). The methodology of shortening the project duration at the lowest possible cost is quite elementary whenever the desired project duration is greater than the critical path. What required in this case according to Siemens (1971, p.355) is,

> to rank the activities on the critical path in order of ascending cost slope, shortening the lowest-cost-slope activities as much as possible and continuing to shorten the progressively higher-cost-slope activities until the critical path has been shortened by the required amount. However, when the desired project duration is less than the second-longest network path, it is not only necessary to shorten the critical path, but one or more sub critical paths as well.

So, if an additional critical path is created, the activity should not be expedited to its minimum time; instead it should be expedited only enough to make the additional path critical.

Ramini (1986) proposed the algorithm of incorporating the criticality indices for crashing the project networks. Ramini's approach suggests that the activities with highest criticality index should be accelerated in the crashing process. In the same regard, Johnson and Schou (1990) suggested a model to compare three rules for crashing sophisticated networks. They suggested a criterion of selecting the crashed activity is as per the following rules:

1- Select the lowest cost slope activity or activities that will shorten the critical path(s).
2- Select the activity with the highest criticality index. In the case of ties, choose the alternative that costs least per unit of time to reduce. The criticality index should ideally be recomputed at each step in crashing a project.
3- Select the least cost/day activity first. It reflects the idea of selecting the least cost expected value.

Thus, it is not just a simple matter of shortening those activities with the lowest cost slopes. Some activities may be constituents of more than one critical path requiring reduction.

Consequently, it may be less costly to crash a reasonably high cost slope activity that is common to several paths requiring shortening than to crash the lowest cost slope activity that occurs only on one of the paths that need shortening (Feltz, 1970; Beckwith, 1971). Finally, as Beckwith stated (1971, p.63), the minimum project duration schedule can be achieved,

> if any critical path is comprised only of activities which can not be further expedited, or equivalently if no cut through the network exists where all the critical path activities can be expedited; otherwise the project duration can be further reduced by repeating the algorithm.

2.6.3 Quantifying the Costs of Acceleration:

As shown, the overall project duration can be shortened only by accelerating the activities on the critical path through the process of acceleration and recalculation of the critical path. Thus, the cost of accelerating a certain project is the cost associated with accelerating the activities on its critical path through the process of schedule crashing. Still, as illustrated in the process of schedule crashing, other paths may become critical. So, the cost of non-critical activities should be considered in the process and the cost of accelerating all activities with a float should be calculated, assuming no re-sequencing is being performed (Mohan, 2008).

Still, when activities are being re-sequenced through the acceleration effort, the non-critical paths in the original schedule could change as part of the process. Furthermore, more than one critical path can be obtained in the process, and those should be accelerated in a parallel sequence together with the same amount of duration (Beckwith, 1971). Therefore, the cost of accelerating each successive critical path has to be calculated until the target completion date is reached (Feltz, 1970) or the optimum duration as will be shown further. “Then the total rate of cost increase for each cut through the network is the sum of the rates of cost increase for all activities on critical paths which would need to be simultaneously expedited” (Beckwith, 1971, p.63).

According to Mohan (2008), an important matter to be considered in determining the cost of acceleration is the associated loss of productivity. Re-sequencing the schedule plan can lead to a certain loss of efficiency either because of the additional set-up and mobilization time required or because of the inefficient utilization of resources. Similarly, reducing the material delivery times could result in additional material handling and transportation costs as well as supplementary storage requirements. The addition of equipment needed in the project results, in some cases, in less than optimal use. Furthermore, as shown previously, the addition of man-power and labourers could lead to overcrowding at the project site (Cookson, 2005). Furthermore, according to Mohan (2008, p.4), “the loss of efficiencies because of overtime is well documented”. So, as evidenced, the methods of acceleration could result in productivity losses and supplementary costs, which need to be considered in the quantification of costs to arrive at the target completion date or the optimum duration (Cookson, 2005).

Mohan (2008) suggested that while calculating the cost associated with the loss of productivity, many available standard factors can be used such as those provided by the National

Electrical Contractors Association (NECA) and Mechanical Contractors Association of America (MCAA). Still, “care should be taken to ensure that the factors used are those developed from similar projects and trades, or if not, suitable adjustments should be made and the basis of these adjustments documented” (Mohan, 2008, p.4). Therefore, the acceleration costs should be documented under separate cost codes in order to assist the contractor with tracking costs for the acceleration and crashing efforts. Subsequently, these documents can then be used while calculating the overall acceleration costs for the purposes of proper planning and budgeting in the future.

2.6.4 Project Budget/Schedule Optimization:

It is well-known that changes to a project's original plan during the execution stage can cause significant disruption, and greatly extend a project's duration. However, it is also well-known that the opposite policy, that of throwing as many resources as possible at the problem to try to keep to the original schedule, can be very expensive, and is in fact often counter-productive (Williams, 1999).

According to Kramer and Hwang (1991), the project schedule should be originally developed to reflect the main objectives of the organization. Particularly, major project scheduling objectives are either to minimize the project duration, minimize the cost of the project, or to utilize the project resources at a controlled rate. So, for the planner to schedule the project, especially after a crisis, the project duration should optimize the associated cost of the project. Consequently, to minimize project cost, the cost of completing each activity should be calculated. The cost of the project activities is calculated as a function of the activity duration, as a function of the amounts and rates of resources used by the activity, or as an estimate of the cost under each particular mode of activity completion (Kramer and Hwang, 1991). It should be mentioned that activity cost does not vary as a linear function of activity duration.

In real-life projects, however, there are due dates for completion of the project or parts thereof. Rewards for timely or early completion and penalties for delays may sometimes be levied through contractual obligations (Kanda and Singh, 1988). Elmaghraby and Pulat (1979) studied the problem of the determination of activity durations and schedules to minimize total project cost when this cost involves a linear penalty for tardiness of a set of key events and linear crashing costs for activities. Consequently, the final optimum duration can be determined by adding the direct, indirect, and penalty costs as well as bonus money rewards together through all possible cases of project duration. According to Kramer and Hwang (1991, p.55), "it may be desirable to include a penalty cost for the late completion of an activity and/or bonus payments for the early completion of an activity". So, this approach of introducing a penalty and reward system will result in monitoring the contractors to mitigate the crisis impacts in the first place. It will give a clearer visualization for the process of optimizing the cost and duration of the project plans as well.

It should be mentioned that time/cost relationships of the project activities can either be linear (Kelley, 1961) or nonlinear (Elmaghraby, 1968). Thus, Kanda and Singh (1988) developed three different types of penalty/reward functions in order to determine the optimal cost of the project schedule. These three combinations are the following:

1- Piecewise linear penalty costs with linear rewards.
2- Piecewise linear penalty costs with a fixed reward.
3- Fixed penalties and rewards in different ranges of project completion.

2.7 Conclusion:

It should be highlighted that as per the English Proverb, "the only thing that overcomes hard luck is hard work". So, authorities should benefit from all the already studies and evaluated techniques in the literature. Lots of researches have already been conducted on the issues of project crises as well as crisis management and mitigation. Still, after a crisis, organizations should learn by examining, evaluating, and responding to what went well and what went poorly in terms of project execution. Signals and events are reviewed to ascertain and acknowledge any errors and determine how things might be done differently in the future. These changes are then formalized in amendments to policies and procedures (Pearson and Rodinelli, 1998). As per Smith (1999, p.167), "the greatest improvement in the productive powers of labour, and the greater part of the skill, dexterity, and judgment with which it is anywhere directed, or applied, seem to have been the effects of the division of labour".

3.0 Conceptual Framework and Research Methodology:

3.1 Conceptual Framework

Business organizations around the world are facing increased competition in today's rapidly developing market. Especially in the construction field, companies are being forced to continuously evolve to keep pace with market changes in order to complete existing projects. Nevertheless, many companies find their projects veer off course and end up accomplished away from their identified objectives and/or exceeding the time and cost limits. At the time that Abu Dhabi Emirates has visualized its 2030 vision plan, it has opened new complete infrastructure and construction markets for governments, developers and investors. Still, the management of complex projects that consist of a large number of interrelated activities poses problems involved in planning, scheduling, and control that most often lead to project crises. This has been noted in existing researches and experienced in the daily activities of project execution.

As shown in Figure 3.1, the previous review of extant literature indicated a wealth of solid research and reference material about project crisis management. However, the following gaps were found and this study aims to focus on them,

- There is neither reliable research study of project crisis management in the United Arab Emirates (UAE) nor identification of the main reasons for the crises. Additionally, no proposed mitigation techniques for minimizing the project crises have been established.
- Most of the current researches are approached and analysed from the contractor's point of view. However, no studies were found to tackle the project crises issue from the client's perspective. Additionally, this study focuses on governmental authorities as clients of projects that aim to develop the society rather than guarantee profits.
- Available studies in the literature focus on one client bearing responsibility for the executed projects. However, in the case of this study, multiple clients are involved in each of the projects and each party owns a portion of the project but has different objectives. In this regard, the project variables in this case differ from the normal project cases where the project chart only consists of one client with one or more contractor and consultant.
- Finally, all the literature studies found focus only on one particular part of the project crisis management practices (planning, estimation, control, risks, or mitigation). In

addition, the studies available in the literature focus on one of the project constraints (time, money, quality or resources). However, a full study is needed to link all of the practices together as an integrated package that combines all the required practices to be performed while tackling all the project constraints.

So, as indicated in Figure 3.1, this study aims to fill the missing gaps in the literature and assist the project managers and other personnel to better manage and run projects. The research focus of the study concentrates on project crises in regards to cost and time. Mainly, the study is conceptualized to deliver the following:

- Draw attention to the main drawbacks of project management practices within the concerned authorities in this particular research study. This has been emphasized through conducting interviews with representatives in these authorities and then analysing them through literature findings.
- Highlight the main reasons that lead to project crises in regard to time and cost within the scope studied. This has been accomplished through identifying all project crisis reasons studied in the literature and then analysing them in the project of the study scope. This will enable the project personnel to identify the crisis reasons in order to focus on them.
- Propose an integrated project crisis management package including different project stages to fulfil the gaps in the current practises. This package combines different techniques for planning, control, and crisis mitigation together as a sequence of project management practices. It will enable project managers to better control their projects to avoid crisis occurrences as well as to minimize the harmful impacts if any crisis occurred.
- Finally, implement some of the proposed techniques upon the findings and outcomes of the study on real project cases. The case studies illustrate the procedure of implementing the techniques extensively. As well, they illustrate the advantages of implementing the techniques further to the theoretical perspective.

For identifying crisis reasons in infrastructure projects, extensive study has been undertaken using the extant literature. Then those causes have been combined with causes experienced in the real project management practises. Subsequently, as demonstrated in the following methodology section, a statistical analysis has been conducted to study the correlation of the identified causes with the project crises. This will be useful for personnel who work in project management to clarify the main reasons behind crises in their own projects. Consequently, they will be able to consider them while running future projects.

Then, an integrated package has been proposed as a combination of all the management practises. These proposed practices are needed to fulfil the gabs of the current practises within the studied authorities. The integrated package will also allow managers and all involved parties to manage and control their projects in a way to minimize the causes identified previously. As well, it will enable them to mitigate harmful impacts in the case of crisis occurrence.

In order to propose the integrated package, planning techniques, which can assist in better estimate the time and money needed to accomplish the project, have first been investigated. Additionally, techniques that identify sources of risk that can hit the project have been studied. Here, the crisis reasons identified previously have been analysed for their impact on projects.

Afterwards, cost control and monitoring methods have been introduced. These techniques were developed from practiced approaches being used in different area of the world as well as different fields of projects. These techniques have been proposed to be used in order to better monitor current performance and control the existing situation. Furthermore, these techniques will be essential in order to forecast the future according to the running performance situation. They will assist project managers to predict potential crises before their severe impacts, as well.

After that, methodologies for crisis mitigation techniques have been investigated. These are the techniques being adopted during a crisis situation to minimize the impacts and overcome the cost overruns and schedule delays. Above all, the principle of project Cost/Duration optimization strategy has been anticipated, taking in consideration rewards and penalties in order to develop the best response for the current crisis. All planning, controlling, and mitigation techniques have been combined together and developed as an integrated package to be proposed.

Finally, some of the proposed techniques and methodologies have been tested on real project cases. This was an exercise to test the proposed integrated planning, control and mitigation package. In this exercise, a comparison between the normal practices with the proposed techniques has been conducted. This has been illustrated as a practical application of the proposed package and recommendations of the study. In addition, it shows the need for the proposed package as well as some tangible results of utilizing it.

3.2 Research Methodology:

In this dissertation as shown in Figure 3.1, the concepts of project crisis have been extensively studied via a review of existing Literature including books and journal articles. Then different kinds of crises that can disrupt projects have been introduced. It should be noted that cost overruns and schedule delays were the concentration of this particular study. First of all, intensive research has been carried on to explore the concept of project crises in terms of cost overruns and schedule delays, as explained in the framework section. Then, all reasons and crisis roots that result in exceeding the defined cost and time have been identified, studied and illustrated. Data obtained from literature have been analysed and examined toward the real life project cases included in the scope of this study.

In this particular research study, both quantitative and qualitative approaches have been adopted for the process of testing literature review outputs and collecting data from real project cases. The qualitative approach has been adopted mainly to collect data out from real projects that are accomplished by the government authorities contained within the research scope. In addition, the quantitative approach has been used to test the reasons behind crises and the circumstances mentioned in the literature review. Interviews and questionnaires have been used to guarantee feedback from concerned personnel working at the different authorities included in the research scope. Additionally, surveys were distributed to collect data about real project cases, the current practises, and the existing situation. Feedback data have then been statistically analysed to test the correlation among the different reasons and their impact on the projects' costs and schedules.

Qualitative research has been conducted to gather preliminarily information. Qualitative research is necessary for this research study because the root causes of crises were difficult to discern particularly in the scope of this study. So it has been adopted in order to determine what factors merit the most consideration. It should be noted that the data presented from qualitative research were much of responses than pure numbers. Instead, qualitative research yields subjective descriptions of feelings and experiences. Still, feedback of the qualitative research made it easier to categorize the real-life faced problems that usually result in project crises.

Qualitative research methodologies that have been adopted were designed to gain the different perspectives of targeted personnel who are responsible for the concerned development projects. Qualitative methods that were used include observations, in-depth interviews and focus group meetings. These methods were designed to aid understanding of the meanings people assigned to project crisis incidents and assist in clarifying the processes used in response to the crises. The advantage of using qualitative methods is the accumulation of rich and detailed data that provides insight into the views of personnel and presents a context for the needed data.

On the other hand, quantitative research has been used to collect data that is absolute such as the reasons of crisis in the organizations included in the scope of this dissertation. These reasons have been examined in as unbiased and objective manner as possible. The main idea behind using the quantitative approach was to be able to identify the root causes of crises easily so that they can be counted and modelled statistically. It has been used to remove factors that may distract from the intent of the research. Quantitative research included methods adopted to ensure objectivity, generalizability and reliability. The used technique for the quantitative research was the standardized questionnaires. The received data have then been analysed using statistical methods to test the relationships between specific root causes and project crises. The research participants were selected randomly from the study population in an unbiased manner.

A questionnaire approach was used as a methodology for collecting data in the second part of this study as shown in Figure 3.1. The advantage of this approach is that the surveys can be managed from remote locations via email and telephone calls. In addition, the standardized questions of the questionnaires have made measurement more specific by imposing uniform definitions among the participants. The first part of the questionnaire as shown in Appendix 1.0 was developed to collect general information about projects. The general information included the project type, status, location, budgeted cost, actual cost, estimated duration, and actual duration and different parties involved.

The second questionnaire was distributed to project managers involved in the execution of the development projects within the study scope. The aim of this survey was to collect useful data about the main factors that are motives for project crises as mentioned in literature. Real data about projects' uncertainties including scope definition, initial estimation, technical difficulties, roles and responsibilities, resources availability and contingency plans was collected. The data obtained from the survey results were liquidised into numbers for the purpose of the statistical analysis. This survey consisted of 57 focused questions that each asks about a particular measure of a particular independent variable, as shown in Appendix 1.0. The questionnaire employed a five-point scale in 'Likert' format in which the highest scale was '5' which represented ‘Strongly Disagree’ and the lowest was ‘1’ which represented ‘Strongly Agree’. This format has assisted in obtaining exact answer that represents specific level of agreement associated with each of measures stated.

It should be noted that a pilot study was conducted in an early stage of the study in order to identify the validity, reliability and the easiness of filling the questionnaire as a research instrument. In this pilot study, data of 13 projects were obtained and the project managers of those projects filled the surveys. This exercise had been required to make sure that the questions included in the surveys were adequate to measure the identified variables of the study. This had also been needed to ensure that the language of survey was well understandable for the project managers. Consequently, different opinions and comments from the participants were obtained and incorporated to end up having a more valid and clear questionnaire. Afterward, the main surveys were distributed in order to obtain the required data from the entire study sample.

In the main study, SPSS software was then used to statistically analyse the data obtained from the questionnaires. In the SPSS analysis, the project time and money crises have been considered as dependent variables whereas the crisis reasons, which were identified previously, have been considered to be independent variables. In the analysis, three main tests have been performed in the collected data, including the reliability test, the correlation test, and the regression test.

First of all, the reliability test has been used to check whether the determined measures can be used as representations of the independent variable. In the reliability test, the Cronbach's alpha (α) value was used as a measure of the internal consistency or reliability of a psychometric test score for a sample of examinees (Cronbach and Richard, 2004). As a rule of thumb, the Cronbach’s value of 0.7 is required in the reliability test so a certain measure can be used as an instrument (Allen and Yen, 2002). However, Gliem and Gliem (2003) noted that the good value of Cronbach’s alpha is 0.8 and reasonable to be set as a goal. In this contribution, each independent variable has been tested separately with its measures where the Cronbach's Alpha value was set to 0.80. For example, the tests were conducted on the scopes’ definition in the different companies involved in the studied development projects in order to check how reliably they can be considered as a measure for the scope definition independent variable. So, if the Cronbach's Alpha value obtained from the SPSS was more than 0.8, in this case the scope definition value would be represented as the average of its measures. If not, a certain measure would be excluded using the 'if item deleted' procedure acquired from SPSS. The same procedure had to be conducted to test the reliability of all other independent variables' measures.

After that, the correlation test was conducted to determine the relation of the dependent variables along with each of the independent variables separately. In this regard, project duration and project cost were tackled as dependent variables that represent the project crisis factors. It should be noted that the measures that failed in the previous test were not included in the averaged value of the independent variable. The level of significance α is usually used to represent the rejection region of sampling distribution to test how the result of the sample can be generalized to the true value of the population. The popular levels of significance are 5% (0.05), 1% (0.01) and 0.1% (0.001) (Thompson, 2004). However, a level of 5% is widely chosen for being conventional (Stigler, 2008). For the purpose of this analysis, the significance level has been considered to be 0.05 which means 95% confidence level. Also, the p value, which is the observed level of significance, is used to check the validity of the correlation. In this case scenario, if the p value is greater than or equal to α, the null hypothesis will not be rejected and vice versa. For instance, if the p value of the scope definition test was greater than 0.05, there would be no statistical evidence of any correlation of the scope definition with the project crisis.

Finally, the regression test was carried out to determine the relation of the dependent variables (project duration and project cost) together with the correlated independent variables. It should be mentioned that the independent variables failed in the correlation test would not be included in this test at the time that they did already not correlate with the project crises individually. The coefficient of correlation r^2 has been calculated to measure the proportion of the variation that is explained by the independent variables. For instance, if the r^2 value was 0.90, it would mean that 90% of the variation of the project crises dependent variable can be explained by the variability of the independent variables together. In other words, project crises variable is 90 % affected by the independent variables. In addition, the regression test was utilized to calculate the coefficient (β) of the linear relationship between the dependent variables and the identified independent variables as per the following equation:

$$Y = \beta_0 + \beta_1 X_2 + \beta_2 X_2 + ... + \beta_k X_k + \varepsilon$$

Further to the regression test, the analysis of variables (ANOVA) has been conducted, as well. This analysis is used mainly to check if the results of the regression test can be significantly safe to be replicated to the entire population. That is because the test was conducted on a sample of project as per the study scope. So, this test was required to check if the generated results are reliable to be used for the entire population. It should be noted that if the significant value was less that 0.05, then it would be significantly safe to replicate the test's results to the entire population. In this test, the significant values were obtained from SPSS.

In the statistical analysis, the following should be assumed:

- The input data can fit in a linear equation.
- The individual values of the error terms are statistically independent of each other.
- The distribution of all errors is normal.
- The distribution of error values has equal variances for all values of independent variables.
- The independent variables are not correlated among themselves.
- The means of the dependant variable for all specified values of the independent variables can be connected by a straight line.

In the statistical analysis, all project crisis reasons that are applicable to the scope of this project were identified. Then a second phase of literature review has been conducted to research methodologies which can better run projects and minimize crises and their impacts. The research was not just limited to techniques used and adapted during a crisis situation. It has encompassed all techniques that are used through a project's life cycle. All main processes of the project life cycle (planning, monitoring and control) have been tackled. The techniques have been extensively studied and then they were be linked all together as a one package in order to enable project managers to run their projects efficiently and minimize the probability of crises. in addition, it will assist project managers to mitigate their project and minimize the harmful impacts of the crises if any occurred.

Finally, some of the proposed and suggested techniques have been implemented on real project cases. This implementation, of the recommended techniques, illustrates the detailed procedures of the techniques and demonstrate the advantages of the utilizing them. For this matter, project cases were selected upon required if the usage of the requested techniques would be appropriate. It should be mentioned that details of the selected cases have been obtained from the client authority; however, they were simplified for the sake of respecting the data's confidentialities.

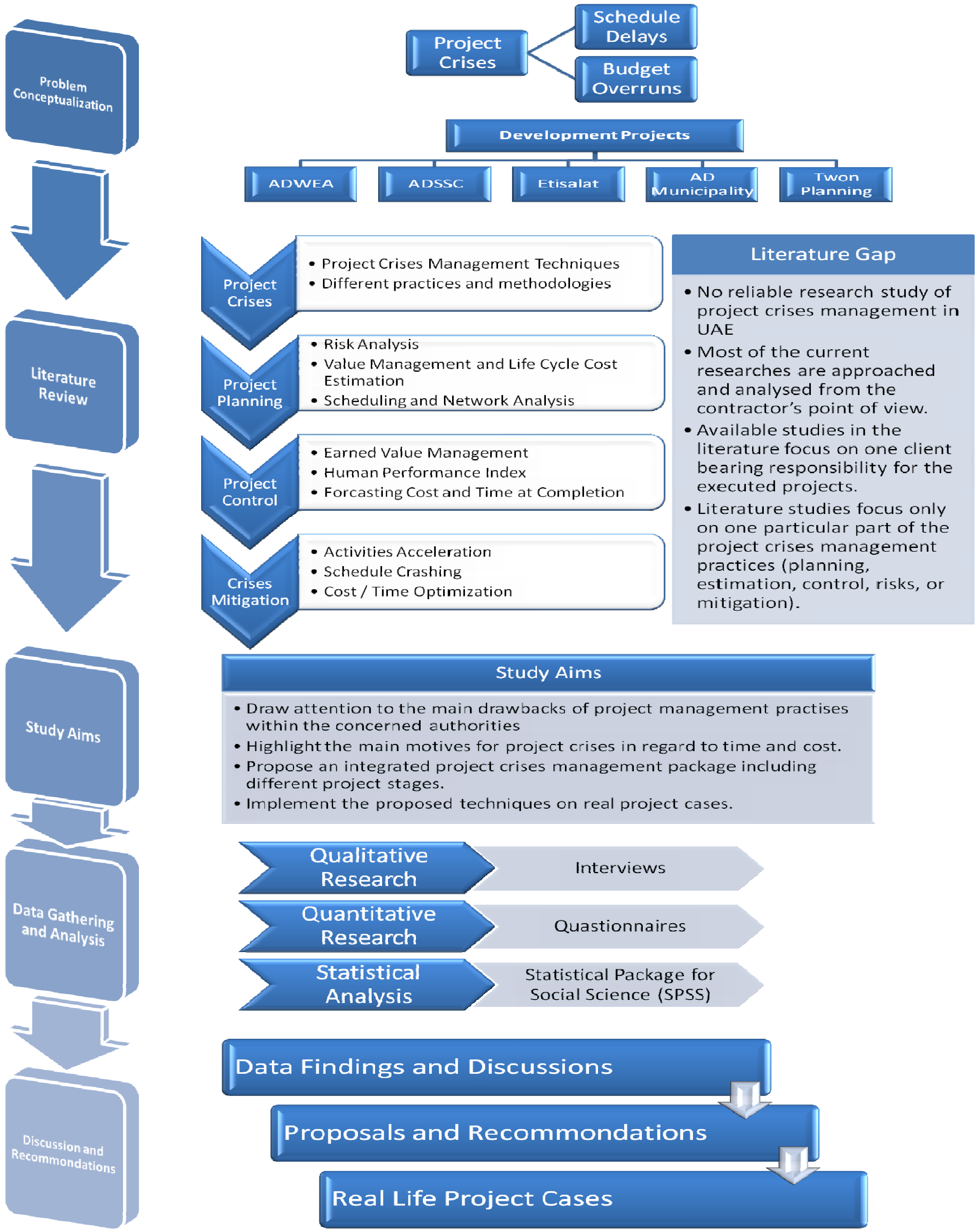

Figure 3.1: Research Conceptual Framework and Methodology

4.0 Data Collection and Analysis

4.1 Introduction to Data Collection and Analysis:

In the previous sections, the concepts of project crises and crises management have been extensively studied using the Literature Review references. In this section, as extensively described in the methodology section, both quantitative and qualitative approaches will be adopted. This process is implemented in order to test the Literature Review outputs on the project within the scope of this study through gaining data from real project cases. Afterward, those data will be analysed statistically in order to produce reliable outcomes and recommendations based on objective analysis. The qualitative approach will be adopted mainly to collect data out from real projects that have been accomplished by the government authorities contained within the research scope. In addition, the quantitative approach will be used to test the problems' reasons and circumstances adopted from the literature review.

Then, the data obtained from the qualitative approach will be categorized into groups of opinions as the main drawbacks of normal practises in the management of projects within the study scope. Additionally, the data gained through the quantitative approach will be analysed statistically using the SPSS (Statistical Package for Social Science) software applications in order to determine a subjective outcomes of the main project crises reasons. Those outcomes will then be the basis for the recommended practises to be implemented and the proposed methodologies to be adopted as it will be represented afterwards accordingly. Finally, based on the resulting outcomes, some major drawbacks of the existing procedures and practises would be illustrated in which the suggested techniques would be implemented on real project cases.

4.2 Study Samples

For this study, data was collected from fulltime employees of five leading government authorities based in Abu Dhabi, the capital of the United Arab Emirates (U.A.E) in 2010. For this study, a sample of government employees was selected because it was believed that this study would contribute useful guidelines to the government authorities in the UAE to possibly enhance the management processes of executing projects and eliminate the frequent problems of cost overruns and schedule delays.

In order to select a representative sample for this study, the random sampling technique was utilized and the study questionnaires were distributed in person with an attached letter indicating the purpose, assuring respondents of anonymity and explaining that the subsequent results will be strictly used for study purposes only. For accuracy and convenience of the participants, the questionnaire was conducted in the English language. The selected sample size for the qualitative research was chosen in order to have more than one quarter of engineers responsible for managing the development projects interviewed. Regarding the quantitative research, all development projects executed during 2007-2009 were concerned. These particular projects were selected as they are newly accomplished and their data can be accessed. Furthermore, these projects better represent the actual situation of the project management practises as they are the most recently accomplished ones. In here, it should be mentioned that data regarding the concerned projects was obtained for each project from the main project manager who was responsible in executing the project and collaborating with other concerned authorities.

Detailed description of the study samples will be represented in the following dissertation’s sections.

4.3 Qualitative Research Approach

Qualitative research was used as a preliminary form of research to start the data collection exercise. Qualitative research was necessary for this research study because the main reasons for project crises are unclear within the authorities particularly included in this study scope. So, it was adapted to able to determine what reasons are important to be considered and what are not. In here; the data presented from qualitative research was much less tangible than pure numbers. Instead, qualitative research yields descriptions of feelings and experiences. Such feedback makes it easier to categorize the main problems faced in reality that usually result in project crises.

The adopted qualitative research methodologies were designed to gain the different perspectives of the targeted personnel responsible for the projects included in the scope of this study. Qualitative methods that were used include observations, in-depth interviews and focus groups. These methods were designed to help in understanding the meanings people assign to project crises incidents and assist in clarifying the processes used in response to the crises. The advantage of using qualitative methods was the generation of rich and detailed data that symbolizes the personnel's views and presents a context for the needed data.

In this regard, personal interviews as well as telephone interviews were conducted with personnel responsible for managing projects from all the different authorities included in the study. For the sake of eliminating personal perspectives and for the data triangulation purpose, more than one person from each authority was contacted. Those authorities' representatives were asked to give their opinions about the drawbacks of the existing practices as well as why they think projects end up being delayed and over costing. Furthermore, some questions about particular practises of the different stages of the project would be asked. The areas highlighted in the qualitative investigation approach include the followings:

- Project identification process among different parties involved
- Project requirements and resources identification and assignment
- Cost and time estimations
- Communication protocols and responsibilities assignment
- Project uncertainties usually faced
- Risks analysis and management
- Cost and time control practices.

- Contingency planning

For this particular part of the data gaining exercise, random representatives were chosen from the authorities included in this particular study's scope. The selection of respondents ensured that the representatives chosen have good theoretical knowledge and practical experience in managing projects. Furthermore, the chosen authorities' representatives are responsible in their organizations for managing some of the projects concerned in this study scope. Above all, this exercise was conducted with more than one representative of each authority in order to make sure that the gathered data is not subjective and to eliminate personal opinions of special cases.

It should be mentioned that through the interview process, certain skills were used in order to gain more reliable information and feedback. In this regard, the followings were ensured while extracting information and cross checking observations:

- The data gained is opinion reflecting facts occurred in the past.
- The feedback reflects expressions regarding similar project to those tackled in this study.
- Further discussions were conversed in order to confirm the data's reliability as well as to enhance the understanding of the situation.
- Data was clarified whether they reflect general frequent attitude or just one occasional situation.
- Respondents were asked whether the practices generating negative feedback are still currently in use or there were some improvements introduced.

Finally, the gained data gathered from all authorities' representatives about the current practices were integrated together. Afterwards, they were categorized into groups of drawbacks of the existing project management practices within the scope on this study. Moreover, the obtained data regarding the main causes for projects being delivered late and above budget were integrated with the main projects' uncertainties obtained from the literature review. Consequently, these forms the basic variables used in the research's quantitative approach afterwards.

4.3.1 Data Presentation

Table 4.1 presents the summery of the opinions of personnel responsible for executing projects in the different authorities included in this research scope. Their opinions were obtained through personal and group interviews as well as phone calls as part of the first data gaining exercise. In this stage, the opinions of the following number of personnel were obtained:

- 6 Project Engineer form ADDC and 4 Projects Engineers from TRANSCO to represent ADWEA
- 4 Project Managers from ETISALAT
- 5 Project Engineers from ADSSC
- 4 Project Managers from ADM
- 3 Planning Engineers from Town Planning

In this Qualitative Research exercise, the different personnel were asked to give their opinion of the execution practises in managing the development projects in Abu Dhabi in which most of the Authorities participate together. That is because this research study, as clarified in the Study Scope Section previously, is addressing the development projects in which more than one authority participate as clients rather than the typical projects were only one authority plays the role of the client. During the exercise, it was ensured to transparently share the technical opinions of the personnel asked to participate about the processes practically utilized rather than the theoretical techniques known. It should be mentioned that the data obtained in this stage is general regardless of the project’s traits.

As illustrated in Table 4.1, the responses of all personnel participated was categorised mainly in 7 groups that represent the main procedure stages in managing projects. The first and main issue that was concluded is that the negative response consolidated in the running stage of the projects. As can be seen, only the Authority of Town Planning has problem with the categories of project identifications and project requirements practises. Instead, most of the negative response is concentrated in the management practices during the stages subsequent to the start of project execution. As it can be seen, most authorities expressed negative response through the interview regarding the risk analysis and management practices as well as the control techniques of cost and time. It should be noted that different response was expressed regarding cost and time estimations, which can be explained by the common practise of neglecting the associated risks. Furthermore, it should be highlighted that all authorities stated their dissatisfaction regarding the amount of effort spent on the contingency planning.

Those findings will be extensively discussed in the following section. However, it should be noted that the critical areas highlighted will be integrated with the other tests' results in order to get a clearer understanding the situation.

Table 4.1: Authorities' Personnel Responses

	ADDC	TRANSCO	Etisalat	ADM	ADSSC	Town Planning
Project Identification	***O***	***O***	***O***	***O***	***O***	***X***
Project Requirements	***O***	***O***	***O***	***N***	***N***	***X***
Communication Protocols	***N***	***O***	***N***	***X***	***N***	***N***
Cost and Time Estimations	***X***	***N***	***N***	***X***	***O***	***N***
Risk Management	***N***	***X***	***O***	***X***	***X***	***X***
Cost and Time Control	***X***	***X***	***X***	***X***	***N***	***O***
Contingency Planning	***X***	***X***	***X***	***X***	***X***	***X***

O = Positive response X= Negative response N=Neutral response

In this concern, all comments about project conceptualization and initiation were combined under the category of Project Identification. All comments about the resources and requirements identifications and assignments as well as comments regarding tendering and selecting the consultants and contractors were combined under the category of Project Requirements. All comments about the communication practises among the different parties involved in the projects were combined under the category of Communication Protocols. All comments about the processes of estimating time and cost of projects were combined under the category of Cost and Time Estimations. All comments about Risk analysis, identification and preparations combined under the category of Risk Analysis. All comments about the processes of evaluating and monitoring the time and cost of projects while executing were combined under the category of Cost and Time Control. Finally, all comments about the preparation of crises plans in order to mitigate their impacts were combined under the category of Contingency Planning.

As it can be noted in the figure 4.1 below, most of the negative responses were consolidated in the stages of management processes while executing the projects. In the other hand, negative response was minimal in the managerial practices of initiating projects, formalizing the team, and assigning requirements. Another interesting finding is that none of the focused practises gained positive response from all authorities, while that contingency planning received negative response from all authorities' personnel interviewed.

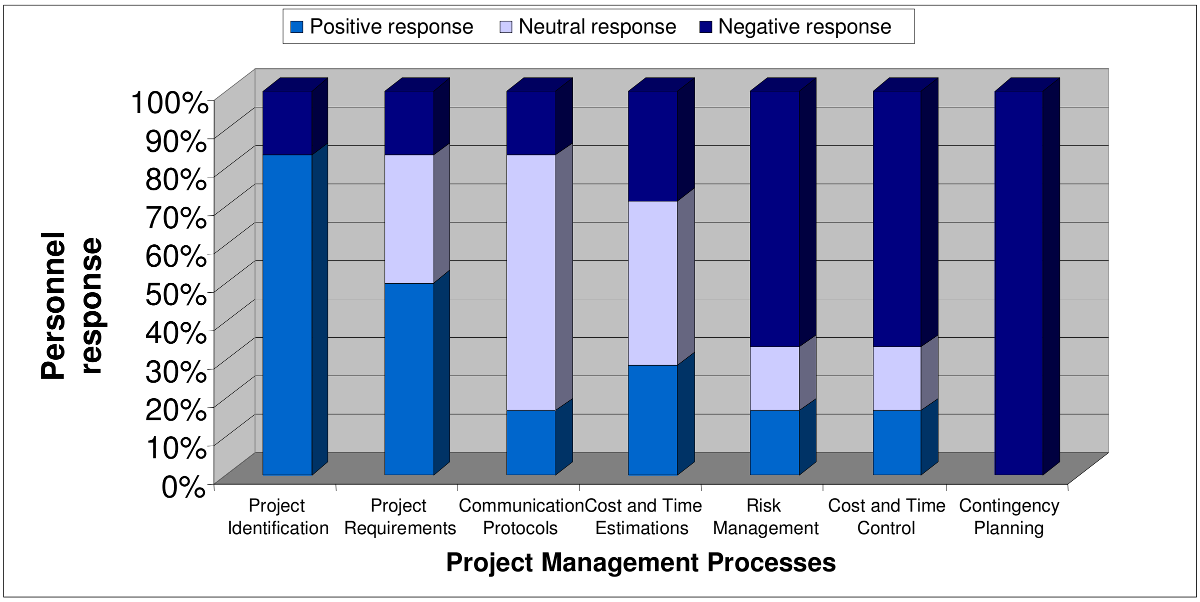

Figure 4.1: Authorities' Personnel Responses

Further to the response about the drawbacks of the practises used to manage the projects, the qualitative research exercise included collecting opinions about the frequent project uncertainties and crises reasons. As shown, all authorities' personnel commented negatively about the contingency planning practices, so they were asked to list what they think contributes to projects being accomplished late with extra costs. Those comments were categorized into main project uncertainties as shown in Figure 4.2. It should be mentioned that the personnel were asked to express their comments based on their experiences of running similar projects in the past within the context of this research scope. Those recognized project uncertainties would be integrated with the project uncertainties identified in the Literature previously, forming the base of the quantitative research approach afterwards.

As illustrated in Figure 4.2, the project uncertainties that lead to accomplishing projects late with extra costs above the planned budget are consolidated and combined into 6 categories. At this Stage, these categories were not ranked according to response repetitiveness because, it was intended to statistically examine the data as part of the quantitative approach of this study. This stage was mainly focused on opinion acquisition in order to consolidate the data obtained from the Literature.

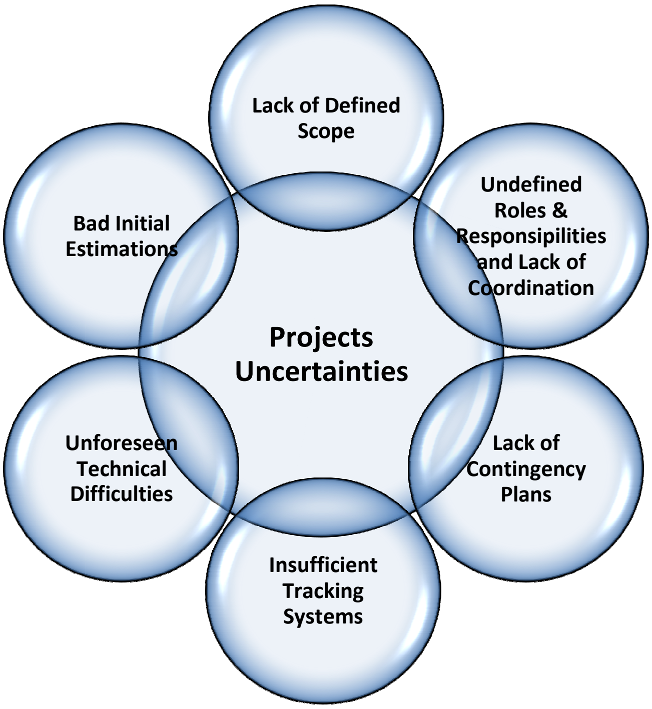

Figure 4.2: The opinions of the concerned Authorities' personnel about the main project uncertainties

As illustrated in Figure 4.2, the following list represents generally the detail feedbacks expressed by the personnel who participated in discussions regarding each of the above mentioned project uncertainty categories,

- Lack of Defined Scope:
  - Many variation orders are added to the projects after starting the execution.
  - Other valuable alternatives are not usually considered.
- Undefined Roles and Responsibilities
  - The responsibilities of the tendering are not well managed.
  - Meetings are well arranged during the projects conceptualization, however, few meetings are arranged afterwards.

- Managing the contractors and consultants are often problematic.
- The relationships among different authorities' contractors and consultants are frequently neglected.

- Bad Initial Estimations
  - Mostly, the construction costs are considered while other costs of commissioning, operation and maintenance are neglected.
  - Risk analysis is not well carried out.
  - Net Present Value of options' life-cycle costs is not considered.
- Unforeseen Technical Difficulties
  - The long technical evaluation process is delaying the projects.
  - The availability of sufficient resources and the proper utilization is often a problem.
  - Third party policies and limitations consume lot of time that is regularly unpredicted.
- Insufficient Tracking Systems
  - Execution is not usually monitored from the time perspective.
  - Money is only monitored through checking payments.
  - The earned value method is not practised by any of the authorities.
- Lack of Contingency Plans
  - No contingency planning is properly practised.
  - No mitigation plans are usually introduced.

4.3.2 Data Analysis and Findings Discussion

In this particular section, the findings gained through obtained data will be extensively discussed and analysed. As was shown previously, the authorities seem to initiate the projects well with all involved parties. All included authorities, except for Town Planning, gave positive feedback regarding the process of project initiation. It was obvious from the feedback that several meetings are usually arranged prior to starting the tendering stage in order to ensure that all authorities are satisfied with the scope of work. Yet, some negative comments were received about the process of identifying the project requirements as well as acquiring and assigning them. However, the Town Planning authority in particular raised the issue that the contractors and consultants are usually being assigned by the other authorities before the Town Planning gets introduced into the projects. This can be a major drawback as the Town Planning Authority is still an essential part of the infrastructure development projects.

However, in the main processes of the tendering stage, the positive feedback started to a negative incline as illustrated previously in Figure 4.1. This was clear in the categories of different parties' communications as well as time and money estimations. Particularly for the case of communications, most of the authorities insisted that the communication among different parties usually starts in a good manner. However, the communication among authorities gets limited to emergencies after starting the execution of the projects. All the authorities, except TRANSCO, highlighted that progress meetings and monthly reports are usually separated for each authority after starting the execution stage. In other words, each company does its own meetings and reports individually and does not usually share the information with other authorities. This can be highlighted as a major drawback at the time all authorities are working together on the development of the same project. That is because, even if each company is concerned with its own scope of work, practically, the different authorities scopes are integrated and being executed in a parallel manner. Furthermore, in the case of time and money estimations, it was obvious that all authorities are relying on the similar previous projects in estimating the required time and cost. Still, many comments were raised about neglecting both the risk analysis and the entire life cycle of the projects. Neglecting these two essential practices lead to insufficient alternatives comparison. Many real project cases were highlighted in which better alternatives could be chosen if the assessment of different alternatives was well practiced. For this regard, one of these cases will be extensively studied afterwards in this study to illustrate practically how value engineering can be utilized in assessing different alternatives.

The feedback gained for the processes used while executing the projects was almost uniformly negative. As illustrated earlier, only Etisalat was satisfied with the risk management process, and only Town Planning Authority expressed its satisfaction regarding the cost and time control. In this regard, it should be mentioned that the Etisalat infrastructure network is usually the shallowest among all other infrastructure networks. In other words, this means that particularly, Etisalat works are the least risky tasks among other authorities. That might be the reason behind their positive satisfaction. Still, in general authorities expressed that associated risks are badly identified and not well planned for. Additionally, they have declared that risk control during execution is weak and should be improved. As it was discussed earlier in the literature review section, risk management is an essential practice that should be further enhanced for the case of authorities included in this particular study. In addition, the majority of authorities expressed that time and cost are badly controlled. As different authorities' personnel stated, the cost of projects are only being monitored by checking the payments received from contractors. However, the earned value of time and money are never considered. Many cases were mentioned by the authorities' personnel where projects were discovered to be late and over costing at the very late stages of the projects. Afterwards in this research, one of these cases will be extensively studied and the earned value practices will be illustrated. It should be mentioned here, that neglecting the monitoring practices while executing the projects is the main reason behind the repetitive practice of adding many variation orders for time extension and cost enhancement.

Finally, when the topic of contingency planning was opened with the personnel interviewed, only negative feedbacks was expressed. Though all of the respondents stated that it is a normal case for a project to end up been accomplished with extra time and money compared to the planned duration and budget. Still, crises mitigation techniques are not being practiced by any of the authorities concerned in this study. It was claimed that project managers and engineers are limited with the procedures implemented by the system that does not include identifying the main reasons for project delays and over costing. In addition, practises for mitigating the harmful impacts of crises on projects are not introduced to be implemented or practised. Consequently, the frequent practise is to introduce variation orders for the contractors of extra time and money.

Those variation orders cause harmful impacts for the authorities especially for not matching the required deadlines. It should be mentioned in here that although money is important for the government authorities, still achieving the time deadlines is the most essential because these authorities are government organizations that serve the public. This public service limits the authorities with fixed deadlines. In this regard, a real project case where the project failed to meet its deadlines will be studied in this examined in order to demonstrate how project crises mitigation techniques can be practically used.

Above all, there are several related major concerns were observed through the interviews conducted. Those observations are as following:

- In the process of selecting options among different alternatives, the authorities consider the national suppliers' products and local producers' materials. This practice limits the process of the value engineering practices. It also makes the process of tendering not to utilize the advantages of the competition of open tendering.
- The tendering process for the concerned development projects is mainly being managed by the Abu Dhabi municipality. This usual practice eliminates the enrolment of the other authorities involved in the project to evaluate the time and cost of the bids, as well as it removes the other concerned authorities' ability to review the bidders' capabilities.
- The Town Planning Authority seems to be involved in the projects after the associated design phase is finalized. This usual practice is the reason why many change orders and variation orders are introduced after starting the execution of the projects which frequently lead to messing up the plans. At the end, these circumstances result in accomplishing the projects with extra time and higher costs than originally planned. However, as an authority responsible for planning the scheme of the city's future, the Town Planning Authority should be involved from the beginning. That is in order to eliminate conflicts between its prepared plans and the project executed by the other infrastructure authorities.
- Finally, the concept of bonuses and penalties is not utilized in the management practises as a sequence of early or late completion of the projects. Although, some authorities add a condition in the contract that the contractor will be fined a certain amount if any of the contract specifications were not met, yet this is not a particular condition for the delayed delivery. On the other hand, no clear bonus policy is clearly included in the contracts of

the concerned projects. However, early completion is only considered for the contractor at the time of awarding the urgent projects which usually do not go through the normal tendering process. Yet, a specified linear percentage of bonuses and penalties to be introduced will motivate the contractor to adhere to the specified completion date, if not earlier.

Furthermore, several specific findings were concluded through analysing the feedback of the participating personnel regarding the main reasons for schedule delays and cost overruns. This exercise was conducted mainly in order to collect practical reasons for the projects crises within authorities included in this research scope. Although previously several reasons were obtained from the literature references, the objective of this part of quantitative research is to consolidate the reasons behind project crises with those reasons affecting the projects included in this particular study. The following is an extensive analysis of the integrated comments:

- The project scope of the certain project is well defined, however the scope is not integrated with the longer plans of different authorities. Thus many variation orders are being raised during the execution stage of the projects. Consequently, this will usually lead to postponing the completion date and adding costs to the project.
- The process of design evaluation does not integrate the life cycle assessment. In addition, it does not include the value engineering evaluation of different alternatives. Consequently, while executing the projects and operating and maintaining the deliverables, the different client bodies face added costs that were not budgeted originally. This is seen as a major threat to the authorities at the time that each project's budget is being allocated from the early stages of project conceptualization.
- Coordination meetings among different authorities' representatives are not adequate during the execution stage of the process. Subsequently, each authority handles only the related partial scope of works rather than the overall integrated scope. This leads to differentiating the authorities' objectives, which afterwards leads to conflicts and clashes.
- Similarly, it was noticed that the contractors of each authority are not cooperating with other authorities' contractors on site properly. It should be mentioned here that each client authority hire a different contractor and consultant particularly for the scope of the authority. So, the project ends up being carried out through so many contractors that the

authorities should make sure that proper coordination is being taking place during the process of execution at the site.

- Risk Management techniques and procedures are essential to be well practiced during the early stages of the projects. However, it was observed that the processes of risk identification and planning are inadequate within the concerned authorities. As shown in the literature review, there are many practical processes based on theoretical backgrounds that can be used to identify, measure and account the potential risks. However, the usual practice within the concerned authorities is just to account a certain percentage added to the total time and budget.
- As discussed earlier, the frequent practice for tendering the development projects of the included authorities is managed through the Abu Dhabi municipality with limited enrolment of the other authorities. This is the main reason tendered contracts are sometimes awarded to incapable contractors. Similarly, this is the case for tendering and awarding the consultancy contract. Therefore, the insufficient contractors and consultancies result in a lack of smooth progress of the projects.
- As mentioned previously, time and money control techniques are not being implemented in all of the projects. This means that the existing progress of work is not always monitored and not compared to the planned schedules and budgets. Thus, any delays or over costing sequences are regularly not being recognized until the very late stages of the projects execution.
- Contingency reaction plans are never introduced as a specific requirement in the process of managing the concerned projects. Thus, if any delay or over costing occurred, no sufficient practice would be implemented. This would further amplify the impacts of the delays and over costing rather than mitigating them.

4.4 Quantitative Research Approach

At this stage, quantitative research was used to gather statistical data that is absolute about the correlation of project crises with the reasons in the organizations included in the scope of this dissertation. This was examined as unbiased a manner as possible. There are many principles adopted along with quantitative research to help promote its supposed neutrality. Quantitative research comes later in this research, once the scope of the project is well understood.

The main idea behind using the quantitative approach is to be able to separate the crises reasons easily so that they can be counted and modelled statistically. Additionally, it is used to remove factors that may distract from the intent of the research. Quantitative research included methods adopted to ensure objectivity, generalizability and reliability. The techniques used covered the standardized questionnaires as well as interviews. Then, the received data was analysed using statistical methods to test the relationships between specific reasons and the project crises. The research participants were selected randomly from the study population in an unbiased manner.

The first part of the questionnaire was distributed to collect general information about projects. Such information includes the project type, status, location, budgeted cost, actual cost, estimated duration, and actual duration and different parties involved. The second survey was distributed to project managers involved in the execution of the trip projects of within the study scope. The aim of this survey was to collect useful data about the main factors that are motives for project crises as mentioned in literature. Real data about projects' uncertainties including scope definition, initial estimation, technical difficulties, roles and responsibilities, resources availability and contingency plan was collected. It should be noted that the general information required in this particular survey as well as the answers' variations were formalized through discussions with the participants of the qualitative research interviews.

Interviews and questionnaires were used to get feedback from concerned personnel working at the different authorities included in the research scope. Surveys were distributed to collect data about real project cases, the current practises, and the existing situation. Feedback data was then be statistically analyzed to test the correlation among the different reasons and their impact on the projects' costs and schedules. It should be noted that the surveys were theoretically designed in a way to ask particular questions as measurements for each of the independent variables identified through the qualitative research approach earlier.

It should be mentioned here that from the qualitative research approach, six main concerns were raised. Those concerns are integrated with the project crises motives adopted from the literature review so they can be tackled as independent variables in the quantitative research. Those main independent variables are scope definition, roles and responsibilities identification and parties' coordination, initial estimations, tracking practices and control systems, technical related concerns and contingency planning. Each of those independent variables will be measured through collecting exact focused data about the measures that represent each variable.

As discussed earlier, two sets of surveys were distributed in the process of the quantitative research approach. The first survey, as shown in Appendix 1, aimed to collect general information about the projects included in this study. This particular survey focused on the two main dependent variables of the research study at the time the planned duration and the allocated budget of each project are obtained. Moreover, the percentages of cost enhancement and extra time needed are gained in order to measure the dependent variables later on. Moreover, this survey asked about general information of the projects such as the authorities who participated, project status, location and number of variation orders initiated. That information is required to enhance the understanding of the projects included in the study, as well as to show their variability.

The second survey distributed, as shown in Appendix 1, aimed to collect particular details about each of the concerned independent variables identified as project crises motives. Those data were obtained in order to measure their impact on the two dependent variables of the study, project duration and project cost. This survey consisted of 57 focused questions that each asks about a particular measure of a particular independent variable. The questionnaire employed a five-point scale in Likert format in which the highest scale is "5" which represents "Strongly Disagree" and the lowest is "1" which represents "Strongly Agree". This format assisted in obtaining exact answers that represent a specific level of agreement associated with each of the measures stated.

As it was extensively discussed in the methodology chapter, SPSS software was then used in the statistical analysis to statistically analyse the data obtained from the questionnaires. In the SPSS analysis, the project crisis is considered as a dependent variable whereas the projects' uncertainties that were identified previously are considered to be independent variables. In the analysis, three main tests were performed in the collected data which are the reliability test, the correlation test, and the regression test. The reliability test was used to check whether the determined measures can be used as representations of the independent variables. Then, the correlation test was conducted to determine the relation of the dependent variables (project duration and project cost) along with each of the independent variables separately. Finally, the regression test was carried out to determine the relation of the dependent variables (project duration and project cost) with the correlated independent variables all together.

As mentioned previously in the methodology chapter, a pilot study was conducted in a previous stage of the study in order to identify the validity, reliability and the easiness of filling the questionnaire as a research instrument. In this called pilot study, data of 13 projects were obtained and the surveys were filled by project managers of those projects. This exercise was required to make sure that the questions included in the surveys are adequate to measure the identified variables of the study. Furthermore, this was needed to ensure that the language of survey is well understandable for the project managers. Consequently, different opinions and comments from the participants were incorporated in the final version of the questionnaire. The data obtained from the pilot study were tested in SPSS software. The regression test was applied to check the defined relation among the dependent variables and independent variables. The coefficient of correlation r^2 was calculated to be 0.94 for the regression of the cost enhancement variable with all the independent variables. Moreover, the coefficient of correlation r^2 was calculated to be 0.84 for the regression of the time enhancement variable with all the independent variables.

4.4.1 Data Presentation

Table 4.2 presents the summary of projects characteristics as obtained by the first survey conducted. It should be mentioned that this exercise was conducted on 67 development projects that were executed during 2007-2009. However, due to various circumstances, data were able to be obtained for 63 of the 67 projects. It is obvious that most of the authorities participated together in accomplishing the development projects studied. As illustrated in table 4.2, the majority of studied projects accomplished during 2007-2009 were accomplished in the Eastern and Western Regions of Abu Dhabi which represents the vision of the Emirate to expand out of Abu Dhabi Island. Additionally, the majority of the projects executed were initiated with a normal status, which means that they were not urgently required to be accomplished nor were them developed for important and sensitive purposes.

From the first survey conducted, it was obvious that most of the projects were executed with extra costs added to the allocated budget. Additionally, extra time was added to the planned duration of the majority of the projects. Thus, variation orders were added initiated to the projects in order to cover the needed money and required duration. The survey illustrated that only 3 projects among the entire sample were executed without any added variation orders. It showed also that an average of 2 variation orders was usually initiated and added to original plans of the development project.

The following figures, illustrate in detail the sample characteristics of the development projects studied.

Table 4.2: Summary of Projects' Characteristics

	Authorities Participated	Project Initial Status	Project Location	Project Budget	Cost Enhancement Required	Project Duration	Extra Time Required	No. of VO
ADWEA	60							
ADSSC	60							
Etisalat	62							
Abu Dhabi Municipality	63							
Town Planning	61							
Normal		46						
Urgent		10						
Important		7						
Central Region			7					
Eastern Region			23					
Western Region			33					
Less than 40 million AED				7				
40 - 60 million AED				14				
60 - 80 million AED				15				
80 - 100 million AED				17				
Greater than 100 million				10				
As planned					4			
Less than 5%					18			
5% - 10 %					18			
10% - 15%					16			
Greater that 15%					7			
Less than 9 months						8		
9 - 12 months						14		
12 - 15 months						15		
15 - 18 months						15		
18 months or above						11		
As planned							5	
Less than 5%							16	
5% - 10 %							17	
10% - 15%							16	
Greater than 15%							9	
None								6
1								17
2								20
3								14
4 and Greater								6

As shown by the data in Table 4.2 and illustrated in the below Figure 4.3, the development projects concerned in this particular study were executed by the five government authorities discussed previously. Since the development projects model was conceptualized in 2007, the five authorities have been working side by side to develop the new areas and zones all over the Emirates of Abu Dhabi. For the 63 projects studied, all five authorities worked together in the execution of 60 projects. Abu Dhabi Municipality as shown is the only authority that participated in all the development projects covered in this particular study.

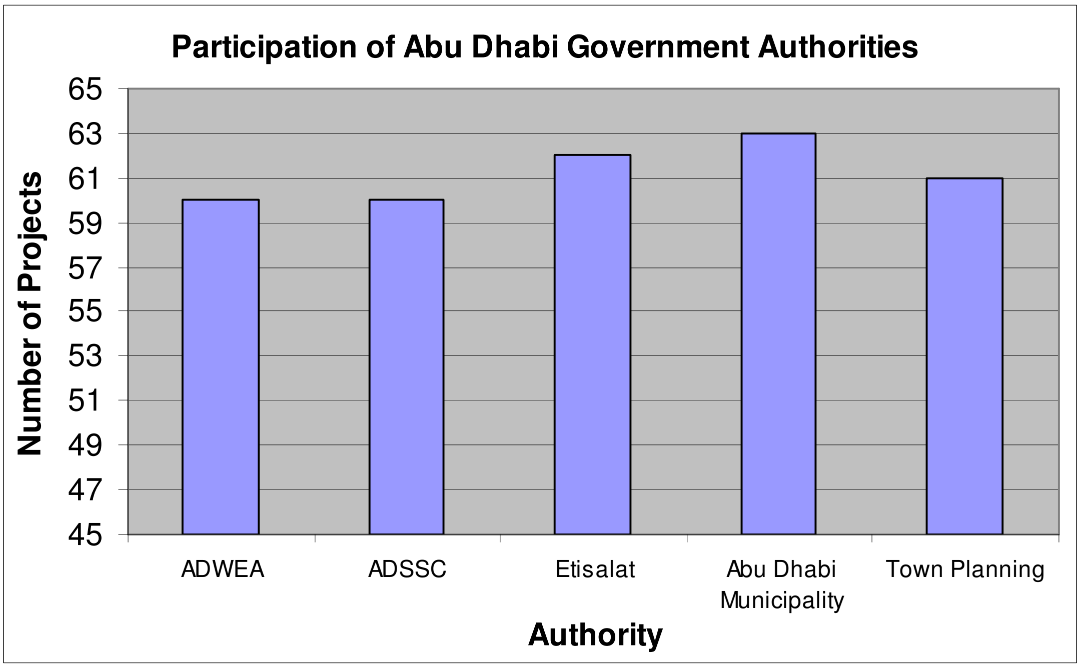

Figure 4.3: Authorities Participation

Moreover, as shown in Table 4.2 and illustrated in the below Figure 4.4, the majority of the development projects concerned in this particular study were initially estimated to cost between 40 and 100 million dirhams. The average of the allocated budget for all the projects included in this study was about 74 million dirhams. It should be mentioned that 10 projects, which is more that 15% of the sample, were initially estimated to cost more than 100 million dirhams each. In addition, as illustrated in the below Figure 4.5, most of the projects (more than 93% of the sample) were executed with budget enhancements. The average budget enhancement percentage for all the projects studied is almost 8.7%. That would mean that on average, 6.44 million dirhams are being added to the budget of every project during execution. Finally, it should be noted that more than 10% of the projects were executed with a budget enhancement of more than 15% of the original allocated budget.

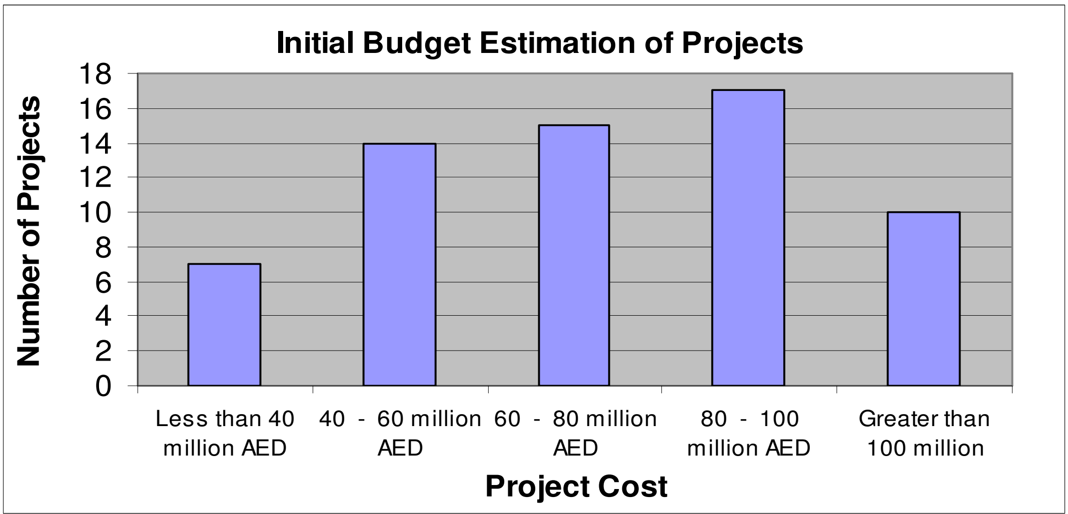

Figure 4.4: Initial Budget Estimations

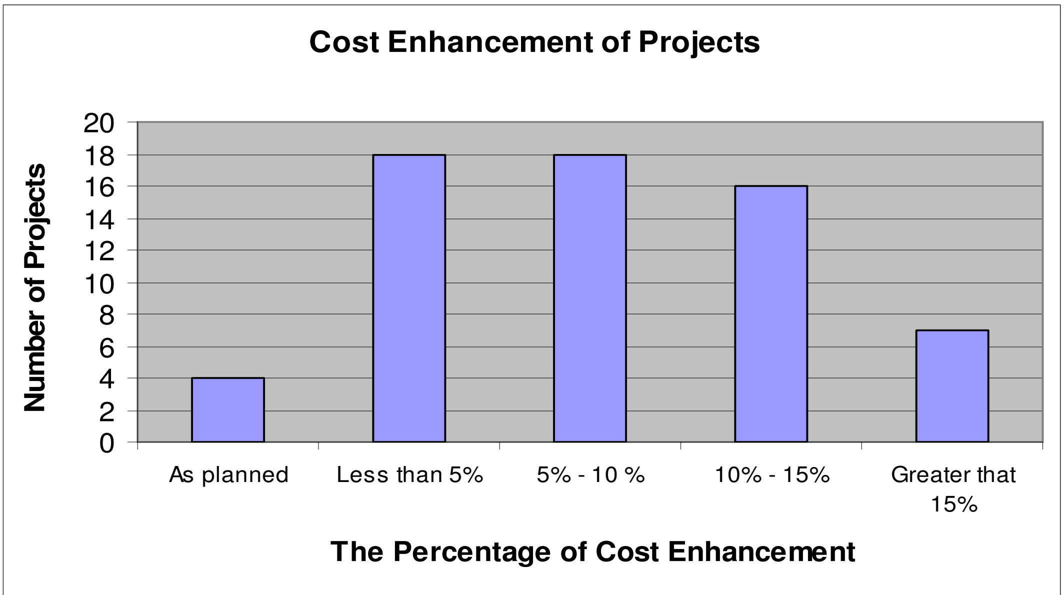

Figure 4.5: Authorities' Personnel Responses

Furthermore, as evidenced in Table 4.2 and illustrated in the below Figure 4.6, the majority of the development projects concerned in this particular study were initially forecasted to be executed between 9 and 18 months duration. The average of the planned duration for all the projects included in this study was about 13.5 months. However, as illustrated in the bellow Figure 4.7, only 5 projects, less than 10% of the entire sample, were executed on time. In addition, the average added time duration percentage for all the projects studied is 8.4%. That would mean that on average, more than one month's time is being added to the planned duration of every project during execution. Finally, it should be noted that more than 14% of the projects were executed with an extended duration of more than 15% of the original estimated duration.

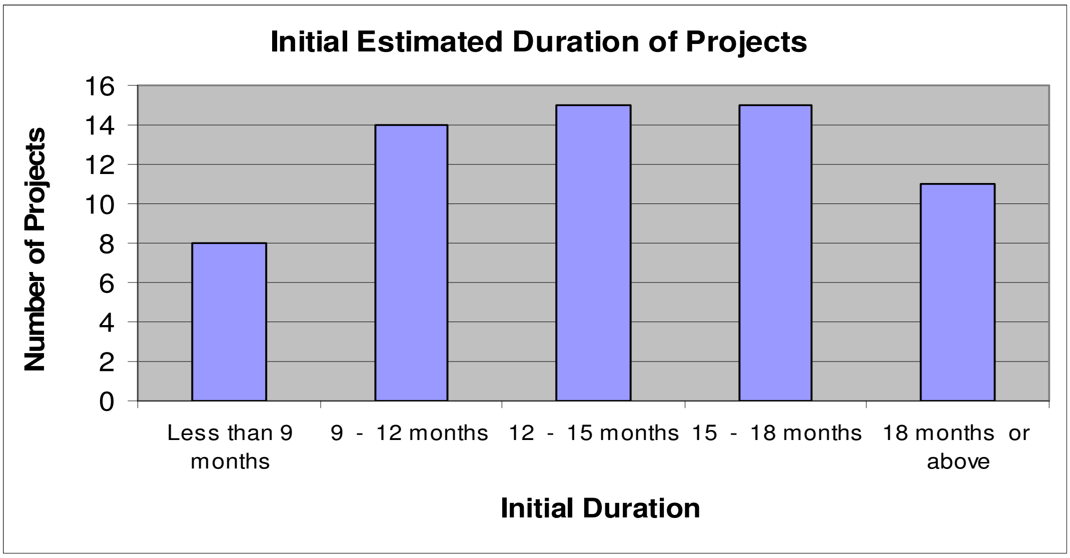

Figure 4.6: Authorities' Personnel Responses

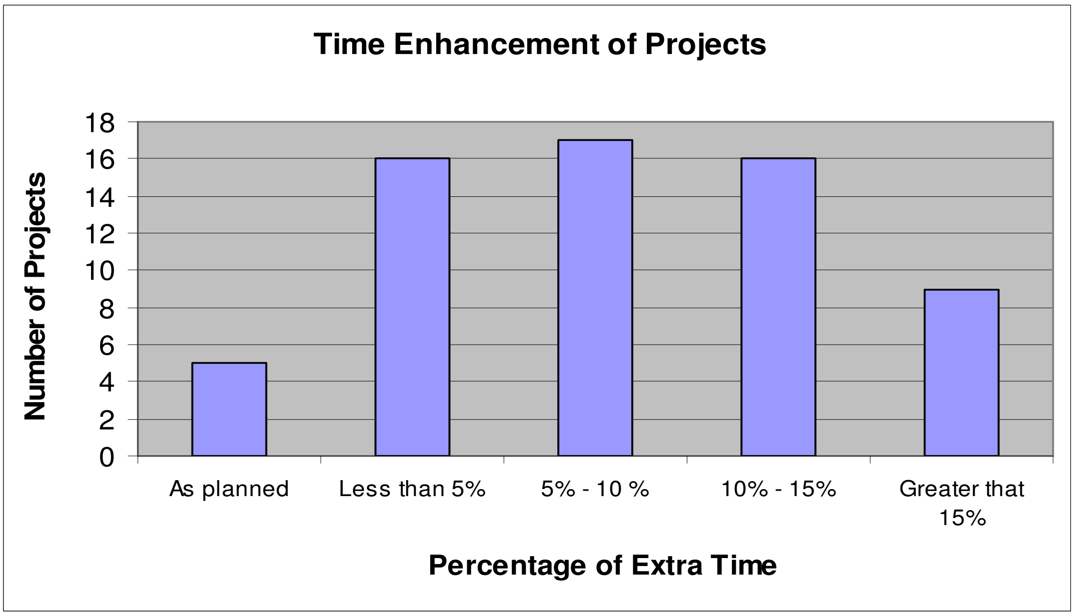

Figure 4.7: Authorities' Personnel Responses

Additionally, Table 4.3, shown afterwards, presents a summary of the participants' answers obtained from the second survey about the studied real life project cases. Those answers are analysed later as the data of the research variables associated with each of the development projects.

Table 4.3: Summary of the Participants' Answers

Project	Cost	CostENH	Time	TimeENH	VO	S1	S2	S3	S4	S5	S6	S7	RR1	RR2	RR3	RR4	RR5	RR6	RR7	RR8	RR9	RR10	Est1	Est2	Est3	Est4	Est5	Est6	Est7	Est8
1	1	1	1	1	1	1	1	2	1	2	1	3	1	2	1	1	1	1	2	1	1	2	1	3	1	1	1	2	1	1
2	5	2	5	4	2	3	2	3	2	3	2	5	3	2	3	2	2	2	2	3	2	4	2	1	2	2	2	2	2	2
3	2	2	1	2	2	2	1	2	1	1	2	2	2	2	1	1	2	2	2	2	1	1	2	2	1	2	1	1	1	2
4	3	4	2	2	2	3	2	3	4	3	4	4	4	2	4	3	3	3	2	3	4	3	2	4	4	4	4	3	3	4
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Est9	Est10	Est11	Est12	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	Tech1	Tech2	Tech3	Tech4	Tech5	Tech6	Cont1	Cont2	Cont3	Cont4	Cont5	Cont6	Cont7	Cont8	Cont9
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3	5	1	5	5	3	5	3	3	5	5	4	3	3	5	4	5	2	3	2	2	5	3	4	3	4	5	4	3	3	5	5
5	4	3	3	4	5	4	4	5	4	4	4	5	5	4	5	5	2	1	3	2	4	5	5	4	4	5	4	4	5	4	4
4	3	3	4	4	4	3	3	4	3	3	3	5	4	3	3	4	2	3	2	2	3	4	4	4	3	3	3	4	4	3	3
3	4	4	4	3	3	3	3	3	3	3	3	3	3	3	4	3	1	2	2	2	3	3	3	2	3	3	3	3	2	3	3
3	4	1	3	3	2	2	1	2	3	2	2	2	3	3	2	3	2	3	2	2	2	2	2	3	2	3	3	2	2	2	3
4	4	4	3	4	5	4	2	3	5	5	3	3	4	3	3	3	2	1	3	2	4	3	3	3	3	5	3	4	5	3	4
5	3	5	4	3	4	3	3	5	3	3	4	3	3	4	4	4	2	1	3	2	3	3	3	3	4	3	3	3	5	3	3
2	3	3	2	2	4	2	2	2	3	2	3	2	2	3	2	3	3	2	1	1	2	2	3	2	2	3	2	3	2	2	2
3	4	2	1	4	4	3	4	4	3	4	4	4	3	4	3	4	3	2	2	3	4	4	3	4	4	3	5	4	4	3	4
2	3	2	2	3	4	3	4	3	3	2	3	4	3	4	3	3	2	3	2	2	3	3	3	3	2	3	2	3	2	2	3
3	3	3	2	2	4	2	3	3	3	2	2	3	4	2	3	3	3	2	1	1	2	4	2	4	2	3	3	3	2	2	4
4	3	3	5	4	2	4	4	4	3	4	4	4	2	4	3	2	3	2	2	3	4	2	4	4	2	4	2	4	4	4	2
3	3	2	2	3	4	3	3	3	3	3	4	3	4	3	4	3	2	2	1	3	3	4	3	3	4	3	4	3	3	3	4
1	3	3	3	2	2	2	1	1	2	2	2	2	2	2	1	2	2	1	2	2	2	2	2	2	2	2	2	2	1	1	2
2	3	2	2	2	4	2	2	2	2	2	4	2	3	2	2	2	2	2	3	1	3	2	2	2	3	2	4	2	2	2	3
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	2	2	2	1	3	3	3	3	4	3	4	3	3	3	3
1	2	3	5	2	3	2	1	2	2	2	3	2	2	3	1	2	2	1	2	1	2	2	2	2	2	4	1	2	3	2	3
3	4	3	3	2	3	2	3	3	4	2	2	3	3	2	3	3	2	2	1	3	3	2	2	3	2	3	3	4	2	2	3
3	2	5	4	3	2	3	3	3	1	1	2	3	2	3	2	3	1	2	2	1	2	3	1	3	4	3	2	3	2	3	2
4	4	4	2	4	3	4	4	4	4	4	4	4	3	4	4	2	2	2	3	4	4	3	4	4	3	4	3	4	4	4	3
2	2	5	1	2	3	3	2	2	2	2	3	3	2	3	1	3	2	2	1	1	3	3	2	2	3	3	3	3	1	2	3
3	4	2	3	4	4	3	4	4	3	4	5	5	4	4	3	3	1	2	2	4	5	4	3	3	4	4	4	3	3	4	4
2	2	5	4	1	1	1	2	2	1	1	1	1	1	1	1	1	1	1	3	1	1	1	1	1	1	1	1	1	1	2	1
2	2	4	4	2	3	2	2	2	4	2	3	2	2	2	3	2	1	2	2	2	2	2	2	2	3	2	2	3	2	2	3
4	4	4	1	4	3	4	3	4	3	4	2	3	3	4	3	4	2	3	2	2	4	3	4	3	3	3	3	3	4	4	3

4.4.2 The Study Model and Variables

The study includes two main dependent variables that represent the project crises concerns. Those two dependent variables are namely, project duration, and project cost. Additionally, six independent variables were tested to check their correlation with the two dependent variables. Each of the three variables has different levels or facets. Each of the dependent variables was determined through several measures that represent the variable. It should be mentioned that those measures were tested through the reliability test in this study to ensure that the identified measures can be used to represent the dependent variables. Figure 4.8 below illustrates the intended investigation relationship among dependent and independent variables of this study.

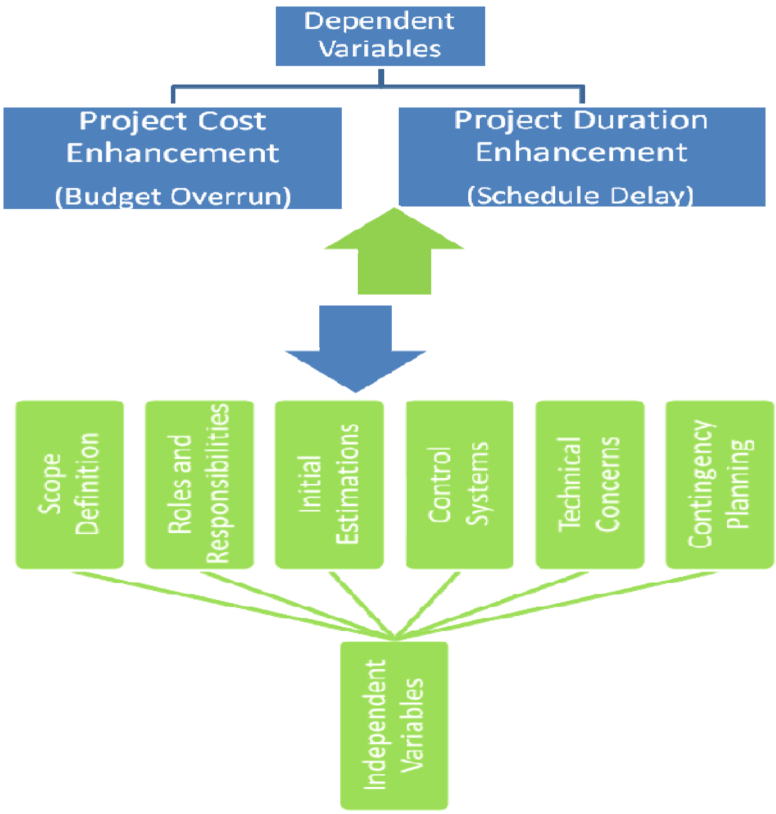


Figure 4.8: Study of Dependent and Independent Variables

4.4.3 Study Variables:

The study model as presented in Figure 4.8, assumes the following:

- The independent variables are not correlated among themselves.
- The means of the dependent variable for all specified values of the independent variables can be connected by a straight line.
- The linear relationship between a dependent variable and k of independent variables is presented by the following linear regression model:

$$Y = \beta_0 + \beta_1 X_2 + \beta_2 X_2 + \ldots + \beta_k X_k + \varepsilon$$

Where:

- Xs: independent variables
- Ys: Dependent variable;
- Bs: the regression coefficients
- ε is the error term.

4.4.4 Variables Definitions and Measurements

The study instrument is a questionnaire that includes 57 items designed to measure the relationship of the two main dependent variables with the six independent variables included in the study. The questionnaire employed a five-point scale in Likert format in which the highest scale of 5 that represents “Strongly Disagree” and the lowest scale of 1 represents “Strongly Agree”. The overall reliability, correlation and regression tests for all these 57 measures are represented later in the Data Analysis section.

In this study, the relations among both of the dependent variables with the independent variables are concerned separately in the following section of data analysis. First, the data will be tested statistically to study the relation of the cost enhancement dependent variable (which represents the schedule delay of projects) with the identified independent variables. Similarly, the time enhancement dependent variable (which represents the schedule delay of projects) will then be tested with the independent variables. As discussed in the methodology chapter, the relationship among dependent and independent variables will be tested through the correlation and regression tests. It should be noted that, even the projects that were accomplished on time and on budget, were included in the analysis. That is to highlight the characteristics of those projects and their relation with the studied variables.

4.4.5 Data Analysis

In this particular section, the data obtained from the quantitative research approach through the distributed surveys are analysed. Then, findings of data analysis attained by using the SPSS software are represented. Here; the statistical analysis procedures are demonstrated as identified in the methodology section.

First, the reliability test was used to check whether the determined measures can be used as representations of the independent variable. In this test, each independent variable was tested separately with its measures where the Cronbach's Alpha value will be set to 0.80. For example, the test is conducted on the scopes' definition in the different companies involved in the studied development projects in order to check how reliably they can be considered as a measure for the scope definition independent variable. So, if the Cronbach's Alpha value obtained from the SPSS is more than 0.8, in this case the scope definition value will be represented as the average of its measures. If not, a certain measure will be excluded using the "if item deleted" procedure acquired from SPSS. The same procedure was conducted to test the reliability of all other independent variables' measures.

After that, the correlation test was conducted to determine the relation of the dependent variables along with each of the independent variables separately. In this regard, project duration and project cost was tackled as dependent variables that represent the project crises factor. It should be noted that the measure that failed in the previous test was not included in the averaged value of the independent variable. The level of significance α is used to represent the rejection region of sampling distribution to test how the result of the sample can be generalized to the true value of the population. For the purpose of this analysis, the significance level will be considered to be 0.05 which means 95% confidence level. Also, the *p* value, which is the observed level of significance, test was used to check the validity of the correlation. In this case scenario, if the *p* value is greater than or equal to α, the null hypothesis will not be rejected and vice versa. For instance, if the *p* value of the scope definition test is greater than 0.05, there will be no statistical evidence of any correlation of the scope definition with the project crisis.

Finally, the regression test was carried out to determine the relation of the dependent variables (project duration and project cost) together with the correlated independent variables. It should be mentioned that the independent variables that showed no individual correlation with the dependent variable in the correlation test will not be included in this test. The coefficient of correlation r^2 will be calculated to measure the proportion of the variation that is explained by the independent variables. For instance, if the r^2 value is 0.90, it will mean that 90% of the variation of the project crises dependent variable can be explained by the variability of the independent variables together. In other words, project crises variable is 90 % affected by the independent variables.

As discussed in the methodology chapter, the following assumptions should be taken into consideration in the statistical analysis:

- The input data can fit in a linear equation.
- The individual values of the error terms are statistically independent of each other.
- The distribution of all errors is normal.
- The distribution of error values has equal variances for all values of independent variables.
- The independent variables are not correlated among themselves.
- The means of the dependant variable for all specified values of the independent variables can be connected by a straight line.

4.4.5.1 Reliability Test:

First of all, the reliability test was conducted through SPSS. The reliability test was used in order to examine the scales adopted to measure the studied independent variables. For the sake of accurateness of the research, the accepted Cronbach's Alpha value was assumed to be at least 0.8 so the independent variables can be tested using the measures.

First of all, the test was done to examine the reliability of the different measures representing the Scope Definition Independent Variable. As seen in Tables 4.4 and 4.5 extracted from SPSS, the Cronbach's Alpha value is 0.765 which is an unacceptable result value.

Table 4.4: Reliability Statistics (Scope Independent Variable)

Cronbach's Alpha	N of Items
.765	7

Table 4.5: Item-Total Statistics (Scope Independent Variable)

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
S1	17.19	23.415	.777	.726
S2	17.29	24.369	.672	.741
S3	17.17	25.405	.688	.741
S4	17.22	22.821	.768	.726
S5	17.27	23.394	.757	.728
S6	17.11	23.552	.711	.735
S7	17.13	28.532	.195	.809

However, as seen in Table 4.6 of the "Cronbach's Alpha if Item Deleted", the value would become 0.809 if the measure "S7" was not included in the test. Consequently, this particular measure can not be considered as a measure for the overall Scope Definition Independent Variable in this research. Table 4.0 below shows the new Cronbach's Alpha value equals to 0.809 after excluding that measure. It should be highlighted that this Cronbach's Alpha value is an acceptable result value so the rest of identified measures can be considered representations for this independent variable.

Table 4.6: Reliability Statistics 2 (Scope Independent Variable)

Cronbach's Alpha	N of Items
.809	6

Next, the test was done to examine the reliability of the different measures representing the Roles and Responsibilities Independent Variable. As seen in Table 4.7 and 4.8 extracted from SPSS, the Cronbach's Alpha value is 0.945 which is an acceptable result value so the 10 identified measures can be considered representations for the Roles and Responsibilities independent variable.

Table 4.7: Reliability Statistics (Responsibility Independent Variable)

Cronbach's Alpha	N of Items
.945	10

Table 4.8 : Item-Total Statistics (Responsibility Independent Variable)

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
RR1	26.32	59.870	.767	.939
RR2	26.38	63.406	.601	.946
RR3	26.56	59.712	.785	.938
RR4	26.50	57.064	.829	.936
RR5	26.37	59.731	.809	.937
RR6	26.49	59.914	.846	.936
RR7	26.42	63.089	.612	.946
RR8	26.38	59.889	.820	.937
RR9	26.32	59.135	.790	.938
RR10	26.58	58.811	.848	.935

Then, the test was done to examine the reliability of the different measures representing the Initial Estimation Independent Variable. As seen in Tables 4.9 and 4.10 extracted from SPSS, the Cronbach's Alpha value is 0.757 which is an unacceptable result value.

Table 4.9: Reliability Statistics (Estimation Independent Variable)

Cronbach's Alpha	N of Items
.757	12

Table 4.10 : Item-Total Statistics (Estimation Independent Variable)

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Est1	32.50	56.750	.699	.733
Est2	32.56	64.888	.114	.878
Est3	32.40	54.898	.710	.743
Est4	32.51	56.031	.708	.732
Est5	32.51	55.269	.784	.731
Est6	32.59	56.374	.749	.729
Est7	32.43	55.849	.711	.730
Est8	32.54	56.587	.778	.732
Est9	32.45	55.748	.773	.736
Est10	32.21	58.428	.717	.740
Est11	32.32	72.500	-.244	.896
Est12	32.39	61.650	.295	.864

However, as seen in Table 4.11 of the "Cronbach's Alpha if Item Deleted", the value would increase if the measures Est2, Est11, and Est12 were not included in the test. Consequently, those three measures can not be considered as representations for the overall Initial Estimation Independent Variable in this research. Table 4.0 below shows the new Cronbach's Alpha value to become 0.857 after excluding those measures. It should be highlighted that this Cronbach's Alpha value is an acceptable result value so the rest of the identified measures can be considered representations for this independent variable.

Table 4.11 : Reliability Statistics 2 (Estimation Independent Variable)

Cronbach's Alpha	N of Items
.857	9

Afterwards, the test was done to examine the reliability of the different measures representing the Control Techniques Independent Variable. As seen in Tables 4.12 and 4.13 extracted from SPSS, the Cronbach's Alpha value is 0.920 which is an acceptable result value so the 13 identified measures can be considered representations for this independent variable.

Table 4.12: Reliability Statistics (Control Independent Variable)

Cronbach's Alpha	N of Items
.920	13

Table 4.13: Item-Total Statistics (Control Independent Variable)

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
C1	35.63	107.409	.799	.917
C2	35.44	110.756	.680	.920
C3	35.66	108.509	.816	.916
C4	35.71	108.614	.811	.917
C5	35.53	107.967	.820	.916
C6	35.50	108.260	.823	.916
C7	35.57	106.633	.820	.916
C8	35.47	109.694	.745	.918
C9	35.44	105.107	.855	.915
C10	35.57	110.912	.724	.919
C11	35.43	105.308	.853	.915
C12	35.58	109.052	.723	.919
C13	35.52	108.380	.790	.917

Then, the test was done to examine the reliability of the different measures representing the Technical Concerns Independent Variable. As seen in Tables 4.14 and 4.15 extracted from SPSS, the Cronbach's Alpha value is 0.637 which is an unacceptable result value.

Table 4.14: Reliability Statistics (Technical Independent Variable)

Cronbach's Alpha	N of Items
.637	6

Table 4.15: Item-Total Statistics (Technical Independent Variable)

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Tech1	12.05	7.949	.269	.726
Tech2	12.05	8.562	.089	.775
Tech3	12.00	8.710	.047	.787
Tech4	11.90	6.313	.494	.541
Tech5	10.97	4.870	.724	.408
Tech6	11.19	5.544	.569	.499

However, as seen in Table 4.16 of the "Cronbach's Alpha if Item Deleted", the value would increase if the measures Tech1, Tech2, and Tech3 were not included in the test. Consequently, those three measures can not be considered as representations for the overall Independent Variable in this research. Table 4.0 below shows the new Cronbach's Alpha value to become 0.837 after excluding those measures. It should be highlighted that this Cronbach's Alpha value is an acceptable result value so the rest of identified measures can be considered representations for this independent variable.

Table 4.16 : Reliability Statistics 2 (Technical Independent Variable)

Cronbach's Alpha	N of Items
.837	3

Finally, the test was done to examine the reliability of the different measures representing the Contingency Planning Independent Variable. As seen in Tables 4.17 and 4.18 extracted from SPSS, the Cronbach's Alpha value is 0.941 which is an acceptable result value so the 9 identified measures can be considered representations for this independent variable.

Table 4.17: Reliability Statistics (Contingency Independent Variable)

Cronbach's Alpha	N of Items
.941	9

Table 4.18 : Item-Total Statistics (Contingency Independent Variable)

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Cont1	23.40	48.110	.779	.934
Cont2	23.46	49.034	.780	.934
Cont3	23.40	49.148	.739	.936
Cont4	23.38	47.373	.821	.932
Cont5	23.44	49.080	.733	.937
Cont6	23.45	48.482	.789	.933
Cont7	23.44	48.038	.755	.935
Cont8	23.41	47.649	.807	.932
Cont9	23.54	49.310	.760	.935

As a result of the reliability test, the certain measures that failed to maintain the value of Cronbach's Alpha to be at least 0.8 will be excluded in the rest of statistical analysis tests. Subsequently, each independent variable per project will be expressed afterward by averaging the values of its measures as shown in Table 4.19 afterwards. It should be highlighted that the measures coloured in red are excluded measures that failed the reliability test.

Table 4.19: Study Independent Variables

Project	Status	Location	Cost	CostENH	Time	TimeENH	VO	**Scope**	S1	S2	S3	S4	S5	S6	S7	**Roles**	RR1	RR2	RR3	RR4	RR5	RR6	RR7	RR8	RR9	RR10	**IntEst**	Est1	Est2	Est3	Est4	Est5	Est6
1	1	2	1	1	1	1	1	**1.33**	1	1	2	1	2	1	3	**1.30**	1	2	1	1	1	1	2	1	1	2	**1.26**	1	3	1	1	1	2
2	1	1	5	2	1	4	2	**2.50**	3	2	3	2	3	2	5	**2.50**	3	2	3	2	2	2	2	3	2	4	**2.13**	2	1	2	2	2	2
3	2	1	2	2	5	2	2	**1.50**	2	1	2	1	1	2	2	**1.60**	2	2	1	1	2	2	2	2	1	1	**1.46**	2	2	1	2	1	1
4	3	2	3	4	2	2	2	**3.17**	3	2	3	4	3	4	4	**3.10**	4	2	4	3	3	3	2	3	4	3	**3.69**	2	4	4	4	4	3
5	1	2	5	2	1	1	2	**1.33**	2	1	1	1	2	1	1	**1.50**	2	1	1	2	2	2	1	1	1	2	**1.39**	1	1	1	1	1	2
6	1	1	3	4	4	4	3	**3.33**	3	4	3	4	3	3	1	**3.30**	3	3	3	4	3	4	3	3	4	3	**3.75**	4	1	5	3	3	3
7	2	3	2	2	2	2	2	**2.00**	2	2	3	2	1	2	3	**2.10**	1	2	3	2	2	2	2	2	3	2	**1.50**	2	5	2	1	2	2
8	1	3	1	5	5	5	5	**4.67**	4	5	5	5	4	5	3	**4.40**	4	5	4	4	5	4	5	5	4	4	**4.30**	4	1	5	4	4	5
9	1	3	2	1	2	3	2	**1.67**	1	2	2	1	1	3	3	**1.40**	1	2	1	1	2	1	1	1	3	1	**1.48**	1	2	1	2	1	2
10	2	2	1	2	1	2	2	**1.50**	2	1	2	1	1	2	1	**1.60**	2	2	1	1	2	2	2	2	1	1	**1.71**	1	1	2	2	1	1
11	1	3	4	3	3	2	4	**2.33**	3	1	3	3	3	1	1	**2.60**	3	2	1	3	3	2	3	4	3	2	**2.81**	3	1	3	2	2	3
12	1	3	3	4	3	4	4	**3.50**	4	3	4	3	4	3	3	**3.90**	3	4	4	4	5	4	3	4	4	4	**3.62**	4	2	4	3	4	3
13	1	2	2	3	4	2	2	**2.50**	3	2	2	3	3	2	4	**2.80**	3	3	2	3	3	3	2	3	3	3	**2.49**	3	5	2	2	3	3
14	1	3	5	2	5	3	4	**2.50**	3	2	2	3	3	2	2	**2.30**	3	3	2	1	3	3	1	3	3	1	**2.38**	3	2	1	3	2	3
15	3	1	3	2	2	4	3	**2.50**	3	3	2	2	2	3	1	**2.20**	3	2	2	2	3	2	2	2	2	2	**2.46**	2	3	3	2	2	2
16	2	2	2	4	4	4	4	**3.33**	3	4	3	3	3	4	5	**3.30**	3	4	3	4	3	3	4	3	3	3	**3.64**	3	2	5	4	3	3
17	1	3	2	4	2	4	2	**3.50**	4	4	3	4	3	3	2	**3.60**	4	2	4	4	4	4	2	4	4	4	**3.35**	2	2	4	4	2	4
18	1	2	4	4	4	4	3	**4.17**	5	3	4	5	5	3	2	**3.70**	3	3	3	4	5	4	3	3	5	4	**3.65**	3	2	5	3	4	3
19	1	3	2	5	2	2	3	**3.67**	3	4	3	4	3	5	3	**3.60**	5	3	3	5	3	3	3	3	5	3	**3.43**	5	3	3	5	3	3
20	1	2	5	4	3	5	5	**3.67**	3	5	4	3	3	4	5	**3.30**	3	4	3	3	3	3	4	4	3	3	**3.64**	3	5	4	4	3	4
21	1	3	3	4	4	2	3	**3.50**	4	3	3	3	4	4	2	**3.60**	4	3	3	4	4	4	3	4	3	4	**3.67**	3	2	3	4	3	4
22	1	3	4	5	3	5	5	**4.83**	5	5	4	5	5	5	4	**4.70**	5	4	5	5	5	5	4	4	5	5	**4.62**	4	4	4	5	5	4
23	2	3	2	5	2	3	2	**3.67**	4	3	3	4	4	4	4	**3.80**	4	3	4	4	4	4	4	3	4	4	**3.99**	4	4	3	4	5	4
24	1	2	3	3	4	3	3	**3.17**	4	3	3	2	4	3	3	**3.10**	4	3	4	2	3	2	3	3	4	3	**3.26**	3	4	4	3	3	3
25	3	2	4	3	4	5	4	**3.00**	4	2	3	2	4	3	5	**3.70**	4	4	3	4	3	4	3	4	4	4	**3.88**	4	5	4	4	4	4
26	1	3	3	2	3	3	2	**2.17**	1	2	3	3	2	2	3	**2.20**	2	3	2	1	2	2	3	2	2	3	**2.13**	2	1	2	2	3	1
27	3	3	4	2	2	2	2	**1.33**	1	2	2	1	1	1	4	**1.40**	1	2	1	1	2	1	2	2	1	1	**1.63**	1	4	1	2	1	2
28	1	1	5	2	3	4	2	**2.33**	2	2	3	2	3	2	3	**2.50**	2	3	3	2	2	2	3	3	3	2	**2.33**	2	3	2	2	3	2
29	2	2	3	4	4	2	3	**3.67**	4	3	3	4	3	5	4	**3.60**	4	3	4	3	4	4	3	4	4	3	**3.62**	3	4	4	3	3	4
30	1	3	2	2	4	2	3	**1.83**	2	1	2	3	2	1	4	**2.00**	2	3	1	2	2	3	1	2	3	1	**2.25**	3	5	3	1	2	3
31	1	3	4	3	2	3	3	**2.67**	3	3	2	3	2	3	2	**3.10**	2	3	3	4	3	3	4	3	3	3	**3.13**	3	2	4	3	2	3
32	1	3	4	5	1	5	5	**4.67**	5	4	5	5	5	4	5	**4.50**	5	5	3	5	4	5	4	5	5	4	**4.60**	5	2	5	4	5	4
33	1	2	4	2	3	4	4	**2.50**	2	3	2	3	2	3	3	**2.70**	3	1	3	3	3	3	2	3	3	3	**2.13**	3	3	2	1	3	3
34	2	3	1	3	5	3	4	**3.17**	3	4	2	3	3	4	1	**3.20**	3	4	3	3	3	3	3	4	3	3	**3.18**	4	1	3	4	3	2
35	3	3	3	2	4	4	3	**2.33**	2	3	3	2	2	2	3	**2.20**	2	3	2	2	2	2	3	2	2	2	**2.13**	3	3	2	3	1	2
36	1	3	2	3	2	4	4	**2.67**	2	4	2	2	2	4	3	**2.90**	4	4	2	2	3	2	4	4	2	2	**3.24**	4	1	2	3	4	3
37	1	2	4	3	5	5	4	**3.50**	3	4	4	3	3	4	4	**3.60**	4	5	3	3	4	3	4	3	4	3	**3.68**	4	4	4	3	4	4
38	1	3	5	3	5	3	3	**3.17**	3	4	3	3	3	3	2	**3.10**	3	3	3	3	3	3	4	3	3	3	**3.11**	3	2	2	3	4	3
39	2	3	3	5	4	3	3	**3.67**	4	3	3	5	4	3	5	**4.10**	5	3	5	5	4	4	3	3	5	4	**3.91**	5	4	4	3	4	5
40	1	2	4	5	3	4	5	**4.50**	4	5	5	4	4	5	3	**4.30**	4	5	4	4	4	4	5	5	4	4	**4.38**	4	3	5	4	4	5
41	1	1	4	4	3	4	4	**3.33**	3	3	4	3	3	4	4	**3.50**	4	4	3	3	5	3	4	3	3	3	**3.55**	3	4	4	5	3	3
42	1	2	2	3	2	3	3	**2.83**	3	2	2	3	3	4	2	**3.20**	3	3	3	2	4	3	4	3	4	3	**3.18**	3	4	3	4	3	2
43	1	3	3	3	3	2	2	**2.33**	2	2	2	3	2	3	3	**2.30**	2	2	3	2	3	3	2	3	1	2	**2.75**	2	3	2	3	3	2
44	1	2	5	3	5	5	5	**3.33**	3	3	3	4	4	3	3	**3.62**	4	4	3	4	3	4	4	4	3	4	**3.75**	5	2	4	5	3	3
45	1	3	4	4	1	3	3	**3.50**	4	3	4	3	4	3	4	**3.20**	3	3	4	3	4	3	3	3	3	3	**3.63**	3	4	3	3	4	3
46	1	2	2	3	3	2	2	**2.33**	2	2	3	2	3	2	2	**2.40**	4	2	2	2	2	2	3	2	2	3	**2.63**	2	2	4	2	2	2
47	1	2	4	4	2	3	4	**3.50**	4	3	3	4	4	3	1	**3.80**	4	4	3	4	3	4	4	4	4	4	**3.63**	3	1	5	4	4	3
48	1	3	5	3	5	2	3	**2.67**	3	2	3	2	3	3	2	**3.10**	3	4	3	3	2	3	3	3	4	3	**2.88**	4	2	3	2	3	3
49	3	3	1	3	4	3	3	**2.67**	2	3	4	2	2	3	2	**2.60**	2	4	2	2	3	2	4	3	2	2	**3.23**	4	2	2	3	4	4
50	1	2	2	4	3	1	2	**3.33**	4	2	2	4	4	4	5	**3.60**	4	2	4	4	4	4	2	4	4	4	**3.60**	2	5	4	4	3	4
51	1	3	4	4	4	3	4	**3.67**	3	4	4	4	4	3	2	**3.20**	3	4	3	3	3	3	4	3	3	3	**3.33**	4	2	3	3	4	3
52	1	3	3	1	2	1	1	**1.50**	2	2	1	2	1	1	3	**1.40**	1	2	1	1	1	2	2	1	2	1	**1.53**	2	3	1	1	2	1
53	1	2	3	2	4	3	4	**2.17**	2	2	3	2	2	2	2	**2.40**	2	4	2	2	2	2	4	2	2	2	**2.13**	2	2	2	2	2	2
54	1	3	4	3	5	4	3	**2.33**	1	3	2	3	2	3	3	**3.20**	4	3	3	3	3	3	4	3	3	3	**3.38**	3	3	3	4	4	3
55	3	3	5	2	3	5	2	**2.17**	2	3	2	2	3	1	5	**2.30**	4	2	3	4	2	1	2	2	2	1	**1.78**	2	5	3	2	2	1
56	2	2	3	3	4	2	3	**2.50**	2	3	3	2	2	3	3	**3.10**	2	3	3	4	3	3	4	3	3	3	**2.89**	3	3	2	3	3	3
57	1	3	4	2	3	2	4	**2.33**	3	2	3	2	1	3	4	**2.50**	3	2	2	3	2	3	2	2	3	3	**2.38**	3	4	3	1	3	2
58	1	2	1	4	1	4	3	**3.67**	4	3	4	3	4	4	2	**3.90**	4	3	4	4	5	4	3	4	4	4	**3.68**	3	2	4	4	3	4
59	1	3	3	2	5	4	3	**2.33**	2	3	3	3	1	2	1	**2.30**	2	3	3	1	2	2	3	3	3	1	**2.16**	2	1	2	2	3	1
60	2	3	2	4	1	3	4	**4.33**	5	4	4	5	3	5	3	**3.80**	3	3	5	5	3	3	4	5	3	4	**3.48**	4	3	3	2	4	3
61	1	1	4	1	2	1	1	**1.17**	1	1	1	1	1	2	4	**1.30**	2	1	2	1	1	1	2	1	1	1	**1.59**	1	4	2	2	1	1
62	1	3	5	2	3	5	2	**2.50**	3	2	3	2	3	2	3	**2.30**	2	3	2	2	2	3	2	2	3	2	**2.13**	2	4	2	3	2	2
63	1	2	1	3	5	3	3	**2.33**	2	3	3	1	2	3	1	**3.60**	4	3	4	3	4	4	3	3	4	4	**3.36**	3	5	4	3	3	3

Est7	Est8	Est9	Est10	Est11	Est12	Control	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	Technical	Tech1	Tech2	Tech3	Tech4	Tech5	Tech6	Contingency	Cont1	Cont2	Cont3	Cont4	Cont5	Cont6	Cont7	Cont8	Cont9
1	1	1	2	5	3	**1.33**	1	2	1	1	1	1	1	2	1	2	1	2	1	**1.50**	1	2	2	1	2	1	**1.36**	1	1	2	1	2	1	2	1	1
2	2	2	3	4	5	**2.31**	2	3	2	2	2	3	2	2	3	2	2	3	2	**2.00**	2	3	2	2	2	2	**2.11**	2	2	2	2	2	3	2	2	2
1	2	2	2	5	2	**1.55**	2	2	1	2	2	1	2	2	1	2	1	1	1	**1.50**	2	1	2	2	2	1	**1.49**	1	2	2	1	2	1	1	2	1
3	4	4	4	3	4	**3.42**	3	2	4	4	4	4	4	3	4	2	4	4	3	**3.00**	2	2	2	3	4	2	**3.06**	4	3	2	3	3	4	3	4	2
1	1	1	3	1	1	**1.32**	2	1	1	1	1	2	2	1	1	1	1	2	1	**1.00**	1	2	2	1	1	1	**1.33**	2	2	1	1	1	1	2	1	1
4	3	5	4	2	1	**3.38**	4	3	3	3	3	4	3	3	3	3	4	4	4	**3.00**	1	2	2	4	3	3	**3.78**	4	3	3	5	3	5	3	5	3
1	2	1	1	3	3	**1.92**	2	2	2	2	1	2	2	2	2	2	2	2	2	**2.00**	1	2	1	1	2	2	**1.78**	2	1	2	2	2	2	1	2	2
4	3	5	4	3	4	**4.34**	4	5	4	3	5	4	4	4	5	5	4	5	4	**4.50**	2	2	2	3	4	5	**4.22**	5	4	4	5	4	3	5	4	4
1	1	2	2	5	3	**1.16**	1	1	1	1	2	1	1	1	1	1	1	2	1	**1.00**	1	2	1	1	1	1	**1.13**	1	1	1	1	1	1	2	1	1
2	2	2	2	4	1	**1.62**	2	2	1	2	2	1	2	2	1	2	1	1	2	**1.50**	1	1	3	1	2	1	**1.49**	1	2	2	1	2	1	1	2	1
4	2	4	3	4	1	**2.96**	3	2	3	2	4	3	3	4	3	3	4	3	2	**3.50**	2	3	2	1	4	3	**2.61**	3	3	2	2	4	2	3	3	2
4	4	4	4	4	3	**3.77**	3	4	4	4	4	4	4	4	4	4	4	3	4	**4.00**	2	2	3	4	4	4	**3.68**	4	3	4	3	4	4	4	4	4
3	2	2	3	3	4	**2.76**	3	3	3	2	2	3	3	3	3	2	3	3	3	**2.50**	2	3	1	2	2	3	**2.66**	3	3	3	2	2	3	3	3	2
3	2	3	2	4	2	**2.38**	1	2	3	1	3	2	3	2	3	2	3	3	3	**2.50**	3	1	2	2	2	3	**3.33**	3	3	4	3	4	3	3	3	4
2	3	3	3	4	1	**2.28**	3	2	2	3	3	2	3	2	2	2	2	2	2	**2.00**	2	1	2	2	2	2	**2.44**	3	3	2	2	2	2	2	3	3
3	4	4	3	2	5	**3.55**	3	4	3	4	4	3	3	3	4	4	3	5	3	**3.50**	1	2	1	3	3	4	**3.52**	5	4	3	3	3	4	4	3	3
2	4	4	3	2	2	**3.45**	4	2	4	4	4	3	4	5	3	2	4	3	3	**3.00**	2	3	2	2	4	2	**3.29**	4	4	2	4	2	4	4	4	2
4	3	3	4	2	2	**3.63**	2	3	4	3	3	4	5	4	3	3	5	3	5	**4.00**	2	1	3	2	5	3	**3.67**	3	3	5	4	5	3	3	4	3
3	3	4	3	2	3	**3.70**	5	3	3	4	4	3	3	3	5	3	5	4	3	**3.00**	2	2	2	3	3	3	**3.86**	3	5	5	3	3	4	4	5	3
3	4	4	3	1	5	**3.72**	3	4	3	5	4	3	3	3	4	4	5	3	4	**3.50**	3	2	2	3	3	4	**3.67**	4	4	3	4	3	5	4	3	3
5	3	4	3	3	2	**3.41**	4	3	3	3	4	3	3	4	4	3	3	4	3	**3.00**	2	2	3	4	3	3	**3.33**	3	4	3	4	3	3	4	3	3
5	5	5	5	5	4	**4.69**	5	4	5	5	5	5	5	5	5	4	5	4	5	**4.50**	3	2	2	3	5	4	**4.57**	4	5	5	4	5	5	5	5	4
5	4	4	4	2	4	**3.77**	4	3	4	4	4	4	5	4	4	3	4	4	3	**3.50**	2	2	4	3	4	3	**4.02**	3	4	5	4	5	4	4	4	4
3	3	4	3	3	4	**3.39**	4	3	4	3	4	3	4	4	3	3	4	2	3	**3.50**	2	3	1	2	4	3	**3.56**	4	3	4	3	4	3	4	4	3
3	4	4	4	2	5	**3.54**	3	4	3	3	4	3	4	3	3	4	3	5	4	**4.00**	4	3	1	2	4	4	**3.67**	4	4	3	4	4	2	4	4	4
2	2	2	3	4	3	**2.15**	2	1	3	2	3	2	2	1	2	3	2	3	2	**2.00**	3	1	3	2	2	2	**2.11**	2	2	2	2	2	2	3	2	2
3	2	1	1	4	4	**1.54**	1	2	1	2	1	1	1	2	1	2	1	2	3	**1.50**	2	1	2	2	2	1	**1.56**	1	1	2	1	2	1	3	1	2
3	2	2	2	4	3	**2.58**	2	3	3	2	2	2	2	3	3	3	3	2	3	**3.00**	2	2	3	2	3	3	**2.40**	2	3	3	2	2	2	2	3	2
3	4	4	4	2	4	**3.69**	4	3	4	4	3	4	4	3	5	3	4	3	4	**3.50**	2	3	2	2	4	3	**3.85**	4	5	3	4	3	4	5	4	3
2	1	3	3	1	4	**2.31**	1	2	3	2	3	2	3	3	2	3	3	1	2	**3.00**	1	2	1	1	3	3	**2.67**	3	2	3	3	3	3	2	3	2
3	4	3	3	3	2	**3.08**	3	4	2	3	3	3	3	4	3	2	3	4	3	**3.00**	2	3	2	1	3	3	**2.67**	4	3	2	3	2	3	2	3	2
5	5	4	5	4	5	**4.60**	5	5	3	5	4	5	5	5	4	5	5	4	5	**5.00**	2	2	3	3	5	5	**4.67**	5	4	5	4	5	5	4	5	5
1	2	3	2	2	3	**3.23**	3	4	3	3	3	3	3	4	3	4	3	3	3	**3.50**	3	2	2	2	4	3	**2.78**	3	2	3	3	2	3	3	4	2
3	4	3	4	3	1	**3.42**	3	4	3	4	3	4	3	3	4	4	3	4	3	**3.50**	2	1	2	1	3	4	**2.74**	3	2	3	4	3	2	3	3	2
2	2	3	2	1	3	**2.23**	2	3	2	2	2	2	2	3	2	3	2	2	2	**2.50**	2	3	2	2	3	2	**2.33**	2	2	3	2	3	2	2	2	3
4	3	3	4	3	3	**2.92**	2	4	2	3	3	4	2	2	4	4	2	3	3	**3.00**	2	1	2	3	2	4	**3.14**	2	3	4	3	4	3	3	2	4
4	3	3	4	3	4	**3.49**	2	4	3	2	5	4	3	3	4	4	4	3	4	**4.50**	2	2	2	3	5	4	**3.89**	5	3	4	4	4	3	5	3	4
4	3	3	3	3	2	**3.23**	3	3	4	3	3	3	3	3	4	4	3	2	4	**3.00**	3	2	1	3	3	3	**2.67**	3	3	3	2	3	2	3	2	3
4	3	3	5	1	5	**4.10**	5	3	5	3	3	5	5	4	3	3	5	4	5	**4.00**	2	3	2	2	5	3	**4.03**	4	3	4	5	4	3	3	5	5
4	4	5	4	3	3	**4.47**	4	5	4	4	5	4	4	4	5	5	4	5	5	**4.50**	2	1	3	2	4	5	**4.32**	5	4	4	5	4	4	5	4	4
3	3	4	3	3	4	**3.57**	4	4	3	3	4	3	3	3	5	4	3	3	4	**3.50**	2	3	2	2	3	4	**3.44**	4	4	3	3	3	4	4	3	3
3	4	3	4	4	4	**3.08**	3	3	3	3	3	3	3	3	3	3	3	4	3	**3.00**	1	2	2	2	3	3	**2.78**	3	2	3	3	3	3	2	3	3
3	2	3	4	1	3	**2.31**	3	2	2	1	2	3	2	2	2	3	3	2	3	**2.00**	2	3	2	2	2	2	**2.44**	2	3	2	3	3	2	2	2	3
4	3	4	4	4	3	**3.62**	4	5	4	2	3	5	5	3	3	4	3	3	3	**3.50**	2	1	3	2	4	3	**3.67**	3	3	3	5	3	4	5	3	4
5	3	5	3	5	4	**3.54**	3	4	3	3	5	3	3	4	3	3	4	4	4	**3.00**	2	1	3	2	3	3	**3.33**	3	3	4	3	3	3	5	3	3
2	4	2	3	3	2	**2.46**	2	4	2	2	2	3	2	3	2	2	3	2	3	**2.00**	3	2	1	1	2	2	**2.33**	3	2	2	3	2	3	2	2	2
2	4	3	4	2	1	**3.69**	4	4	3	4	4	3	4	4	4	3	4	3	4	**4.00**	3	2	2	3	4	4	**3.78**	3	4	4	3	5	4	4	3	4
4	3	2	3	2	2	**3.23**	3	4	3	4	3	3	2	3	4	3	4	3	3	**3.00**	2	3	2	2	3	3	**2.56**	3	3	2	3	2	3	2	2	3
4	3	3	3	3	2	**2.76**	2	4	2	3	3	3	2	2	3	4	2	3	3	**3.00**	3	2	1	1	2	4	**2.76**	2	4	2	3	3	3	2	2	4
3	4	4	3	3	5	**3.37**	4	2	4	4	4	3	4	4	4	2	4	3	2	**3.00**	3	2	2	3	4	2	**3.29**	4	4	2	4	2	4	4	4	2
4	3	3	3	2	2	**3.35**	3	4	3	3	3	3	3	4	3	4	3	4	3	**3.50**	2	2	1	3	3	4	**3.36**	3	3	4	3	4	3	3	3	4
2	1	1	3	3	3	**1.78**	2	2	2	1	1	2	2	2	2	2	2	1	2	**2.00**	2	1	2	2	2	2	**1.78**	2	2	2	2	2	2	1	1	2
2	2	2	3	2	2	**2.38**	2	4	2	2	2	2	2	4	2	3	2	2	2	**2.50**	2	2	3	1	3	2	**2.44**	2	2	3	2	4	2	2	2	3
4	3	3	3	3	3	**3.15**	3	3	3	3	3	3	3	3	3	3	3	4	4	**3.00**	2	2	2	1	3	3	**3.22**	3	3	4	3	4	3	3	3	3
2	1	1	2	3	5	**2.09**	2	3	2	1	2	2	2	3	2	2	3	1	2	**2.00**	2	1	2	1	2	2	**2.33**	2	2	2	4	1	2	3	2	3
3	3	3	4	3	3	**2.63**	2	3	2	3	3	4	2	2	3	3	2	3	3	**2.50**	2	2	1	3	3	2	**2.57**	2	3	2	3	3	4	2	2	3
2	3	3	2	5	4	**2.38**	3	2	3	3	3	1	1	2	3	2	3	2	3	**2.50**	1	2	2	1	2	3	**2.56**	1	3	4	3	2	3	2	3	2
3	4	4	4	4	2	**3.65**	4	3	4	4	4	4	4	4	4	3	4	4	2	**3.50**	2	2	3	4	4	3	**3.64**	4	4	3	4	3	4	4	4	3
3	2	2	2	5	1	**2.41**	2	3	3	2	2	2	2	3	3	2	3	1	3	**3.00**	2	2	1	1	3	3	**2.47**	2	2	3	3	3	3	1	2	3
4	5	3	4	2	3	**3.85**	4	4	3	4	4	3	4	5	5	4	4	3	3	**4.50**	1	2	2	4	5	4	**3.56**	3	3	4	4	4	3	3	4	4
1	2	2	2	5	4	**1.16**	1	1	1	2	2	1	1	1	1	1	1	1	1	**1.00**	1	1	3	1	1	1	**1.16**	1	1	1	1	1	1	1	2	1
2	2	2	2	4	4	**2.38**	2	3	2	2	2	4	2	3	2	2	2	3	2	**2.00**	1	2	2	2	2	2	**2.33**	2	2	3	2	2	3	2	2	3
3	3	4	4	4	1	**3.37**	4	3	4	3	4	3	4	2	3	3	4	3	4	**3.50**	2	3	2	2	4	3	**3.32**	4	3	3	3	3	3	4	4	3

4.4.5.2 Correlation Test:

After collecting the data representing the independent variables from their own measures, the correlation test was performed to measure the relationship of each independent variable separately with both of the dependent variables. Table 4.20 below, shows the result obtained from the correlation test using SPSS software. This table shows of the relationship of the independent variables with the cost enhancement dependent variable.

Table 4.20 : Correlations of Independent Variables with Cost Enhancement

		Scope Ind Variable	Roles & Responsibilities Ind Variable	Initial Estimation Ind. Variable	Project Control Ind. Variable	Technical Aspects Ind. Variable	Contingency Planning Ind. Variable
% Cost Enhancement	Pearson Correlation	.905*	.907*	.918**	.908*	.776*	.882**
	Sig. (2-tailed)	.017	.022	.008	.013	.024	.007
	N	63	63	63	63	63	63

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

This particular test is used to examine the acceptance of the relationship of the cost enhancement dependent variable with each of the independent variables as assumed in this study. As mentioned in the methodology section, a *p* value test was used to check the correlation. For the sake of this research appropriateness, the confidence level was assumed to be 95%, which means that α equals to 0.05 in the 2-tailed method. In the findings of the Pearson Correlation approach, if the *p* value is greater than α, there would be no correlation. As seen in Table 2, the *p* values of all the independent variables are less than α (0.05), thus there are correlation relationships between the cost enhancement dependent variable and each of the separate identified independent variables.

Similarly, table 4.21 below shows the result obtained from the correlation test using SPSS software to determine the relationship of the independent variables with the time enhancement dependent variable.

Table 4.21 : Correlations of Independent Variables with Time Enhancement

		Scope Ind Variable	Roles & Responsibilities Ind Variable	Initial Estimation Ind. Variable	Project Control Ind. Variable	Technical Aspects Ind. Variable	Contingency Planning Ind. Variable
% Time Enhancement	Pearson Correlation	.523*	.504*	.465**	.504**	.541*	.538**
	Sig. (2-tailed)	.012	.025	.003	.006	.038	.009
	N	63	63	63	63	63	63

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

This particular test is used to examine the acceptance of the relationship of the time enhancement dependent variable with each of the independent variables as assumed in this study. As mentioned in the methodology section, a *p* value test was used to check the correlation. For the sake of this research appropriateness, the confidence level was assumed to be 95%, which means that α equals to 0.05 in the 2-tailed method. In the findings of the Pearson Correlation approach, if the *p* value greater than α, there would be no correlation. As seen in Table 2, the *p* values of all the independent variables are less than α (0.05), thus there are correlation relationships between the time enhancement dependent variable and each of the separate identified independent variables.

4.1.1.1 Regression Test

After determining which independent variables are in correlation separately with each of the dependent variables, the regression test was performed in order to analyze the relationship that exist between the correlated independent variables together and the dependent variables. First, the test was conducted to test the relation among the cost enhancement variable and all of the independent variables. As shown in the below Tables 4.22 extracted from SPSS, the regression (SSR) value is equal to 69.789 and the total (SST) value is equal to 77.746. Thus, the r^2 value is equal to 69.789/78.746 = 0.886 and the adjusted r^2 value is equal to 0.878 as shown in Table 4.22.

Table 4.22: Regression Model Summary (Cost Enhancement)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.941[a]	.886	.878	.377

Predictors: (Constant), Contingency Planning Ind. Variable, Technical Aspects Ind. Variable, Scope Ind Variable, Initial Estimation Ind. Variable, Roles & Responsibilities Ind Variable, Project Control Ind. Variable

Hence, almost 88.6% of the variation in cost enhancement in the studied projects can be explained by the variability in the independent variables studied.

Furthermore, as per the ANOVA test in Table 4.23, the significant value is 0.017. This value indicates that it is significantly safe to replicate the results of the sample on the entire population.

Table 4.23: ANOVA (Cost Enhancement)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	69.789	6	11.632	81.862	.017[a]
	Residual	8.957	56	.160		
	Total	78.746	62			

a. Predictors: (Constant), Contingency Planning Ind. Variable, Technical Aspects Ind. Variable, Scope Ind Variable, Initial Estimation Ind. Variable, Roles & Responsibilities Ind Variable, Project Control Ind. Variable

b. Dependent Variable: % Cost Enhancement

As continuation of the regression analysis, Table 4.24 illustrates the coefficients (β) of the linear relationship between the dependent variable (% of Cost Enhancement) and the identified independent variables as per the following equation:

$$Y = \beta_0 + \beta_1 X_2 + \beta_2 X_2 + ... + \beta_k X_k + \varepsilon$$

The coefficients (β) shown in Table 4.24 shows the effect of changing each of the independent variable, on changing the percentage of Cost Enhancement.

Table 4.24: Regression's Coefficients (Cost Enhancement)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.481	.173		2.783	.007
	Scope Ind Variable	.400	.172	.318	2.321	.024
	Roles & Responsibilities Ind Variable	.072	.277	.055	.261	.005
	Initial Estimation Ind. Variable	.463	.215	.365	2.149	.036
	Project Control Ind. Variable	.821	.363	.634	2.262	.028
	Technical Aspects Ind. Variable	.621	.155	.522	4.009	.001
	Contingency Planning Ind. Variable	.079	.212	.061	.373	.010

a. Dependent Variable: % Cost Enhancement

As shown in Table 4.24, all the coefficients are positive and significant. So, to change the % of Cost Enhancement from one category to another, each of the independent variables should be changed by the associated coefficient Beta value.

Then, the regression test was also conducted to test the relationship between the time enhancement variable and all of the independent variables. As shown in the below Table 4.25 extracted from SPSS, the regression (SSR) value is equal to 70.220 and the total (SST) value is equal to 76.984. Thus the r^2 value is equal to 69.220/81.984 = 0.844 and the adjusted r^2 value is equal to 0.841 as shown in Table 4.25.

Table 4.25 : Regression Model Summary (Time Enhancement)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.919[a]	.844	.841	.207

a. Predictors: (Constant), Contingency Planning Ind. Variable, Technical Aspects Ind. Variable, Scope Ind Variable, Initial Estimation Ind. Variable, Roles & Responsibilities Ind Variable, Project Control Ind. Variable

Hence, almost 84% of the variation in time enhancement in the studied projects can be explained by the variability in the independent variables studied.

Furthermore, as per the ANOVA test in Table 4.26, the significant value is 0.024. This value indicates that it is significantly safe to replicate the results of the sample on the entire population.

Table 4.26: ANOVA (Time Enhancement)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	69.220	6	11.537	4.969	.024[a]
	Residual	12.764	56	.228		
	Total	81.984	62			

a. Predictors: (Constant), Contingency Planning Ind. Variable, Technical Aspects Ind. Variable, Scope Ind Variable, Initial Estimation Ind. Variable, Roles & Responsibilities Ind Variable, Project Control Ind. Variable

b. Dependent Variable: % Time Enhancement

As continuation of the regression analysis, Table 4.27 illustrates the coefficients (β) of the linear relationship between the dependent variable (% of Time Enhancement) and the identified independent variables as per the following equation:

$$Y = \beta_0 + \beta_1 X_2 + \beta_2 X_2 + ... + \beta_k X_k + \varepsilon$$

The coefficients (β) shown in Table 4.24 shows the effect of changing each of the independent variable, on changing the percentage of Cost Enhancement.

Table 4.27: Regression's Coefficients (Time Enhancement)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.066	.462		2.309	.025
	Scope Ind Variable	.524	.460	.394	1.140	.039
	Roles & Responsibilities Ind Variable	.384	.740	.279	.519	.006
	Initial Estimation Ind. Variable	.544	.575	.406	.946	.048
	Project Control Ind. Variable	1.033	.969	.755	1.066	.031
	Technical Aspects Ind. Variable	.599	.414	.476	1.446	.034
	Contingency Planning Ind. Variable	.795	.566	.582	1.405	.046

a. Dependent Variable: % Time Enhancement

As shown in Table 4.27, all the coefficients are positive and significant. So, to change the % of Cost Enhancement from one category to another, each of the independent variables should be changed by the associated coefficient Beta value.

4.1.1.2 Further Analysis

In this stage, supplementary statistical analysis tests were carried out on the data obtained from the projects to further understand the variability of the cost enhancement as well as the time enhancement. First, the correlation test was conducted to test the relationship between the initial project budgeted cost and the percentage of cost enhancement. Table 4.28 extracted from SPSS shows that there is no correlation between the initial project cost and the associated cost enhancement percentage.

Table 4.28 : Correlations (Initial Cost with Cost Enhancement)

		Initial Cost	% Cost Enhancement
Initial Cost	Pearson Correlation	1	-.087
	Sig. (2-tailed)		.498
	N	63	63
% Cost Enhancement	Pearson Correlation	-.087	1
	Sig. (2-tailed)	.498	
	N	63	63

Similarly, the correlation test was then conducted to test the relationship between the initial project's planned duration with the percentage of time enhancement. Table 4.29 extracted from SPSS shows that there is also no correlation between the initial project duration and the associated time enhancement percentage.

Table 4.29 : Correlations (Initial Time with Time Enhancement)

		Initial Duration	% Time Enhancement
Initial Duration	Pearson Correlation	1	.201
	Sig. (2-tailed)		.115
	N	63	63
% Time Enhancement	Pearson Correlation	.201	1
	Sig. (2-tailed)	.115	
	N	63	63

In addition, the correlation test was conducted to test the relationship between the initial project as well as the project location with the associated percentage of cost enhancement. Table 4.30 extracted from SPSS shows that there is no correlation between the project characteristics and the associated cost enhancement percentage.

Table 4.30 : Correlations (Cost Enhancement with Project Characteristics)

		% Cost Enhancement	Initial Status	Project Location
% Cost Enhancement	Pearson Correlation	1	-.074	.133
	Sig. (2-tailed)		.562	.298
	N	63	63	63
Initial Status	Pearson Correlation	-.074	1	.003
	Sig. (2-tailed)	.562		.980
	N	63	63	63
Project Location	Pearson Correlation	.133	.003	1
	Sig. (2-tailed)	.298	.980	
	N	63	63	63

Similarly, Table 4.31 extracted from SPSS shows that there is no correlation between the initial project, the project location, and the associated cost enhancement percentage.

Table 4.31 : Correlations (Time Enhancement with Project Characteristics)

		% Time Enhancement	Initial Status	Project Location
% Time Enhancement	Pearson Correlation	1	.019	-.006
	Sig. (2-tailed)		.882	.963
	N	63	63	63
Initial Status	Pearson Correlation	.019	1	.003
	Sig. (2-tailed)	.882		.980
	N	63	63	63
Project Location	Pearson Correlation	-.006	.003	1
	Sig. (2-tailed)	.963	.980	
	N	63	63	63

4.1.2 Data Findings and Discussion

Pursuant to the analysis of the qualitative research approach discussed earlier, the qualitative approach to data obtained via the questionnaires illustrates more detailed findings. The questionnaires were used mainly to test the identified variables of the project crises concepts from the perspective of schedule delays and cost overruns. In the previous stages of literature review, the main variables leading to the concerned project crises concepts were identified, and the measures represent those variables. Afterwards, the qualitative research approach was used to consolidate the research into the variables affecting the projects included in this particular study scope. Consequently, the quantitative approach was conducted in order to investigate the characteristics of the identified variables and measures the and statistically test their relationship with the concerned dependent variables that represent the project crises concept.

As represented in the results of the data analysis of the reliability test, most of the identified measures were statistically proven to be representing their associated independent variables. However, as shown previously, “S7” which represents adjusting the project plan to cater for variation, was insignificant as a measure for the scope definition independent variable. In this case, it might be because variation orders are mainly initiated to cover the extra time and money needed to complete the projects, as shown by the qualitative investigation conducted as well as the data collected by the first survey distributed. This would mean that projects are originally being delayed and costing extra money than initially planned and estimated. On the other hand, the other 6 measures identified and tests showed a Cronbach’s Alpha value of 0.81 which shows that they can be reliable to represent the scope definition independent variable. This shows that the measures gained from the literature and adopted through the interviews were adequate enough for this study.

In the case of the roles and responsibilities identification independent variables, the measures were selected to cover the issues of identifying the roles and responsibilities clearly in a way to reflect the real situation. Moreover, the measures covered the proper understanding of the identified roles and responsibilities and appropriate implementation. Furthermore, sharing knowledge and experiences with all of the team members as well as the concerned stakeholders was part of the measures. All in all, all those measures showed a high Cronbach’s Alpha value of 0.95, which demonstrates that they are well related to each other and they can reliably represent the roles and responsibilities independent value. This output shows that the measures gained from the literature and adopted through the interviews were adequate too for this variable.

In the case of the initial estimation independent variables, the first reliability test showed that the "Est2", "Est11" and "Est12" measures were insignificant to represent the independent variable. Est2 measure covered involving the stakeholders in developing the risk plan as part of the initial estimation. Est11 and Est12 similarly covered sharing the planned costs and duration with the stakeholders. It was highlighted in the interviews that each authority only concerns itself with its own plans. As it was shown in the previous qualitative research approach, the statistical analysis identified that there is no proper plans sharing with different authorities and related stakeholders. On the other hand, the other 9 identified measures covered developing risk plans and reviews, considering life cycle cost analysis, net present value analysis, fuzzy activities and time and cost optimizations. Those identified measures showed an acceptable Cronbach's Alpha value of 0.86 to represent the independent variable after excluding the other 3 measures discussed earlier.

In the case of the control techniques independent variables, the identified measures covered mainly the concepts of cost and time control through the project execution. In details the measures focused on realistically tracking time and money with reference to the original plan. Furthermore, the concept of human resources monitoring was concerned as part of the measures. On the whole, all those measures showed a high Cronbach's Alpha value of 0.92 which demonstrates that they relate to each other and they can reliably represent the control techniques independent value. Consequently, this output shows that the measures gained from the literature and adopted through the interviews were adequate for this variable too.

In the case of the technical concerns independent variables, the first reliability test showed that the "Tech1", "Tech2" and "Tech3" measures were insignificant to represent the independent variable. Those measures covered the competency of the authorities' representatives, consultants, and contractors. The reason behind the incompatibility of those measures with the rest of the measures might be because all of the 5 authorities have processes of evaluating the bidders technically along with the commercial evaluation to ensure of their competency. As some of the interview participants highlighted, the technical evaluation of bidders usually consumes a long time which delays the initiation of the project. This procedure results in ensuring that the consultants and contractors who work in executing the development projects are highly technically competent. On the other hand, the other identified measures included the availability of the sufficient resources required and the efficient utilization of them. After the “Tech1”, “Tech2” and “Tech3” measures were excluded, the Cronbach’s Alpha value became 0.86, which is an acceptable value to consider the left-over measures representatives for the independent variable.

Finally, in the case of the contingency planning independent variables, the identified measures covered mainly the contingency planning process, the activity acceleration concepts and the utilization of penalties and bonuses. All of the 9 identified measures showed a high Cronbach’s Alpha value of 0.94, which that shows that they relate well to each other and they can reliably represent the contingency planning independent value. Above all, it should be stated that the independent variables have been measured for each project through averaging its measures’ values after excluding the measure failed the reliability tests.

In the correlation test, each independent variable was tested to check its individual correlation with the percentage of cost enhancement as well as the percentage of time enhancement. It was found that there are correlation-relationships among all the independent variables studied with the two dependent variables identified to present the project crises concept. As shown previously in Table 4.20 and Table 4.21, Pearson Correlation values were found to have less than α value for the 2-tailed method in all the correlation tests conducted. It should be highlighted that the measures that failed in the reliability tests before, were not included in the correlation test.

As per the interviews outputs mentioned earlier, most of the authorities reflected positive feedback regarding the project identification and initiation practises. In particular, correlations were found between the scope definition variable with the cost enhancement as well as the time enhancement of projects. This means that the identified measures to represent the scope definition variable influence the percentages of time and cost enhancement. Thus, the authorities should strive to maintain a clear definition of the projects’ scopes from the early stages of the projects and share information with each other as well as with the stakeholders concerned. Furthermore, the projects plans should be prepared to reflect the scope clearly so the project team in particular can well understand the project scope. As a result, the negative feedback obtained earlier regarding not integrating the project scopes with all the authorities can be incorporated.

The qualitative research approach conducted earlier showed that there are insufficient cooperation practises within the different teams and parties involved in a certain project. Nevertheless, the statistical correlation test showed that there is a positive relationship between the "roles and responsibilities identification and parties coordination" variable with both time and money enhancements. This means that the improper roles and responsibilities assignment or insufficient coordination among the parties involved would negatively affect the project's targeted cost and duration. Thus, the authorities should insist on clarifying all parties' roles and distribute responsibilities clearly from the early stages of the projects. Furthermore, authorities should ensure proper knowledge sharing among stakeholders and appropriate coordination among involved parties. In general, this will decrease the impact of the negative issues highlighted by the interview participants.

Furthermore, the correlation tests showed that there are positive relationships between the initial estimations and the cost and money enhancement percentages. That is at the time when authorities' representatives expressed that the initial estimations for projects' duration and budgets are inaccurate and should be improved. Further to the participants negative feedbacks and the positive relation between the independent variable's measures, the concerned authorities should consider utilizing the life cycle cost in the process of estimating the projects' costs as well as in choosing among different alternatives. In addition, the time estimation process of estimating the fuzzy activities showed a positive impact of reducing the time enhancement percentage. Above all, the practise of time\cost optimization produces a positive effect in minimizing both the cost and time enhancement.

Additionally, the correlation tests showed that there are relationships between the cost and time enhancement with the controlling systems adopted, which were expressed by the interviews' participants to be inadequate. So, authorities could minimize the probabilities of project's crises by adopting the proper tracking techniques to monitor the cost and time during executing a certain project. Time and cost should be monitored and compared to the original plans and budgets in order to have an early warning of any deviations from the original estimations. Furthermore, project resources, especially the human resources, should be monitored so the actual performance can be tracked and compared to the original plans. Furthermore, as shown from the statistical tests' outputs, the monitoring practices should be carried out all the way through the execution of the project using the latest available data.

Furthermore, authorities' efforts to assure the availability of sufficient required resources and their efficient utilization are essential, though qualitative and quantitative research showed proper technical evaluation practices. This means that the concerned authorities should not just focus on the proper technical initiation of the development projects. They should also ensure the continuity of the appropriate technical practices. In addition, any technical difficulties faced should be well recorded and documented in order to prevent their occurrences in future projects. This is because the statistical tests showed a positive relationship between the occurrence of technical difficulties faced with the cost and time enhancements of projects.

Moreover, the correlation tests show that contingency planning has a positive relationship with the time and cost enhancements. That is when the qualitative research expressed dissatisfactions about the contingency planning practises in all of the five concerned authorities. In particular, having a contingency plan with an exact timeframe to be shared with all authorities is essential to mitigate the problems of cost and time enhancements as proved by the statistical tests. Furthermore, the surveys outputs showed the minimal efforts afforded by the authorities on back up activities acceleration plans as well as the penalty/bonus policies as expressed by the interview participants.

Subsequently, the statistical analysis of the surveys' outputs was also used to test the regression of the relationship of the entire independent variables together with each of the dependent variables. As shown in Table 4.22 and Table 4.25 previously, almost 89% of the variation in the percentage of cost enhancement in the studied projects can be explained by the variability in the studied independent variables. Additionally, almost 84% of the variation in the percentage of time enhancement in these projects can be explained by the variability in the independent variables studied. Hence, the factors represented by the studied independent variables are significant though many of them receive scant attention in the process of managing out the projects included in this study scope. Therefore, the authorities concerned should focus on those clarified variables at the time that the project crises variables are mostly explained through them.

At the end of the statistical analysis, additional tests were conducted to further investigate the relationship of the time and cost enhancement percentages with some of the collected projects characteristics. The correlation tests were conducted to investigate the relationship of the initial projects' cost and time with the associated cost and time enhancement. The correlation tests showed that there is no relationship between the initial budgeted cost and the cost enhancement percentage, nor is there a relationship between the initial planned duration and the time enhancement percentage. This shows that authorities should play equal attention to all of the projects by focusing on the independent variables discussed earlier, regardless of the initial cost estimations and time plans.

Similarly, further correlation tests were conducted to test the variability of cost and time enhancement percentages with different projects' characteristics. The conducted tests showed that there is no relationship between the location of a project, its original status, and the percentage of cost and time enhancement. This means that the concerned authorities face the same problems regardless with of a project's distance from the city center. This can be explained by the extra time and money the contractor usually assigns for projects carried out far away from the downtown area. Subsequently, the independent variables tested and discussed previously affect the projects in the same way regardless of their location.

In addition, it was found that the original importance status of the projects has no relationship with the cost and time enhancement. This means that cost and time enhancement problems are affecting even the projects that need to be accomplished urgently, as well as the projects that high in importance. Particularly, the five concerned authorities should focus on this finding because they assign the project status and its importance in the project contract, yet even the most vital projects are being delayed and going over budget.

5.0 Proposed Recommendations

5.1 Introduction:

Based on the previous chapters of this study, this particular chapter proposes several recommendations for the concerned authorities in order to better manage their development projects. These recommendations are proposed based on the results of the literature review as well as the data analysis. As discussed earlier in this study, there are many factors that can lead to cost overruns and schedule delays. As detailed in this study previously, many techniques are mentioned in the literature to avoid the negative circumstances of the identified project crisis reasons and to mitigate their impacts on the project schedule and budget. Many project management practices, that would assist in better managing projects from conceptualization to completion, have also been reviewed and clarified in this study. So, those useful project management techniques and practices, in conjunction with the findings of this research, provide the basis for practical recommendations. It should be noted that, the recommendations proposed based on the concepts of project crises will fill the missing gaps in the management practises utilized to manage the development projects. In sequence, the combination of these recommendations set a full package to improve the management process of the concerned development projects.

5.2 Drawbacks of Current Practises:

This study found that the biggest drawbacks of current project management practises include inefficiencies in project crisis identifications, project planning and initiation, project monitoring and control, and crisis mitigation. The findings of the interviews conducted showed that there are many drawbacks in the current practises project management practices of the concerned authorities. Interview participants highlighted that the practices of project planning and execution are inadequate and have many drawbacks. Problematic areas of project planning include the processes of scope identification, roles and responsibilities assignment and initial estimation. Inadequate practises of project execution include deficiency in budget and time control and monitoring as well as inappropriate usage of resources. Those improper practises are identified in the literature as some of the main reasons behind project crises. As the statistical analysis of the surveys output showed, these practises are really associated with the project crises concept and their adaptation leads to cost overruns and schedule delays.

The interview findings showed that the five authorities are not practising the contingency planning methods adopted from the project crisis concepts. Many essential techniques for project acceleration and schedule crashing are not practised, though these methods are well known and practised elsewhere to mitigate the adverse impact associated with project crises. The statistical analysis of the data obtained from the concerned development projects clearly showed that the contingency planning is essential to mitigate the harmful impacts of project crises.

This chapter recommends useful techniques to be utilized and practices to be adopted. These proposals and recommendations cover all stages of project management including contingency planning. In the following chapter, some of the proposed techniques are implemented on real project cases from the authorities included in this study scope. This implementation on real project cases is necessary to practically illustrate the utilization of these techniques. In addition, their beneficial usages will be demonstrated.

5.3 Identification of the Reasons behind Project Crises:

- **Authorities should spend some time studying the current performances of project management.**

This is for the authorities to determine the project crisis reasons that usually affect the development projects and lead to budget and time enhancements. The concerned reasons behind project crisis can be determined through conducting an extensive post project review with all the concerned authorities in which all the personnel who participated in a certain project attend. In the review, the personnel should analyse the performance and encountered problems of the previously completed projects so that they can avoid the reoccurrences of problems in future projects.

- **Authorities should keep examining the reasons that lead to the problems of cost overruns and schedule delays.**

This study, as mentioned previously, highlighted many of the project crisis reasons that are related to the projects of the concerned authorities. Authorities should keep examining these reasons in order to overcome those problems.

- **Authorities should conduct similar studies on an ongoing basis to figure out crisis reasons that might appear in the future.**

More advanced study should be conducted in order to determine more crisis motives. That is because the crises independent variables, identified in this study, determine 88.6% and 84% of the cost and time enhancement, respectively. So, the more detailed and advanced exercise is required to find other reasons, too.

5.4 Project Planning and Initiation Process:

In the process of practical project management, many methodologies for proper planning practices are proposed in the literature. These would enable projects' personnel to better plan a project at the conceptualization stage before starting the execution. In addition, appropriate estimation techniques are studied and recommended by scholars in order to start the project with a better understanding of the needed time and money for execution. As revealed by the interview results, planning practices are inadequate; yet, they are affecting the cost and time enhancement as shown by the statistical analysis. It should be highlighted here that the concerned authorities in this study are practising the critical path method for planning the development project, and this method should continue to be utilized and never skipped. However, the additional proposed techniques are recommended to be used along with the CPM method. During the planning stage, appropriate risk management techniques, value management analysis, and network scheduling practises are recommended.

- **The concerned authorities are requested to implement the Monte Carlo simulation for management of risks associated with project's costs.**

As per the qualitative research, authorities personnel expressed that the process of managing the development projects misses the risk analysis practice. So, the use of Monte Carlo simulation is recommended. As outlined in the literature review chapter, in this approach, the associated risk's costs are simulated in the network where each risk is assigned to the affected activity. In this model, a cost breakdown structure is adopted, in which each of the cost items is estimated as a single point estimate. All the identified and quantified risks are included in the model to ascertain where the risks will have particular impacts on the costs.

- **Authorities should analyse risks associated with project duration estimation and time planning by calculating the activity covariance.**

In this regard, the concept of activity covariance should be adopted. The approach is utilized by calculating the covariance of the duration for all the activities. Then, the contingency time of each activity is added to the plan according to the covariance index of each activity.

Utilizing these two approaches are essential for the concerned authorities. That is because, the personnel showed negative responses about the risk management analysis. Yet, the statistical analysis proved that analysing risk associated with both time and money is a measure of the Initial Estimation variable that is correlating with the time and cost enhancements. Using the two recommended approaches of allocating risks in time and cost estimations would enable the project personnel, especially the estimators, to better plan the needed budget and duration from the very early stages.

- **Authorities should estimate the total Life Cycle Cost of the development project.**

In this study, the authorities' personnel expressed non-satisfaction feedback about the budget estimation procedures. However, it was found that it is essential to properly estimate budgets in order to minimize the cost enhancement of projects. In real life cases, the concerned authorities determine project costs on the basis of initial purchase and construction costs. For more accurate assessment, authorities should estimate the total Life Cycle Cost by including all the initial costs of design and construction as well as the net present value of costs associated with operations and maintenance. Budget estimations is also needed to include the net present value of costs for the occasional replacement of elements during the project life cycle as well as the disposal and termination costs. The Life Cycle Cost analysis should, as well, include the cost of natural hazards and other risks all over the project cycle.

- **The present value of all costs should be calculated prior to evaluating alternatives.**

The present value of all costs can be calculated through the utilization of the discounting techniques through which the economic worth of project alternatives can be evaluated. This technique would enable authorities to effectively make discussions about the different available options through considering the impact of all associated costs rather than only initial costs. Consequently, it would enable authorities' management to have a clear idea of the required budget to complete projects. In the case study chapter afterwards, a real life case is illustrated to present how this technique can be applied.

- **Authorities are recommended also to use the "fuzzy concept" approach as part of schedule planning.**

Although the concerned authorities practice the critical path method while developing project schedules and plans, interview participants expressed dissatisfaction feedback about the project scheduling procedures. Yet the statistical analysis showed that proper time estimation minimizes the time enhancement of the project. So, authorities are recommended also to use the 'fuzzy concept' approach in conjunction with the well know critical path method. Here, fuzzy numbers in the process of modelling the activity times. Through adopting this approach, the concerned authorities can replace the vague activity times by fuzzy sets of numbers. In this regard, the plans will be based on more rigid bases in which all the scenarios will be considered. Thus, the critical paths under different possibility levels can also be obtained through the varied possible activities' durations which completely conserve the fuzziness of activity times. By reviewing different potential scenarios, authorities' management would have a full image of how the project is needed to be estimated and planned.

- **Authorities need to devote attention to the required resources to complete the project from the early stages of planning.**

The qualitative research showed the resource allocation and assignment processes are insufficient. Yet, the quantitative research showed that the proper allocation of resources affects the Technical independent variable which correlate with the time and cost enhancements. So, authorities should practice the process of resource allocation, in which all resources required should be assigned to the projects activities. Then, the scheduling of the activities must be adopted within the scheduling techniques proposed previously. Next, a resource graph should be developed for each particular resource separately in which the amount of the resource needed for each activity is illustrated along with the time. Afterwards, the resource aggregation should be practised, in which the amount of each resource is obtained at a certain period of time through the summation of the activities occurring at that time. It is then necessary to compare resource requirements with the available resources. Finally, whenever a certain resource exceeds the available amount at a certain time, resource smoothing should be adopted, in which the activity network logic must be changed accordingly.

5.5 Project Monitoring and Control:

After preparing the projects' plans and budgets appropriately, the authorities must then make the projects plans and budgets the reference through the execution stage. Proper monitoring should be carried out by practising the methodologies of earned value management. This would enable the project's personnel to monitor the current performance on site and compare the actual time and money consumption with the original plans. This is essential because it is very unlikely that the actual duration and cost of a certain activity will be exactly as estimated. Furthermore, it is unlikely that the actual execution sequence of the activities will be performed exactly as planned in the logic network and according to budgets. There are also frequent additions or deletions to the project scope of work that will influence the dates of starting and completing the activities as well as the associated costs.

- **Authorities are requested to utilize the Earned Value Analysis, as part of monitoring.**

The correlation and regression tests showed that the proper control and monitoring of project decreases the percentage of cost and time enhancements. Through the utilization of these earned value analysis (EVA), the concerned authorities can accurately monitor any project and measure the performance of projects against a planned baseline. The monitoring process, followed by the evaluation of the current project status, should be carried out at regular intervals during the execution of the project. It should be mentioned that the data collecting processes of this study showed that authorities already fulfil the prerequisites of earned value analysis. However, they mostly focus on the planned value and actual value of time and money. This earned value analysis will consequently provide a wealth of reliable data that reflects the true status of projects. Then, through the utilization of the following standard equations, the schedule and cost variance can be calculated.

$$SV \text{ (Schedule Variance)} = \text{Earned Value} - \text{Planned Value} = EV - PV$$

$$CV \text{ (Cost Variance)} = \text{Earned Value} - \text{Actual Cost} = EV - AC$$

- **The Earned Value Analysis should be followed by the calculation of cost and schedule indexes.**

Through the utilizing of the same basic variables of the earned value management, performance indexes for schedule and cost can be calculated. Those indexes indicate the true progress of the project with respect to the planned progress. The schedule performance index and cost performance index can be calculated using the following standard equations:

$$SPI\ (Schedule\ Performance\ Index) = Earned / Planned = EV/PV$$

$$CPI\ (Cost\ performance\ Index) = Earned / Actual = EV/AC$$

- **The Human Performance Index should be calculated, as well.**

After evaluating the technical performance with respect to time and cost by the earned value analysis, it is still essential for the authorities to evaluate human performance. The human performance index (HPI) should be adopted in the management process of the concerned development projects in order to evaluate the professionalism of the project's personnel. The HPI index consists of the relationship between the CPI and SPI, and allows the evaluation of the schedule and budget of the activities executed by the resources simultaneously. It is important to evaluate the HPI along with the EVA, not only to evaluate the individual work outcome, but also the whole team's work. As discussed previously, the HPI index can be calculated through the following formula: $HPI = \%_C \ x\ CPI + (1-\%_C)\ x\ SPI$

- **Plans monitoring should be continuously conducted and updates should be carried out when needed.**

As shown previously, there are many factors that can cause the original plans to be inaccurate. So schedule updates should be executed by reviewing and revising the project schedule periodically, and then replacing the original planned dates with actual dates, resulting in an accurate and up-to-date schedule. This is essential because while project planning and scheduling are necessary to ensure that a project is properly and logically organized, it is equally necessary to properly monitor the project progress to ensure that all changes are incorporated into the original plan. The recommended approach by this study for reviewing the project plan involves pre-determined intervallic updates. In this particular approach, the project personnel should determine consistent intervals at which to conduct the updates.

- **Forecasting the time and cost at completion by EVA should be done.**

As mentioned previously in the literature review, the earned value management approach can be utilized to predict the total project cost or time at the end of the project. Yet, the authorities process of managing the projects misses the practice of forecasting the estimates at completion. Thus, it is recommended to utilize the EVA to predict the estimations at completion according to the current performance. The advantage of utilizing this approach is that it relies on the current performances which are measured by the cost, time and human indexes. The estimation at project completion can be calculated using the following equation:

$$EAC = BAC / CPI \text{ or}$$

$$EAC = AC + \{(BAC-EV) / (CPI*SPI)\}$$

Afterwards, the amount of money or effort that will be needed to complete the project, if nothing has changed, is calculated by the following equation:

$$ETC = EAC-AC$$

The project control techniques should be implemented in order to full the missing gaps of monitoring the actual performance during the execution of the project. They are essential components of an early alarm system that gives warnings prior to crisis occurrences. In the following chapter, the Earned Value Analysis techniques are illustrated on a real life case study.

5.6 Crisis Mitigation:

Crisis can still occur because there is a degree of subjectivity in the planning and the estimation procedures. That is because projects can also be impacted by the project uncertainties shown and discussed previously. Yet, project crises can be overcome through the use of a variety of crisis mitigation techniques. Accordingly, project management must continue further to mitigate the impacts of crisis once they occur. In this study, the concerned authorities were found to lack some essential crisis management systems and crisis mitigation techniques. Nevertheless, the statistical analysis found that the Contingency Planning variable is correlating with both, cost enhancement and time enhancement. So, the concerned authorities need to introduce and utilize the concepts of project crisis management. Such a project crisis management system should be a continuous process that includes the reactive actions with the aim of responding to any problem of schedule delays and cost overruns, as well as confronting and resolving them. The recommended techniques are needed to fulfil the missing gaps in the management processes.

- **The activities acceleration practise should be introduced, and implemented when required.**

Firstly, the techniques of activities acceleration should be introduced and utilized in order to shorten the overall project duration whenever a problem of schedule delay and cost overrun occurred. As comprehensively discussed in the literature review chapter, by adding additional people or equipment or by working additional hours, an activity's duration can be shortened, and if it is a critical activity, the whole project will be shortened as well. These techniques should be utilized whenever an activity is needed to be accomplished by a specific date for contractual reasons. Additionally, some activities need to be accelerated in order to be completed more economically within a certain timeframe. Furthermore, the authorities should consider the concept of activities acceleration because the cost of accelerating an activity that will shorten the entire project duration may be less than the overhead cost of running the project for the original duration.

It should be mentioned that activities acceleration, as a concept, is introduced in this study as a tool to be used by the government authorities to shorten the duration of the delayed activities in order to mitigate a crisis occurrence. Accordingly, the project duration would be shortened in the case of crisis occurrences to facilitate minimizing the associated harmful impacts. In real life cases, authorities may also have fixed due dates for completion of an entire project or certain activities. In such cases, authorities should utilize the activities acceleration plans in order to complete the required deliverables by the due date.

This study recommends that these three main techniques to be utilized by the concerned authorities, based on the fact that significant resources are always available for the development projects as shown by the data collection exercises. The recommended techniques are the following:

1- Extending the working hours of existing resources through overtime.
2- Adding to the number of personnel employed, during normal working hours.
3- Utilizing a multiple shifts system.

However, the concerned government authorities should first of all insist on adopting the resource index technique. As shown previously, the resource index would ensure that the most productive resources can be ascertained. Then those critical productive resources can be enhanced accordingly, to keep the project on track.

- **The schedule shortening practises should also be introduced, and implemented when required.**

The proposed technique for shortening the project duration at the lowest possible cost includes specific methodology that authorities should use whenever the desired project duration is delayed compared to the original plan. The first step is to rank the activities on the critical path in the order of cost slope. Then, the duration-shortening process can begin, starting with the lowest-cost-slope activities as much as possible. After that, the process continues to reduce the duration of the progressively higher-cost-slope activities until the critical path has been shortened by the required amount. However, it should be noted that the authorities should not focus just on the critical path, but on the sub-critical paths as well. So, if an additional critical path is created, the activity being shortened should not necessarily be expedited to its minimum time. Instead, the concerned personnel have to ensure that the activity is expedited only enough to make the additional path critical. Afterwards, activities from both critical paths should be shortened simultaneously in order to reduce the overall project schedule.

Consequently, when planners prepare the project plans, especially after crisis occurrences, the project duration should optimize the associated cost of the project. The cost of completing each activity should also be recalculated in order to minimize project cost. In here, the project planners should ensure that the cost of each of the project activities is calculated as a function of the activity duration. This is because, in real cases, the activity cost does not vary as a linear function of activity duration.

- **Reward and Penalty systems should be contractually included.**

It should be highlighted here, as per the data gathered through the literature review stage, and according to the statistical analysis findings, a penalty/bonus system correlates with time and costs enhancements. Thus, reward and penalty systems are proposed to be included in the development projects' contracts. The concept of penalty and bonus system is recommended to be integrated in the project contracts from the early stages of the project. This would motivate the contractors to reprioritise the projects they are working on. Furthermore, as indicated by the survey results and the statistical findings, it is desirable to include a penalty cost for the late completion of an activity as well as bonus payments for the early completion of the whole project.

This proposed approach of introducing a penalty and reward system will result in increased efforts by the contractors to monitor projects carefully and mitigate the crisis impacts in the first place. It will give a clearer view of the process of optimizing the cost and duration of the project plans as well. Furthermore, it will threat contractors with penalties for any delay in the projects. In addition, the authorities can use the penalty/bonus system in order to assign deadlines for some activities that are needed to be completed on exact dates. As discussed in the literature review, it should be highlighted that three different types of penalty/reward functions were developed by scholars in order to determine the optimal cost of the project schedule. These three combinations, authorities can utilize as per the project's requirements, are the following:

1- Linear penalty costs with linear rewards.
2- Linear penalty costs with a fixed reward.
3- Fixed penalties and rewards in different ranges of project completion.

In the following chapter, an implementation of the recommended techniques of crisis mitigation techniques is illustrated on a real life project case.

5.7 Organizational Management Practises:

Further to the qualitative study, it was found that the management systems in the concerned authorities have some drawbacks that affect the management processes negatively. By following certain organizational management practices, authorities can improve their ability to manage projects and ensure their success. Accordingly, this study recommends some proposals for the authorities' structures further to the above project management recommendations. These changes in the authorities' structure would allow the authorities to adopt the previously mentioned recommendations of project procedures.

- **Determining and enrolling all the related parties from the early stages.**

The first essential recommendation for the authorities is to determine all the concerned parties that are related to any project from the earliest stages. In the qualitative study, the participants expressed that the related parties' enrolment are not considered in the early stages of the project. Yet, the personnel of each party should be clarified in order to appropriately identify rules and properly assign responsibilities among all concerned parties. Furthermore, all stakeholders, stockholders and parties that would be impacted by the project, should also be identified. This, will make the concerned authorities be able to prepare for all the requirements of stakeholders and stockholders.

- **Establishing a project organization chart.**

Further to determining all the project related parties, a project organization chart that is specific to a certain project should be formed to contain all the key personnel from all parties. Such a project organization chart is required to make sure all parties understand the roles of others in the project they are working together to accomplish. It will also formalize a proper communication channels during the different stages of the project life cycle. Furthermore, this personnel chart will make it easier for the different parties to meet together frequently and exchange status updates on their portions of the whole project. It should be mentioned that the quantitative study showed that the Roles and Responsibility variable affects the cost and time enhancements. Yet, personnel responses showed that rules and responsibilities among different parties are misunderstood. Utilizing this proposal will make the different parties act as one body through allying all of their individual goals, so the project main deliverables can be achieved efficiently.

- **Authorities should assign a project planning positions in their organization structures.**

Another recommended change in the authorities' structure is to add planning positions in each authority to be responsible for project monitoring processes. The qualitative research of this study found that some of the authorities have designated planning engineers' positions. Still, it is recommended for all authorities to assign the same positions. Authorities should also add to the planning engineers' responsibilities to monitor the real projects' status by calculating the earned value that is needed to conduct the earned value analysis. Then, any schedule delays or cost overruns can be discussed early on. At that point, the different project crisis mitigation techniques can be implemented according to the situation as discussed previously.

- **Authorities should conduct post project review sessions.**

The concerned government organizations should learn from any particular crises that have impacted past projects. By extensively examining, evaluating, and responding to what went well and what went poorly in terms of project execution, authorities can gain powerful insight that will help them in the future. Authorities should conduct review meetings to examine key signal and project impacting event through sessions that gather all concerned parties. These proposed post completion sessions should be conducted for each project in order to gather all concerned authorities, stakeholders, consultants and contractors who worked on the project. These sessions should, as well, be founded and allied into the schedule from the early stages of the projects in order to ascertain and acknowledge any errors and determine how things might be done differently in the future. These changes should be then formalized in amendments to policies and procedures conducted via formal processes. A post project review (PPR) report is also recommended in order to record data from each project experience that can be accessed in the future to benefit the upcoming projects.

- **Authorities should give equal attention to all development projects.**

Above all, the concerned authorities should focus on all projects equally, regardless of their initial status, planned budget, planned duration and distance from the city centre. As highlighted in the data analysis chapter, development projects are suffering from cost overruns and schedule delays regardless of their initial characteristics. This means that all proposed techniques and recommended practices should be applied to each project, and further attention can then be given to sensitive projects. This is simply not to result in extra time and cost than planned even for small projects.

The following Figure 5.1 summarizes all the recommended techniques and practises that are proposed in this study, and should be implemented by the concerned authorities.

Identification of the Reason behind Project Crises

- Authorities should spend time studying the current performance.
- Authorities shouyld keep examining the reasosns contintuesly.
- Authorities should conduct similar study on an going basis.

Project Planning and Initiation Process

- Authorities are requested to implement Monte Carlo simulation
- Authorities should calculate the activity covariance
- Authorities should estimate the Life Cycle Costs
- The net present value of all costs shoule be calculated
- Authorities are recommended to use the Fuzzy Concept
- Authorities should devote attention to the required resources

Project Planning and Control

- Authorities are requested to utilize the Earned Value Analysis
- The EVA should be followed by tha calculation of cost and schedule indexes
- The human performance index should be calculated, as well.
- Plans monitoring should be continuously conducted, and updates should be carried out when needed
- Forcasting time and cost at completion by EVA should be done.

Crisis Mitigation

- The activities acceleration practises should be introduce, and implemented when required.
- The schedule shortening practises should also be introduced, and implemented when required.
- Reward and Penalty systems should be contractually included.

Organizational Management Practises

- Determining and enrolling all parties from the early stages
- Establishing a project organization chart
- Authorities should assign a project planning positions in their organization structures
- Authorities should conduct post project review sessions.
- Authorities should give equal attention to all development projects.

Figure 5.1: Recommendations Summary

5.8 Conclusion:

This section has recommended a number of changes and improvements to authorities' practices and processes of managing the development projects as summarized in Figure 5.1. Many of these changes and new techniques will require a certain amount of investment on the part of authorities. Yet, the proposed recommendations are essential and if adopted, will result in reduced costs and times. Although the recommendations might seem to be costly and time consuming in terms of additional management-based training and processes improvement, they will pay back. As mentioned earlier in the data analysis chapter, the average budget enhancement percentage for all the projects studied was almost 8.7%, which means that an average of 6.44 million Dirhams are being added to the budget of every project during execution. Furthermore, the average added time duration percentage for all the projects studied is 8.4%, which means that an average of one month's time is being added to the planned duration of every project during execution.

It is necessary for all authorities and their personnel to take a serious move towards developing the processes used in managing projects. This will benefit all parties involved as well as the stakeholders and stockholders. The previously proposed recommendations will provide authorities with the tools needed for improved planning, control and monitoring of projects. The time and money spent of projects will consequently be reduced. So, the benefits of implementing these recommendations greatly outweigh their costs. Authorities, therefore, should indeed focus on the matters of cost and time enhancements that are frequently affecting their projects. That is through adopting the proposed techniques of project planning and monitoring as well crisis mitigation plans.

In the following chapter, some of the proposed techniques are applied to real-life project cases to illustrate the methodology of adopting the techniques in practise.

6.0 Project Case Studies:

6.1 Introduction:

In this chapter, some real life project cases that are parts of the projects tackled by this study are illustrated. Then, some of the proposed techniques and recommended practices are implemented practically to show the process of implementation. Four project cases will be studied where each is adopted to illustrate a different techniques of those proposed earlier in the study. In each case, a technique of proper management is practiced in details in order to present how the proposed techniques shall be implemented. Finally, the illustrated real project cases show the main advantages and major benefits of utilizing the proposed techniques. It should be noted that the studied project cases illustrate the main three project crises management stages: planning and estimation, tracking and monitoring, activity acceleration and schedule crashing.

The first project case is about different alternatives estimation and evaluation. In this case, the techniques of proper project cost estimation using net present value method, annual value, and future value are illustrated. Then, the appropriate evaluation process of different alternatives considering the entire project life cycle cost is represented. For this case, the estimation and evaluation process of different alternatives for water pipeline networks is studied.

The second and third project cases deal with the monitoring the controlling techniques. In the second case, the concepts of earned value analysis are practised to measure the accurate performance of the execution, and compare it with the original plans. Furthermore, the EVA concepts are used to predict the costs and times at completion. Then, the required productivity to be enhanced is measured in order to assess the project personnel being able to get back to track. In addition, the practices of human performance evaluation are implemented in the third case. The HPI concepts are implemented to evaluate the productivity of the project's resources.

The last project case is about activities acceleration methods and schedule crashing techniques as part of the project crises mitigation process. In here, the concepts of project acceleration are practised to shorten the project schedule. Then, the processes of penalties and bonuses are illustrated. Consequently, the project time/cost optimization practice if comprehensively implemented and represented. Thus, the principle of crises mitigation is expansively practised and well demonstrated. This particular case deals with a power plant project which is needed to be accelerated in order to be accomplished on soonest.

6.2 Case Study 1: Water Pipeline Project

This project case focuses on the different alternatives estimation and evaluation processes. In this case, the techniques of proper project cost estimation using net present value method, annual value, and future value are illustrated. Then, the appropriate evaluation process for the different alternatives considering the entire project life cycle cost is practised. For this case, the estimation and evaluation process of different alternatives for water pipeline networks are studied and represented.

The first step of the project is to select the proper material of the system according to the conditions of the particular project. Yet, material selection influences the investment cost, project completion schedule, and staging of construction operation activities (Lema and Durendez, 2007). Therefore, a certain criteria of the following factors shall be considered while selecting the suitable pipeline material for this project,

- Mechanical properties of the material including strength and durability.
- Maintenance and operation requirements.
- Protection coating/lining requirements.
- Material availability locally and supply duration.
- Material and construction costs.
- Transportation, storage and handling.
- Construction duration period.

Based on the above criteria, the following pipeline materials have been evaluated for this project:

- o Ductile Iron (DI)
- o High Density Polyethylene (HDPE)

The decision of which material to be used would be made according to cost compression.

6.2.1 Cost Comparison:

Cost comparison between the supply of DI pipes and HDPE pipes (excluding fittings, valves and installation cost) is carried on as follow in Table 6.1:

Table 6.1:Cost Comparison Between Supply of DI and HDPE Pipes

Size (mm)		Unit Rate (Dhs/m) *		Percentage of HDPE Cost Compared to DI
DI (DN)	HDPE (OD)	DI	HDPE	
150	180	157	97	61.78%
200	250	226	184	81.46%
300	355	355	371	104.33%
400	500	685	736	107.38%
500	630	823	1166	141.71%

* Rates are obtained from pipe manufacturers.

It is to be noted that for small diameters (up to 180 mm) the HDPE pipes are less expensive than DI pipes. However, as the pipe diameter increases above 200 mm the DI pipes become less expensive compared to HDPE pipes. This is mainly due to the fact that for HDPE pipes as the pipe diameter increases, the required wall thickness increase significantly in comparison to DI pipes resulting in higher manufacturing and installation cost.

For the expected design of the pipeline network concerned in this project, the costs of the network by using both materials would be as shown in Table 6.2,

Table 6.2: Cost Comparison between Supply of DI and HDPE Network

	HDPE	DI
Initial construction cost	900000	500000
Annual cost for maintenance	16000	35500
Life age of the network	30 years	20 years

*Those costs are just for construction and maintenance, without overhead costs

6.2.2 Materials Selection Criteria:

It is well known that public sector projects are owned and financed by the government and used by the community, whereas corporations, partnerships, and individuals own projects in the private sector. Public sector projects such as this project have a primary purpose to provide services to the community for public good at no profit. However, these projects have a lot of beneficial impact on the society. Subsequence, to choose the best material for the network, Benefit / Cost Analysis method was used. According to Blank and Tarquin, "the benefit / Cost ratio is relied upon as a fundamental analysis method for public sector projects" (2005). In this method, all cost and benefit estimates related to the project should be converted to one familiar equivalent monetary unit such as the present, annual, or future values at a certain discount rate. Then the B/C ratio is calculated by

B/C = PW of benefits / PW of costs = AW of benefits / AW of costs
= FW of benefits / FW of costs

If, and only if, the B/C ratio was more than 1, the project would be economically accepted for the estimates and discount rate applied. Otherwise, it wouldn't be accepted.

In the case of this project, it was estimated that the discount rate for ADWEA network projects to be 7% per year, and according to the planning section, the benefit of this particular project was estimated to be 105000 DHs per year.

So by applying the B/C ratio as followed in Table 6.3, B/C ratio of HDPE pipeline network was calculated to be 1.19 and B/C ratio of DI pipeline network was calculated to be 1.03. Consequently, it was concluded that both materials are economically accepted however, the HDPE network is more economically beneficial to the society.

Table 6.3: B/C ratio for HDPE and DI Networks

	HDPE	DI
Discount Rate	7.00%	7.00%
Initial Construction Costs	900000	700000
Annual Cost for Maintenance	16000	35500
Life Age	30	20
Year		
0	900000	700000
1	16000	35500
2	16000	35500
3	16000	35500
4	16000	35500
5	16000	35500
6	16000	35500
7	16000	35500
8	16000	35500
9	16000	35500
10	16000	35500
11	16000	35500
12	16000	35500
13	16000	35500
14	16000	35500
15	16000	35500
16	16000	35500
17	16000	35500
18	16000	35500
19	16000	35500
20	16000	35500
21	16000	
22	16000	
23	16000	
24	16000	
25	16000	
26	16000	
27	16000	
28	16000	
29	16000	
30	16000	
Present Worth	1,098,544.66	1,076,087.51
Annual Worth	88,527.76	101,575.05
AW Benefit of the project	105000	105000
B/C ratio	1.19	1.03

6.2.3 Construction Methodology:

For the HDPE pipeline network chosen to be used in this project, two equivalent pieces of quality methods are been considered to be applied to construct the designed network. The first one is the mechanical jointing method. This method has less cost for the machine needed and the life age of the machines is expected to be 6 years. However, the second option is the Electrofusion method, which requires more expensive machine that has longer life age. The following Table 6.4 compares the different machines associated with both options.

Table 6.4: Costs of the Different Methods of Jointing

	Mechanical jointing	Electrofusion jointing
Initial Cost	-60000	-200000
Annual maintenance cost	-15000	-17000
Life Age (years)	6	30
Salvage value	10000	20000

The Net Present Value (NPV) analysis had been applied on both options to examine them according to the time value of money to get the best cost-wise option. As well, a discount rate of 7% would be applied in this analysis. According to Blank and Tarquin, “the PW of the alternatives must be compared over the same number of years and end at the same time” (2005). So, to be able to compare the two machines, the two options were compared over a period of time equals to the least common multiple of their life ages. It was assumed that the purchasing of mechanical machine would be purchased 5 times at the same costs to have the same life age of the electrofusion jointing machine.

After applying the NPV analysis, it was concluded that the electrofusion jointing method is more economical at the time it has less Net Present cost over 30 years even though it has more initial cost as presented in Table 6.5.

Table 6.5: NPV Analysis of the Two Jointing Methods

	Mechanical jointing	Electrofusion jointing
Discount Rate	7%	7%
Initial Cost	-60000	-200000
Annual Maintenance Cost	-15000	-17000
Life Age (years)	6	30
Salvage value	+10000	+20000
Year		
0	-60000	-200000
1	-15000	-17000
2	-15000	-17000
3	-15000	-17000
4	-15000	-17000
5	-15000	-17000
6	-15000+10000	-17000
7		-17000
8		-17000
9		-17000
10		-17000
11		-17000
12		-17000
13		-17000
14		-17000
15		-17000
16		-17000
17		-17000
18		-17000
19		-17000
20		-17000
21		-17000
22		-17000
23		-17000
24		-17000
25		-17000
26		-17000
27		-17000
28		-17000
29		-17000
30		-17000+20000
Net Present Value of 6 years	-124,834.67	
Net Present Value of 30 years	-511,846.80	-408,326.36

6.2.4 Case 1 Conclusion:

As illustrated in this case study, the process of project estimation considering the project life cycle cost enable the project planners to better evaluate the different alternatives available. As well, it will make the project personnel aware of all the costs associated with the project life cycle from the early stages of the project. This approach will enable the project personnel to evaluate the different construction methodologies, as well.

It should be recalled that the statistical analysis showed that the Initial Estimation variable correlates with both, the time enhancement and cost enhancement. Although, the qualitative study showed dissatisfaction and negative responses to the utilized estimation processes. The regression test, as well, showed that the estimation practises affect the variation of the time and costs enhancements. All in all, the net present value (or annual value or future value) is required to be implemented to fill the missing gap of the estimation processes utilized by the concerned authorities.

6.3 Case Study 2: Telecommunications Network Project

This project case deals with the monitoring the controlling techniques proposed earlier. In this particular case, the concept of earned value analysis is practised to measure the accurate performance of the execution, and compare it with the original plans. Furthermore, the EVA concepts are used to predict the costs and times at completion. Then, the required productivity to be enhanced is measured in order to assess the project personnel being able to get back to track. For this case, the monitoring practices of a running Etisalat project of telecommunication network is tackled and illustrated. The scope of project part studied can be summarised as laying 15 Km of fibber optics telecommunication cables in an internal network. The allocated budget for this part of the project is 9 million Dhs and the estimated time is 30 weeks.

6.3.1 Project Execution:

At the time of writing this report, 14 weeks of the total period of the project have already passed. So as part of value management process, the actual cost and performance of the project were audited and compared with the budgeted cost and estimated schedule. This was done to make sure that the project is being accomplished smoothly as planned. In this regard, the Earned Value Analysis was used, which is according to Schaufelberger and Holm, "a technique for determining the estimated or budgeted value of the work completed to date and comparing it with the actual cost of work completed" (2002). Subsequently in this project EVA is applied on the actual data of the construction cost and performance of the first 14 weeks of the construction period.

6.3.2 Utilizing the Earned Value Analysis

After applying the EVA as shown in Table 6.6, it is obvious that at the end of week 14, just 6 Km of the network cables were accomplished at a cost of 3,660,000 DHs and 8400 MHrs. This means that the actual expenses are above the budgeted cost for the work performed. Thus, the current performance is behind the scheduled plan. In this study, the technical matters resulted in delaying the project will not be studied. However, the focus will be on the crisis management techniques that can be adopted to get the project back to track with the least impacts.

Table 6.6: EVA Analysis of the Project

Quantity to be completed	15.00	Km
Duration	30.00	Weeks
Budgeted cost	9,000,000.00	DHs
Estimated man hours	18000.00	MHrs
Planned at week 14		
Scheduled to be done	7.00	Km
Scheduled Cost	4,200,000.00	DHs
Scheduled Man Hour	8400.00	Hr
Actual at week 14		
Actual Completed	6.00	Km
Actual Cost	3,660,000.00	DHs
Actual Man Hour	8400.00	MHr
Percentage completion	40.00%	
Earned Value (EV) of the cost	3,600,000.00	DHs
Earned Value (EV) of the performance	7200.00	MHr
Schedule Variance (SV)	-1200.00	Behind schedule
SPI	85.71%	
Cost Variance (CV)	-60,000.00	Above budget
CPI	98.36%	

By using the EVA, it was easy to predict the future of the project future as shown in Table 6.7. In here, according to Frederick (2005), three scenarios are summarizing the end of the project at different conditions,

- The project to continue with the current productivity,

In this case, it is assumed that the work on the project will remain on the same productivity performed during the first 14 weeks.

- The project to continue with the original planned productivity,

In this scenario, it is assumed that the original intended productivity will be applied on the next tasks until the completion of the project.

- The project to continue with better productivity,

This scenario was made as a makeup plan to recover the previous delay and extra cost of the work completed. This case recommends that the productivity rate should increase by 20% of the original estimations. That will result in accomplishing the upcoming work at less time and less money than the original plans.

6.3.3 The Estimation at Completion:

Table 6.7 below, shows the estimated time and cost required to accomplish the project as per the three scenarios discussed.

Table 6.7 : the Estimated Time and Money Needed to Complete the Project

Current Productivity		
Estimate to Completion (ETC) of cost	9,691,000.00	Dhs
Estimate at Completion (EAC) of cost	9,775,000.00	Dhs
Estimate to Completion (ETC) of performance	12600.00	MHrs.
Estimate at Completion (EAC) of performance	21000.00	MHrs.
Original Productivity		
ETC = Budget x Remaining percentage		
EAC = AC + ETC		
Estimate to Completion (ETC) of cost	5,400,000.00	Dhs
Estimate at Completion (EAC) of cost	9,310,000.00	Dhs
Estimate to Completion (ETC) of performance	10800.00	MHrs.
Estimate at Completion (EAC) of performance	19200.00	MHrs.
Different Productivity		
Assumed SPI	1.20	
Assumed CPI	1.20	
Estimate to Completion (ETC) of cost	4,500,000.00	Dhs
Estimate at Completion (EAC) of cost	8,410,000.00	Dhs
Estimate to Completion (ETC) of performance	9000.00	MHrs.
Estimate at Completion (EAC) of performance	17400.00	MHrs.

The following Table 6.8 and the S-curve in Figure 6.1 show the details of the original plan with the future expectation according to the current productivity and the recommended scenario to make up for the delay and extra cost of the first 14 weeks of the project construction duration.

month	1	2	3	4	5	6	7	8	9	10	11	12	13	14
estimation cost per week	100000	150000	170000	190000	200000	200000	200000	250000	250000	250000	566000	566000	566000	542000
estimation cumulative	100000	250000	420000	610000	810000	1010000	1210000	1460000	1710000	1960000	2526000	3092000	3658000	4200000
estimated completion %	1.1%	2.8%	4.7%	6.8%	9.0%	11.2%	13.4%	16.2%	19.0%	21.8%	28.1%	34.4%	40.6%	46.7%

month	1	2	3	4	5	6	7	8	9	10	11	12	13	14
actual cost per week	90000	110000	170000	190000	190000	180000	190000	240000	230000	250000	500000	500000	550000	520000
actual cumulative	90000	200000	370000	560000	750000	930000	1120000	1360000	1590000	1840000	2340000	2840000	3390000	3910000
actual completion %	1%	2%	4%	6%	8%	10%	12%	15%	18%	20%	26%	32%	38%	43%

month	1	2	3	4	5	6	7	8	9	10	11	12	13	14
estimation MHr per week	600	600	600	600	600	600	600	600	600	600	600	600	600	600
estimation cumulative	600	1200	1800	2400	3000	3600	4200	4800	5400	6000	6600	7200	7800	8400
estimated completion %	3.3%	6.7%	10.0%	13.3%	16.7%	20.0%	23.3%	26.7%	30.0%	33.3%	36.7%	40.0%	43.3%	46.7%

month	1	2	3	4	5	6	7	8	9	10	11	12	13	14
actual MHr per week	600	600	600	600	600	600	600	600	600	600	600	600	600	600
cumulative	600	1200	1800	2400	3000	3600	4200	4800	5400	6000	6600	7200	7800	8400
actual completion %	3.33%	6.67%	10.00%	13.33%	16.67%	20.00%	23.33%	26.67%	30.00%	33.33%	36.67%	40.00%	43.33%	46.67%

cost at 1.2 CPI														
month	1	2	3	4	5	6	7	8	9	10	11	12	13	14
actual per week	90000	110000	170000	190000	190000	180000	190000	240000	230000	250000	500000	500000	550000	520000
cumulative	90000	200000	370000	560000	750000	930000	1120000	1360000	1590000	1840000	2340000	2840000	3390000	3910000
completion %	1%	2%	4%	6%	8%	10%	12%	15%	18%	20%	26%	32%	38%	43%

performance at 1.2 SPI														
month	1	2	3	4	5	6	7	8	9	10	11	12	13	14
expected per week	600	600	600	600	600	600	600	600	600	600	600	600	600	600
expected cumulative	600	1200	1800	2400	3000	3600	4200	4800	5400	6000	6600	7200	7800	8400
completion %	3.3%	6.7%	10.0%	13.3%	16.7%	20.0%	23.3%	26.7%	30.0%	33.3%	36.7%	40.0%	43.3%	46.7%

15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
590000	566000	566000	566000	566000	566000	200000	190000	150000	150000	150000	120000	120000	100000	100000	100000
4790000	5356000	5922000	6488000	7054000	7620000	7820000	8010000	8160000	8310000	8460000	8580000	8700000	8800000	8900000	9000000
53.2%	59.5%	65.8%	72.1%	78.4%	84.7%	86.9%	89.0%	90.7%	92.3%	94.0%	95.3%	96.7%	97.8%	98.9%	100.0%

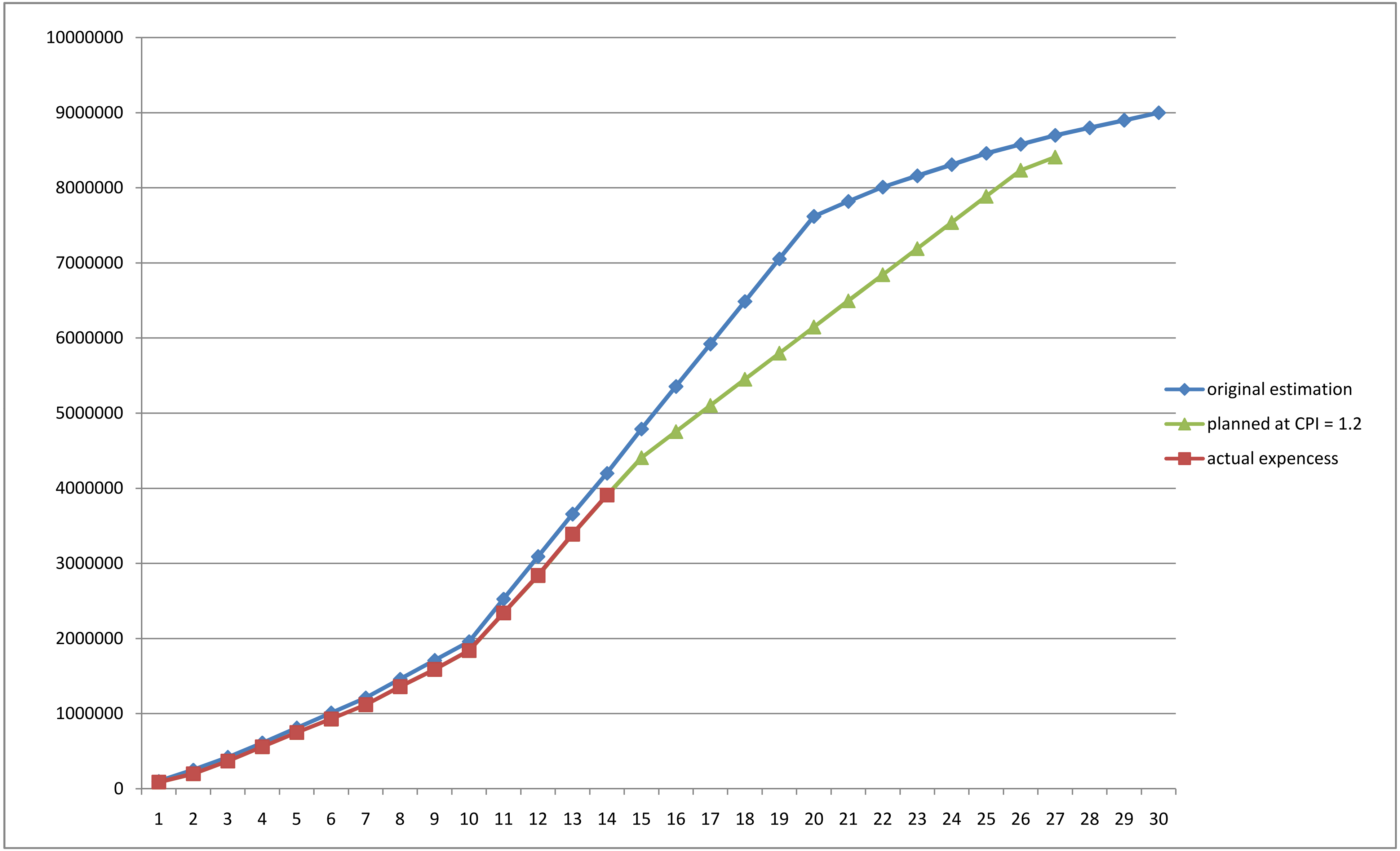
15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600
9000	9600	10200	10800	11400	12000	12600	13200	13800	14400	15000	15600	16200	16800	17400	18000
50.0%	53.3%	56.7%	60.0%	63.3%	66.7%	70.0%	73.3%	76.7%	80.0%	83.3%	86.7%	90.0%	93.3%	96.7%	100.0%

15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
498000	348000	348000	348000	348000	348000	348000	348000	348000	348000	348000	348000	174000			
4408000	4756000	5104000	5452000	5800000	6148000	6496000	6844000	7192000	7540000	7888000	8236000	8410000			
52%	57%	61%	65%	69%	73%	77%	81%	86%	90%	94%	98%	100%			

15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
720	720	720	720	720	720	720	720	720	720	720	720	360			
9120	9840	10560	11280	12000	12720	13440	14160	14880	15600	16320	17040	17400			
52.4%	56.6%	60.7%	64.8%	69.0%	73.1%	77.2%	81.4%	85.5%	89.7%	93.8%	97.9%	100.0%			


original estimation
planned at CPI = 1.2
actual expencess

6.3.4 Case 2 Conclusion:

As illustrated in this case study, the processes of project control and monitoring utilizing the earned value analysis enable the project planners to better evaluate the execution stage of the project. As well, it will make the project personnel aware of the current productivity status and compare it with the original plans. Thus, it can be used as an early alarm system to warn the project personnel prior to the appearance of any cost overruns and schedule delays. In addition, this approach will enable the project personnel forecast the time and cost estimation at the project completion.

It should be evoked that the statistical analysis showed that the Cost and Time Control variable correlates with both, the time enhancement and cost enhancement. Although, the qualitative study showed huge dissatisfaction and negative responses to the utilized control processes. However, the regression test showed that the control practises affect the variation of the time and costs enhancements. All in all, the earned value analysis is essential to be practiced to fill the missing gap of the control processes utilized by the concerned authorities.

6.4 Case Study 3: Road Construction Project

The third project case is about project's teams and personnel evaluation as part of the project control and monitoring process. In this case, the techniques of proper project human monitoring, using the concepts of Earned Value, are illustrated. Then, the appropriate evaluation process for the of projects resources and teams is practised utilizing the Human Performance Index. For this case, a portion of a road construction project is studied and represented.

6.4.1 Resources Distribution:

To illustrate human performance index development, a project portion, of a road construction project, composed of 20 different work packages is considered. This specific task is planned to be performed by five resources in two teams. Resources 1, 2, and 3 belong to Team A and the resources 4 and 5 to Team B, respectively. In Table 6.9, a distribution of the resources in the work packages is shown.

Table 6.9 : Resources Distribution of the Work Packages

	Resource 1	Resource 2	Resource 3	Resource 4	Resource 5	Team A	Team B
Package 1	x		x		x	√	√
Package 2		x	x		x	√	√
Package 3				x			√
Package 4	x	x	x	x		√	√
Package 5			x		x	√	√
Package 6			x		x	√	√
Package 7	x		x			√	
Package 8	x	x	x			√	
Package 9		x		x		√	√
Package 10		x		x	x	√	√
Package 11		x	x		x	√	√
Package 12	x		x			√	
Package 13				x			√
Package 14	x		x	x		√	√
Package 15		x	x		x	√	√
Package 16				x	x		√
Package 17	x		x	x		√	√
Package 18				x			√
Package 19	x				x	√	√
Package 20		x	x		x	√	√

6.4.2 Resources Evaluation:

At a certain time period during the project execution, the package performance inputs were evaluated. The results are shown in Table 6.10, with BCWS, BCWP and ACWP inputs for each work package.

Table 6.10 : Work Packages Evaluation

	% Complete	Budget	BCWS	BCWP	ACWP
Package 1	25%	4,000.00	1,250.00	1,000.00	1,200.00
Package 2	50%	2,400.00	1,320.00	1,200.00	1,000.00
Package 3	100%	2,240.00	2,240.00	2,240.00	2,650.00
Package 4	75%	1,400.00	1,100.00	1,050.00	1,260.00
Package 5	25%	2,400.00	980.00	600.00	980.00
Package 6	50%	1,160.00	560.00	580.00	550.00
Package 7	75%	1,600.00	1,450.00	1,200.00	1,960.00
Package 8	25%	6,400.00	1,670.00	1,600.00	1,920.00
Package 9	100%	3,450.00	3,450.00	3,450.00	4,000.00
Package 10	75%	2,800.00	2,010.00	2,100.00	1,950.00
Package 11	25%	5,000.00	1,230.00	1,250.00	1,250.00
Package 12	50%	5,000.00	2,550.00	2,500.00	3,000.00
Package 13	25%	17,000.00	4,560.00	4,250.00	4,000.00
Package 14	50%	2,400.00	1,200.00	1,200.00	1,350.00
Package 15	100%	450.00	450.00	450.00	450.00
Package 16	75%	400.00	340.00	300.00	300.00
Package 17	25%	6,200.00	1,810.00	1,550.00	1,860.00
Package 18	100%	1,450.00	1,450.00	1,450.00	1,350.00
Package 19	50%	2,600.00	1,100.00	1,300.00	1,200.00
Package 20	25%	3,000.00	820.00	750.00	900.00
Project	42%	71,350.00	31,540.00	30,020.00	33,130.00

Afterwards, the Human Performance Index (HPI) of each one of the resources was obtained, as well as the HPI of each of the teams. Finally, the total HPI of the project is calculated as shown in Table 6.11.

Table 6.11 : Project and Resources HPI Calculation

Resource	BCWS	BCWP	ACWP	CPI	SPI	% Complete	HPI
Resource 1	12,130.00	11,400.00	13,750.00	0.83	0.94	38.51%	0.90
Resource 2	12,050.00	11,850.00	12,730.00	0.93	0.98	47.59%	0.96
Resource 3	16,390.00	14,930.00	17,680.00	0.84	0.91	36.05%	0.89
Resource 4	18,160.00	17,590.00	18,720.00	0.94	0.97	47.11%	0.95
Resource 5	10,060.00	9,530.00	9,780.00	0.97	0.95	39.36%	0.96
Team	**BCWS**	**BCWP**	**ACWP**	**CPI**	**SPI**	**% Complete**	**HPI**
Team 1	22,950.00	21,780.00	24,830.00	0.88	0.95	43.33%	0.92
Team 2	25,870.00	24,720.00	26,250.00	0.94	0.96	42.37%	0.95
Total	**BCWS**	**BCWP**	**ACWP**	**CPI**	**SPI**	**% Complete**	**HPI**
	31,540.00	30,020.00	33,130.00	0.91	0.95	42.07%	0.93

Then, the Human Performance Index (HPI) was calculated for each of the project's resources and teams as shown in Table 6.12.

Table 6.12 : HPI for Project's Resources and Teams

Resource	$HPI_{Individual}$	HPI_{Team}	$HPI_{Project}$
Resource 1	0.9	0.92	0.93
Resource 2	0.96	0.92	0.93
Resource 3	0.89	0.92	0.93
Resource 4	0.95	0.95	0.93
Resource 5	0.96	0.95	0.93

Finally, resources can be evaluated based on the different focus distributions as shown in Table 6.13. Subsequently, Table 6.14 illustrates the final HPI of each resource for the individual, team, project, and the balance profiles of the analysis focus.

Table 6.13 : Weight Distribution for the HPI Resource Composition. Adapted from Vargas (2005)

	$\text{Weight}_{\text{Individual}}$	$\text{Weight}_{\text{Team}}$	$\text{Weight}_{\text{Project}}$
Individual Focus	60	20	20
Team Focus	20	60	20
Project Focus	20	20	60
Balanced Focus	40	30	30

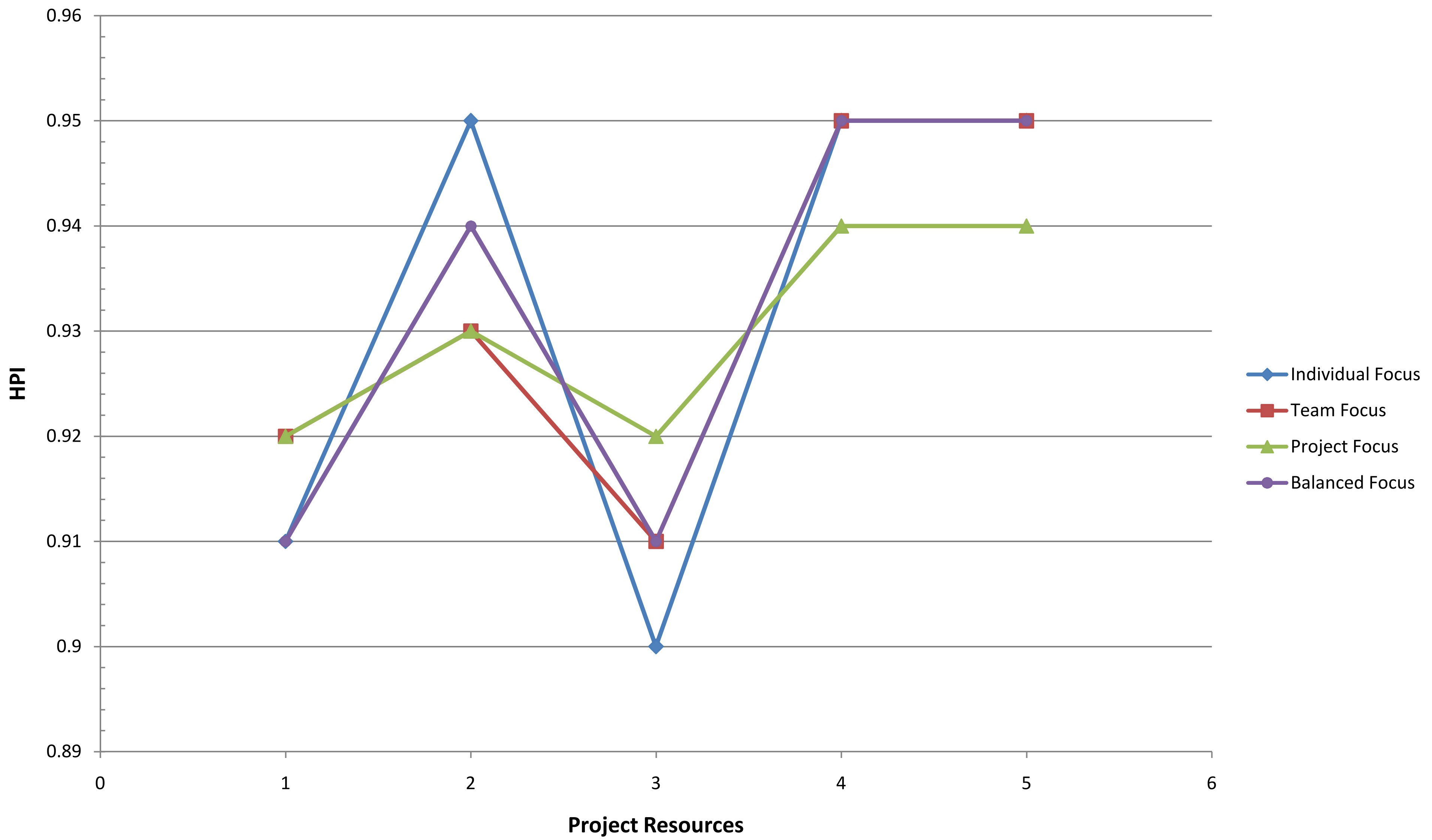
Table 6.14 : Resource Final HPI for each of the Analysis Focuses

HPI	Individual Focus	Team Focus	Project Focus	Balanced Focus
Resource 1	0.91	0.92	0.92	0.91
Resource 2	0.95	0.93	0.93	0.94
Resource 3	0.9	0.91	0.92	0.91
Resource 4	0.95	0.95	0.94	0.95
Resource 5	0.95	0.95	0.94	0.95

6.4.3 HPI Exercise Findings:

From the obtained HPI values, the outcomes of each one of the resources and its contribution for the project and team outcome can be determined as shown in Figure 6.2. it can be concluded that resources 1 and 3 showed a performance lower than their team and project; resource 2 showed a higher individual performance. Nevertheless, the analysis showed that the performance of Team A was damaged by the weak performance of resources 1 and 3. On the other hand, resources 4 and 5 showed a high performance that increased the total performance of Team B. The project performance was lower than the 4 and 5 resources performance and Team B. This was because the members of Team A lowered the global performance by their weak individual performances.

Figure 6.2: Different HPI of Project Resources



6.4.4 Case 3 Conclusion:

As illustrated in this case study, the processes of project control and monitoring utilizing the Human Performance enable the project planners to better evaluate the performances of the project's resources. As well, it will make the project personnel aware of the current productivity status of the project's personnel and compare it with the original plans. Thus, it can be used as an early alarm system to warn the project personnel prior to the appearance of any cost overruns and schedule delays.

It should be highlighted that the statistical analysis showed that the Control variable correlates with both, the time enhancement and cost enhancement. In addition, the regression test showed that the control practises affect the variation of the time and costs enhancements However, the qualitative study showed huge dissatisfaction and negative responses to the utilized control processes. Subsequently, the practices associated with the Human Performance Evaluation are required to be utilized in order to fill the missing gap of the control processes utilized by the concerned authorities.

6.5 Case Study 4: Power Plant Project

The Fourth project case is about activities acceleration methods and schedule crashing techniques as part of the project crises mitigation process. In here, the concepts of project acceleration are practised to shorten the project schedule. Then, the processes of penalties and bonuses are illustrated. Consequently, the project time/cost optimization practice if comprehensively implemented and represented. Thus, the principle of crises mitigation is expansively practised and well demonstrated. This particular case deals with a power plant project which is needed to be accelerated in order to be accomplished on soonest.

One of the major projects in the strategic plan of Abu Dhabi 2030 is the development project of Al Raha Beach. This project was initiated to be heavily relied on. That is because it is one of the hugest projects in Abu Dhabi and it is planned to be accomplished as soon as possible to solve the problem of accommodation shortage problem in Abu Dhabi. This development project consists of all infrastructure projects as well as the superstructure projects. One mega part of this project is the new Power Plant Project (PPP) that would be accomplished by ADWEA. Other than the technical perspective of the PPP, the high importance of completion this project was for two reasons. First, it was found that the PPP is the critical project in the infrastructure stage of the development project, which means that the accomplishment of all infrastructure works is dependent on it. Secondly and more importantly, the superstructure stage of the development project can't be started unless the PPP particularly is been commissioned due to the need of power supply during construction.

After the highly importance of the PPP to be delivered as soon as possible appeared, it is suggested for ADM to offer bonuses of 0.1% per week (80,000 Dhs/week) on early commissioning of the project. As well, ADM to force penalty cost of the same amount on late commissioning. This technique would encourage companies to accomplish their sub projects on time, if not earlier.

6.5.1 Activities Acceleration and Schedule Crashing:

For the case of PPP, the WBS should be developed for the whole activities of the project as well as the duration and the cost of each particular activity. Next, the relationships among activities are needed to be identified in order to develop the project network of the PPP.

Table 6.15 is presenting below all the major activities of the PPP as well as the duration, cost and predecessors associated with all activities.

Table 6.15: Activities Information

	Activity Name	Duration in months	Predecessor	Cost* in Dhs
1	Land Acquisition	6		7000000
2	Mobilization	1	1	4500000
3	Identification of trained personnel in other agencies	3	2	850000
4	Land development and infrastructure	2	1	3400000
5	Systems and Engineering for Control Room	12	1	3400000
6	Lag in Turbine Civil Works	8	1	910000
7	Delivery of TG	12	3	17600000
8	Delivery of Boiler Components	10	1	21000000
9	Joining time for personnel from other agencies	3	3	1340000
10	Boiler preliminary civil works	2	4	1020000
11	Civil works control room	5	5,3	1140000
12	Civil works for TG	9	6	2040000
13	Training at collaborator's end	6	9	340000
14	Final civil works boiler	9	10	3740000
15	Erection of control room equipment	8	11	425000
16	Erection of TG	10	7,12	4760000
17	Boiler erection	12	8,14	13600000
18	Hydraulic test	2	17	825000
19	Boiler light up	1.5	15,18	850000
20	Box up of turbine	3	16	850000
21	Steam blowing and safety valve floating	2.5	19,20	1020000
22	Rolling of turbine	1.5	16	880000
23	Trial run	1	22	660000
24	Synchronization	1	23,21	1680000

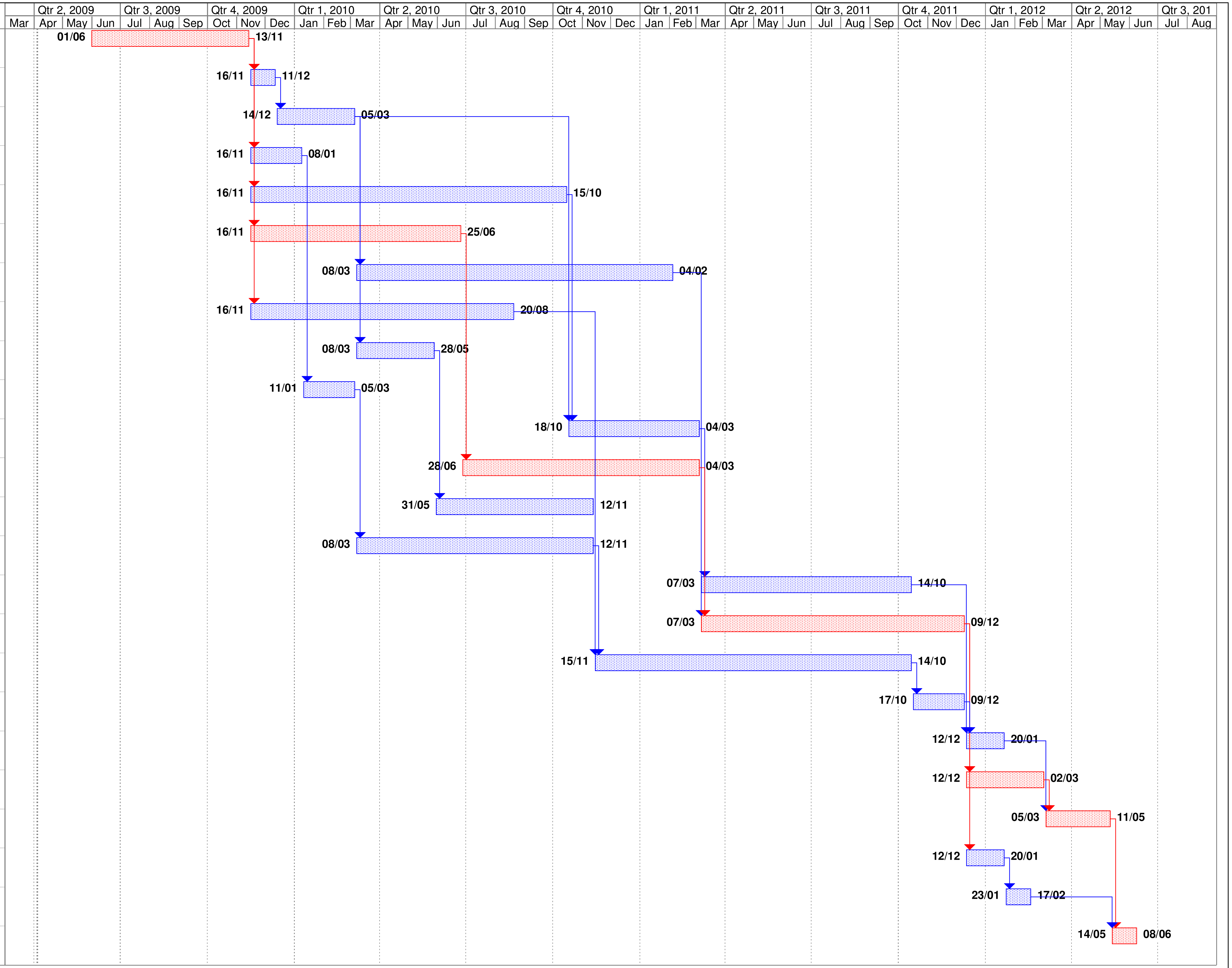
*costs are approximated due to job confidentialities

After that, the first step in determining the optimum duration for a project is to prepare a network schedule and an estimate for the project to define the normal cost for the project. By using the Microsoft Project software, the project plan can be initiated as shown in Table 6.16. As well the Gantt chart of the project is developed and the Critical Path was identified in the project Gant Chart shown in Figure 6.3. Finally, the project network was instigated as in Figure 6.4.

Table 6.16: Activities Plan

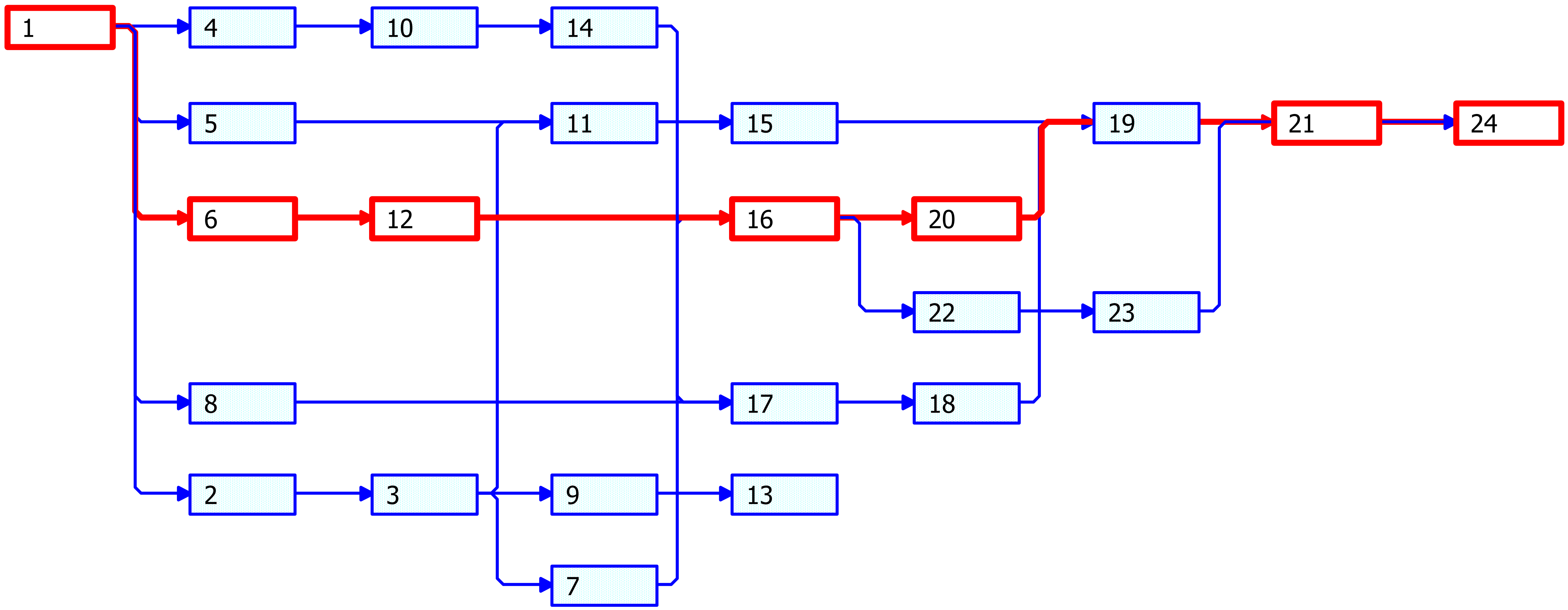
Task Name	Original Duration	Early Start	Early Finish
Land Acquisition	6 mons	01/06/2009 08:00	13/11/2009 17:00
Mobilization	1 mon	16/11/2009 08:00	11/12/2009 17:00
Identification of trained personnel in other agencies	3 mons	14/12/2009 08:00	05/03/2010 17:00
Land development and infrastructure	2 mons	16/11/2009 08:00	08/01/2010 17:00
Systems and Engineering for Control Room	12 mons	16/11/2009 08:00	15/10/2010 17:00
Lag in Turbine Civil Works	8 mons	16/11/2009 08:00	25/06/2010 17:00
Delivery of TG	12 mons	08/03/2010 08:00	04/02/2011 17:00
Delivery of Boiler Components	10 mons	16/11/2009 08:00	20/08/2010 17:00
Joining time for personnel from other agencies	3 mons	08/03/2010 08:00	28/05/2010 17:00
Boiler preliminary civil works	2 mons	11/01/2010 08:00	05/03/2010 17:00
Civil works control room	5 mons	18/10/2010 08:00	04/03/2011 17:00
Civil works for TG	9 mons	28/06/2010 08:00	04/03/2011 17:00
Training at collaborator's end	6 mons	31/05/2010 08:00	12/11/2010 17:00
Final civil works boiler	9 mons	08/03/2010 08:00	12/11/2010 17:00
Erection of control room equipment	8 mons	07/03/2011 08:00	14/10/2011 17:00
Erection of TG	10 mons	07/03/2011 08:00	09/12/2011 17:00
Boiler erection	12 mons	15/11/2010 08:00	14/10/2011 17:00
Hydraulic test	2 mons	17/10/2011 08:00	09/12/2011 17:00
Boiler light up	1.5 mons	12/12/2011 08:00	20/01/2012 17:00
Box up of turbine	3 mons	12/12/2011 08:00	02/03/2012 17:00
Steam blowing and safety valve floating	2.5 mons	05/03/2012 08:00	11/05/2012 17:00
Rolling of turbine	1.5 mons	12/12/2011 08:00	20/01/2012 17:00
Trial run	1 mon	23/01/2012 08:00	17/02/2012 17:00
Synchronization	1 mon	14/05/2012 08:00	08/06/2012 17:00

ID	Task Name
1	Land Acquisition
2	Mobilization
3	Identification of trained personnel in other agencies
4	Land development and infrastructure
5	Systems and Engineering for Control Room
6	Lag in Turbine Civil Works
7	Delivery of TG
8	Delivery of Boiler Components
9	Joining time for personnel from other agencies
10	Boiler preliminary civil works
11	Civil works control room
12	Civil works for TG
13	Training at collaborator's end
14	Final civil works boiler
15	Erection of control room equipment
16	Erection of TG
17	Boiler erection
18	Hydraulic test
19	Boiler light up
20	Box up of turbine
21	Steam blowing and safety valve floating
22	Rolling of turbine
23	Trial run
24	Synchronization

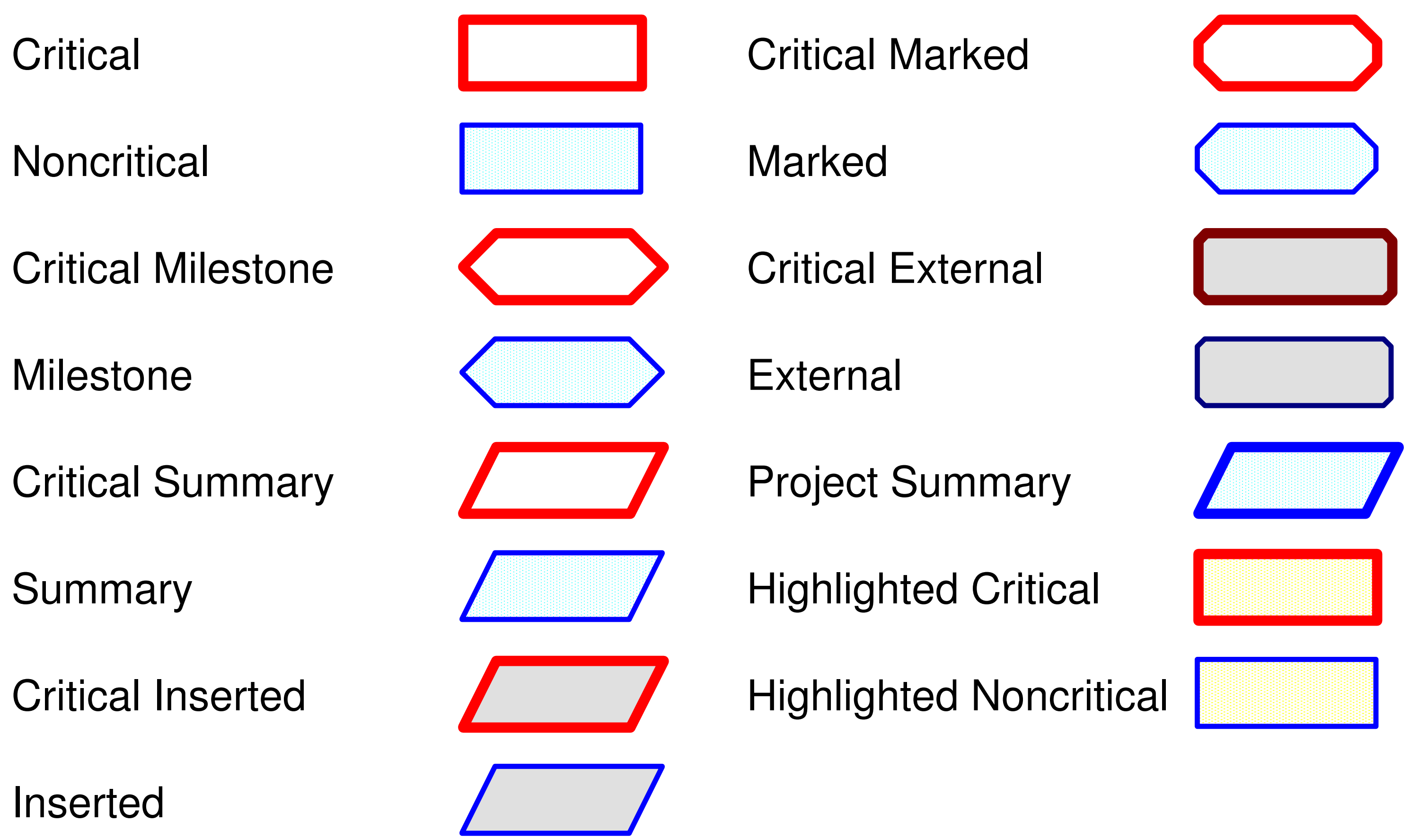


Project: PPP
Title: Project Plan
Student ID: 70103

Task | Critical Task | Progress | Milestone | Summary | Rolled Up Task | Rolled Up Critical Task | Rolled Up Milestone | Rolled Up Progress | Split | External Tasks | Project Summary | Group By Summary | Deadline



Project: PPP
Title: Project Network
Student ID: 70103



After finalizing all the original project plans requirements of the concerned project, the next step would be to study intensively all the activities that would be able to be crushed as well as the duration each activity can be accelerated by with the associated cost. Table 6.17 bellow shows all information regarding activities that could be crashed.

Table 6.17: Crashable Activities

	Activity Name	Original Duration	Cost* in Dhs	Crashable Time	Cost* in Dhs/ Week
1	Land Acquisition	6 months	7000000		
2	Mobilization	1 month	4500000	1 week	300,000
3	Identification of trained personnel in other agencies	3 months	850000	2 week	60,000
4	Land development and infrastructure	2 months	3400000		
5	Systems and Engineering for Control Room	12 months	3400000		
6	Lag in Turbine Civil Works	8 months	910000	5 week	60,000
7	Delivery of TG	12 months	17600000		
8	Delivery of Boiler Components	10 months	21000000		
9	Joining time for personnel from other agencies	3 months	1340000	3 week	105,000
10	Boiler preliminary civil works	2 months	1020000		
11	Civil works control room	5 months	1140000	4 week	135,000
12	Civil works for TG	9 months	2040000	4 week	120,000
13	Training at collaborator's end	6 months	340000.0		
14	Final civil works boiler	9 months	3740000	4 weeks	165,000
15	Erection of control room equipment	8 months	425000		
16	Erection of TG	10 months	4760000	8 week	110,000
17	Boiler erection	12 months	13600000		
18	Hydraulic test	2 months	825000	2 weeks	60,000
19	Boiler light up	1.5 months	850000		
20	Box up of turbine	3 months	850000		
21	Steam blowing and safety valve floating	2.5 months	1020000	2 weeks	100,000
22	Rolling of turbine	1.5 months	880000		
23	Trial run	1 month	660000	1 week	90,000
24	Synchronization	1 month	1680000	1 week	135,000

*costs are approximated due to job confidentialities

The next stage that is needed to complete the project optimization is to calculate the Company's overhead cost saving per week due to shortening the total duration of the project. Table 6.18 bellow briefly represents the overhead costs per week.

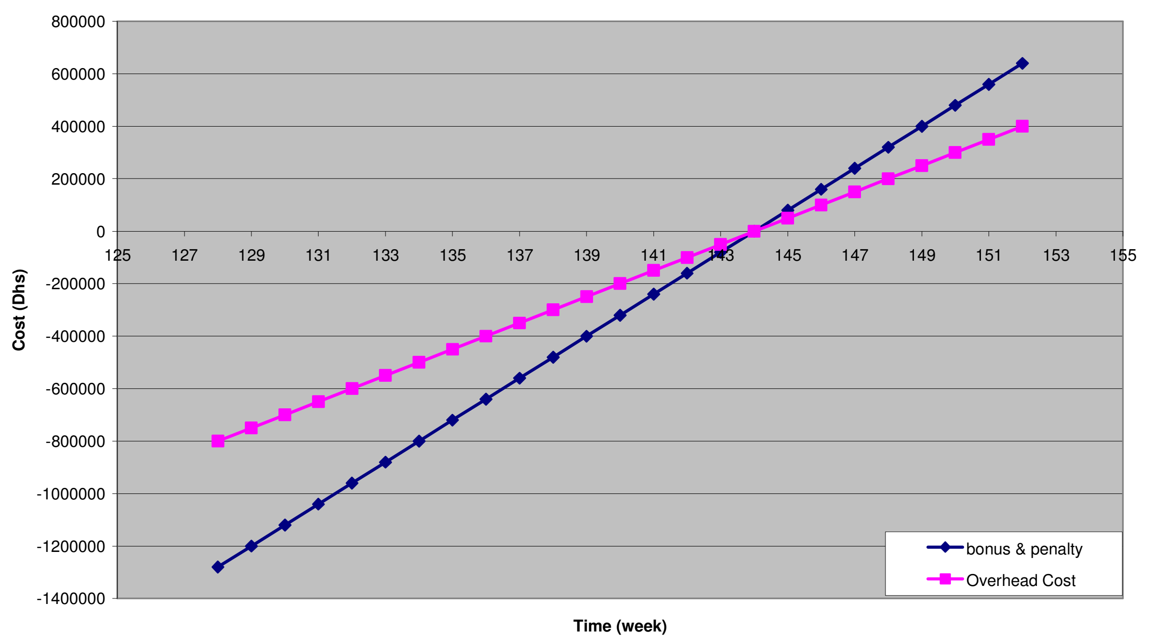
Table 6.18, The Indirect Overhead Cost Saving*

Field Supervision	18,000 Dhs per week
Field Office and Supplies	8,000 Dhs per week
Field Equipment	10,000 Dhs per week
Home Office Support	14,000 Dhs per week
Total	**50,000 Dhs per week**

*costs are approximated due to job confidentialities

As well, Figure 6.5 shows the penalty cost and the bonus savings as well as overhead cost saving per week taking in consideration that the original planned duration is 3 years (144 weeks)

Figure 6.5: Bonus, Penalty and Overhead Costs



After the calculation of the indirect cost curve is accomplished; the direct cost calculation is derived as follow. Shortening the project by crashing one or more activities requires that at least one critical activity be accelerated. Activities that shorten the duration of the least cost are the logical first choice. Logistically, if the cost of accelerating these activities is less than the indirect cost, the crashing makes sense.

Table 6.19 bellow shows the calculation of activities crashing up to the maximum crash duration. It should be mentioned that after every crashing the project by 1 week, the critical path should be recalculated. Finally, in case more than one critical path appeared, activity on every critical path should be shortened at the same time.

Table 6.19: Calculation of Activities Crashing

Stage 1	
Critical Path	1-6-12-16-20-21-24
Activity to be expedited	6 up to 4 weeks
Increase in Direct Cost	60,000 x 4 = 240,000
New Direct Cost	94070000
New Duration	140 weeks

Stage 2	
New Critical Path	1-6-12-16-20-21-24 & 1-2-3-7-16-20-21-24
Activity to be expedited	16 up to 4 weeks
Increase in Direct Cost	110,000 x 4 = 440,000
New Direct Cost	94510000
New Duration	136 weeks

Stage 3	
New Critical Path	1-4-10-14-17-18-19-20-21-24
Activity to be expedited	18 up to 2 weeks
Increase in Direct Cost	60,000 x 2 = 120,000
New Direct Cost	94630000
New Duration	134 weeks

Stage 4	
New Critical Path	1-4-10-14-17-18-19-20-21-24
Activity to be expedited	21 up to 2 weeks
Increase in Direct Cost	100,000 x 2 = 200,000
New Direct Cost	94830000
New Duration	132 weeks

Stage 5	
New Critical Path	1-4-10-14-17-18-19-20-21-24
Activity to be expedited	24 by 1 week
Increase in Direct Cost	135,000 x 1 = 135,000
New Direct Cost	94965000
New Duration	131 weeks

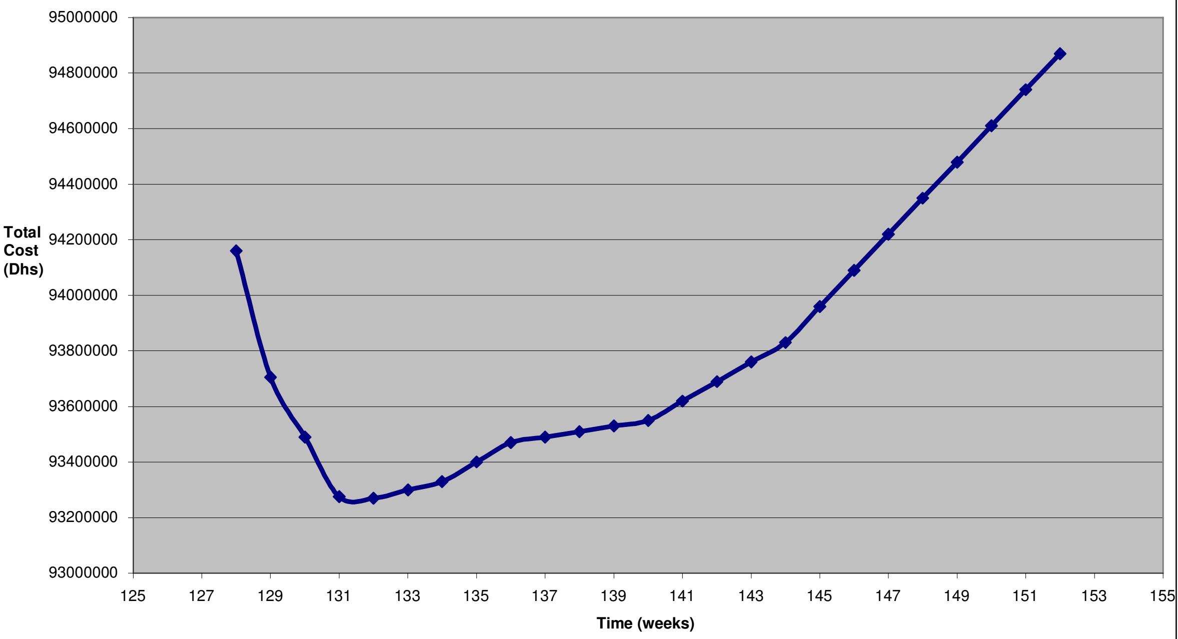
Stage 6	
New Critical Path	1-2-3-7-16-20-21-24 & 1-4-10-14-1718-19-21-24 & 1-6-12-16-20-21-24
Activity to be expedited	3, 12 & 14 up to 2 weeks
Increase in Direct Cost	(60,000 + 120,000 + 165,000) x 2 = 690,000
New Direct Cost	95655000
New Duration	129 weeks

Stage 7	
New Critical Path	1-2-3-7-16-20-21-24 & 1-4-10-14-1718-19-21-24 & 1-6-12-16-20-21-24
Activity to be expedited	2, 12 & 14 up to 1 week
Increase in Direct Cost	(300,000 + 120,000 + 165,000) x 1 = 585,000
New Direct Cost	96240000
New Duration	128 weeks

6.5.2 Recommendations

As appeared, when the project is run at the normal duration of 3 years (144 weeks), the total cost for the project is 93,830,000 Dhs. At the minimum duration of the project, the total cost would be 94160000 Dhs when the total duration became 128 weeks. Figure 6.6, shows the fluctuation of total cost that combines the direct and indirect cost after crashing activates.

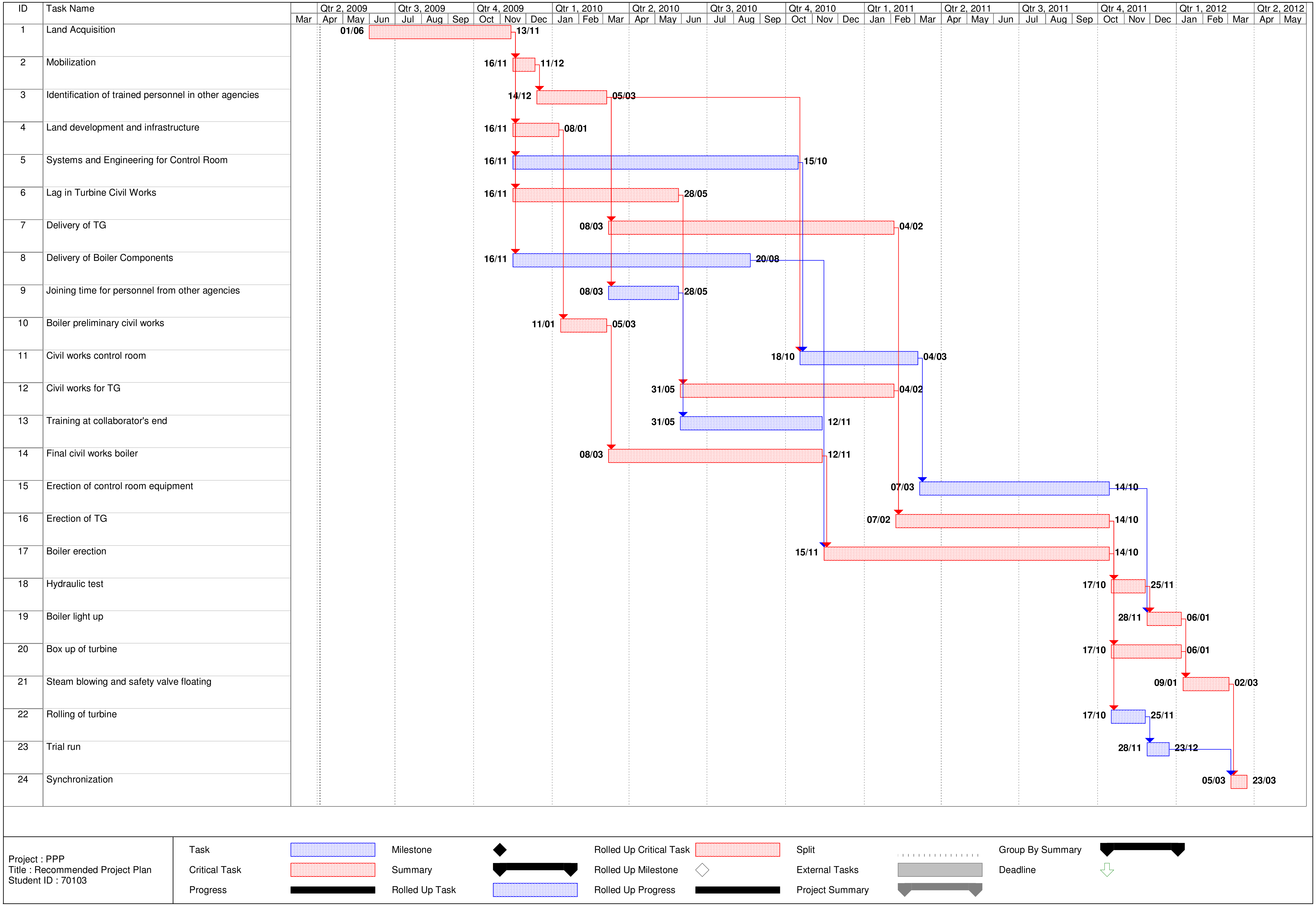
Figure 6.6: Total Cost vs Time



As noted by the lowest point on the graph shown in figure 4, the project's optimum duration is 131 weeks, at a cost of 93275000 Dhs. So it is recommended for this project to be shortened to 131 weeks by crashing the following activities as presented in Table 6.20. As well, Figure 6.7 shows the recommended project plan.

Table 6.20: Recommended Activities to be Crashed

Activity No	Activity Name	Recommended Crashing Duration
6	Lag in Turbine Civil Works	4 weeks
16	Erection of TG	4 weeks
18	Hydraulic test	2 weeks
21	Steam blowing and safety valve floating	2 weeks
24	Synchronization	1 week


ID
Task Name
Qtr 2, 2009
Qtr 3, 2009
Qtr 4, 2009
Qtr 1, 2010
Qtr 2, 2010
Qtr 3, 2010
Qtr 4, 2010
Qtr 1, 2011
Qtr 2, 2011
Qtr 3, 2011
Qtr 4, 2011
Qtr 1, 2012
Qtr 2, 2012
Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May
1 Land Acquisition 01/06 13/11
2 Mobilization 16/11 11/12
3 Identification of trained personnel in other agencies 14/12 05/03
4 Land development and infrastructure 16/11 08/01
5 Systems and Engineering for Control Room 16/11 15/10
6 Lag in Turbine Civil Works 16/11 28/05
7 Delivery of TG 08/03 04/02
8 Delivery of Boiler Components 16/11 20/08
9 Joining time for personnel from other agencies 08/03 28/05
10 Boiler preliminary civil works 11/01 05/03
11 Civil works control room 18/10 04/03
12 Civil works for TG 31/05 04/02
13 Training at collaborator's end 31/05 12/11
14 Final civil works boiler 08/03 12/11
15 Erection of control room equipment 07/03 14/10
16 Erection of TG 07/02 14/10
17 Boiler erection 15/11 14/10
18 Hydraulic test 17/10 25/11
19 Boiler light up 28/11 06/01
20 Box up of turbine 17/10 06/01
21 Steam blowing and safety valve floating 09/01 02/03
22 Rolling of turbine 17/10 25/11
23 Trial run 28/11 23/12
24 Synchronization 05/03 23/03
Project : PPP
Title : Recommended Project Plan
Student ID : 70103
Task
Critical Task
Progress
Milestone
Summary
Rolled Up Task
Rolled Up Critical Task
Rolled Up Milestone
Rolled Up Progress
Split
External Tasks
Project Summary
Group By Summary
Deadline

6.5.3 Case 4 Conclusion:

As illustrated in this case study, applying the concepts of project crises mitigation enables the project personnel to better react at the situations of cost overruns and schedule delays appearance. Utilizing the methodologies for activity acceleration along with the techniques of schedule crashing enables the project personnel to shorten the project schedule. Then, by using the concept of schedule/budget optimization, results in finding the optimum duration to shorten the schedule with respect to cost. In addition, the reward/penalty systems lead to motivate the project contractors stick to the original plans and estimations.

It should be evoked that the statistical analysis showed that the Contingency Planning variable correlates with both, the time enhancement and cost enhancement. Although, the qualitative study's responses expressed that the contingency planning is not utilized within the infrastructure authorities, the regression test showed that the contingency planning affects the variation of the time and costs enhancements. All in all, the techniques of contingency planning are needed to fill the missing processes of mitigation the cost overruns and schedule delays.

7.0 <u>Research Conclusion and Study Continuation:</u>

7.1 Research Conclusion:

In this research, the frequent problems of cost overruns and schedule delays have been studied. The government authorities responsible for the infrastructures in Abu Dhabi/UAE are repeatedly suffering from these problems. This research study showed that more than 93% of the development projects were completed with cost enhancement of an average of almost 8.7% more than their original budgeted cost. Moreover, the study showed that more than 90% of the development projects reviewed executed with delays of an average of 8.3% longer than their planned duration. That would mean that an average of 6.44 million dirhams are being added to the budget of each project during execution with an average of 1 month of delay. So, this research study focused on the development infrastructure projects that have been executed in Abu Dhabi/UAE, with the aim of overcoming the problems of cost overruns and schedule delays.

In order to understand the problem and resolve it, the concept of project crisis management was studied with an extensive literature review. All kinds of project crises were introduced, along with the common identified reasons that lead to cost overruns and schedule delays. Then, the principles of project planning and monitoring were examined in order to understand the available techniques proposed by other researches that aim to adhere to original project budgets and plans. The research proceeded to cover the theories of project crisis mitigation and the techniques of project crashing. This part of the literature review aimed to cover all associated techniques and procedures to better plan the projects, monitor the execution of the project, and mitigate crisis.

After studying all topics related to the identified problems of this study, focused analysis was followed to investigate the current practises and techniques utilized by the government authorities in Abu Dhabi. Firstly, qualitative research was carried out by interviewing personnel from all the authorities included in the scope of this study. In these interviews, all the drawbacks of the existing procedures and practises were highlighted, analysed and discussed. It was mainly found that the concerned authorities have problems in identifying the scopes in the initiation phases along with improper rules and responsibilities assignment. As well, the existing techniques utilized to plan the projects in terms of budget and schedules were found to be problematic, especially since the project life cycle concept was not properly considered. In addition, many drawbacks were noticed in the processes of monitoring the execution phases of the projects, which made it hard for the project personnel to keep track of the running projects. Above all, it was noticed that all authorities lack the proper contingency planning processes that would enable them to have a backup plan in case any crisis was faced.

Based on the findings of the qualitative study, quantitative research was conducted using the technique of questionnaire to investigate the main reasons behind crises and their influence on projects. The questionnaires were distributed to collect data about the concerned development projects that were executed in 2007, 2008 and 2009. In the questionnaires, two kinds of questions were asked: general questions about the characteristics of the development projects, and specific questions about the main reasons behind cost and time crises. Then, all the responses obtained were analysed statistically using the tools of reliability, correlation and regression. It was found that time enhancement and cost enhancement were correlated with all of the identified independent variables (scope identification, rules and responsibilities assignment, initial estimation, project control, technical aspects, and contingency planning). Furthermore, it was found that almost 88.6% of the variation in cost enhancement in the studied projects, and almost 84% of the variation in time enhancement can be explained by the variability in the independent variables studied.

Consequently, several essential recommendations are proposed to be implemented by the authorities. There are five types of recommendations that are required to be adopted in order to overcome the concerned problems of cost overruns and schedule delays. First, the concerned authorities should carefully watch their projects to continuously identify any new crisis reasons that would appear in the future. Thus, a repetitive exercise similar to this research is proposed to be undertaken frequently to highlight the main reasons behind project crises. Secondly, some planning and initiation techniques are proposed to be adopted by the authorities. These techniques are essential to better estimate the associated cost and duration of the project from the early stages. Therefore, it is recommended to utilize Monte Carlo simulation to achieve proper risk assessments. Additionally, it is emphasized that the authorities should account for the entire project life cycle cost when estimating a project's budget. The fuzzy concept is also recommended to enable the authorities to achieve proper planning of project duration.

Thirdly, project monitoring control techniques are proposed to ensure the project adheres to the plans throughout the execution phases. Mainly, the concept of project earned value management is recommended. This concept is required to have an exact idea about the project status during execution compared to the original plans and estimations. So, by utilizing the proposed schedule performance index along with the cost performance index, the authorities will be able to measure the performance of the project against the planned baselines. Also, another index is proposed, the human performance index. This is required to evaluate the performances of the personnel working on executing the projects.

Fourthly, some project crisis mitigation techniques are proposed to enable the authorities to control the situations of cost overruns and schedule delays. Through utilizing the proposed techniques of activities acceleration, the authorities will be able to expedite the execution of some activities. Next, schedule crashing principles are proposed to assist the projects' personnel to shorten the project duration along with adopting the concept of cost/duration optimization. After all, some general organizational practices are proposed to be adopted by the governmental authorities to make the processes of project management run more smoothly.

Finally, it should be highlighted that all proposed recommendations should be considered seriously. Spending on better project management techniques and procedures would be a very good investment for the concerned authorities. As it stands now, a great deal of time and money are being wasted. Infrastructure projects are being accomplished, but at costs far higher than originally planned and with schedules far longer than anticipated. Adopting the recommended techniques proposed by this study would require a small amount of initial investment, but would result in tremendous gains in both cost reduction and schedule adherence.

7.2 Study Continuation:

7.2.2 Research Limitation

This research project aimed to study the concept of project crisis management and apply its techniques to overcome the problems of schedule delays and cost overruns. The scope of this study covered the development infrastructure projects of the government authorities in Abu Dhabi. For reasons of time limitations and data accessibility, 63 projects that were executed in 2007, 2008, and 2009 were covered in this study. This study was mainly conducted to analyse these projects from the perspective of the government authorities, who are the main client responsible for the infrastructure in Abu Dhabi.

This dissertation focused on the technical practises of project management. All principles and techniques of planning, monitoring and control were studied. Additionally, the concepts of project crises and crises mitigation techniques were investigated and introduced. While, the business perspective of project management was not covered in this study, it is essential to be analysed and linked with the concept of project management. Management organization structures, management culture, and leadership style should also be analysed with regard to project management. This is because these fields are probably affecting the way in which the development projects are managed.

In this study, the problems of time and cost enhancement were the major focus. This is because schedule delays and cost overruns are frequent problems in development projects, as shown previously in the study. These problems were extensively studied, the reasons behind the problems were investigated, and many recommendations were proposed to overcome the problems. Yet, the quality of work in the development project is an area to be studied and investigated as well. This is because the standard of quality is required to be maintained along with adhering to cost and time. Furthermore, the effect of the recommended proposals on project quality is another area to be investigated.

Finally, it should be highlighted that in real-life practices, software applications are mainly used in the processes of planning, estimation and scheduling. The two most popular applications used around the world as well as within the concerned authorities are Primavera and Microsoft Project. Yet, both these applications lack the processes of project crises mitigation. Accordingly, the proposed techniques for mitigating the crises are required to be utilized by hand calculations and manual analysis. This would limit the integration of the management processes.

7.2.2 Recommended Future Studies:

In order to have a comprehensive study, the following topics are suggested to be studied in detail. The results and findings of these studies are essential to be combined with the findings and results of this dissertation.

- This study focused on the development projects carried on by the five government authorities, as illustrated in the study scope. Yet, this study should be repeated to focus on the individual projects of each of the authorities. These studies are needed for each of the authorities to assist in managing their own projects.
- The relationship of project crisis to project quality needs to be investigated and studied. This is because quality is one angle of the “project iron triangle” along with cost and time. There is a need to study the reasons and factors that might affect the quality of work, and how to mitigate them.
- The effects of the proposed recommendations on a project's quality should be investigated and addressed, as well. This is because the recommended proposals need to be applied without affecting the standard quality of work.
- An extensive study is required to focus on the concepts of life cycle costs. In this study, all the costs associated with a project should be studied from conceptualization to disposal. This study is required to assist planners and estimators to include in the project budget all associated costs of the project life cycle.
- A study, similar to this research, should be conducted to focus on the contractors and consultants. Then, all the results can be combined together to result in better management practises in all the parties working on the development projects.
- A study should be conducted to focus on the concept of leadership styles. The transformational leadership style is recommended to be investigated. In this style of leadership, the focus includes tasks along with the employees.
- The concepts of organizational structures and their effects on the projects need to be studied. This is because the organizational structure will most probably affect the management style of projects.
- Software development is needed to include the concept of project crises mitigation in management software applications. Although there are applications used for project management, at present, none of them apply the processes of accelerations and crashing.

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Appendix 1: Study Surveys

Date:

Dear Sir/ Madam,

We request you to use this questionnaire set to kindly provide your views on a wide range of issues related to the work conditions regarding Project Management processes. The main purpose of this questionnaire is to collect the primary data needed for an MSc dissertation research study titled “Project Crises Management Techniques to Overcome the Problems of Schedule Delays and Cost Overruns”.

The research studies the development projects being executed in the Emirate of Abu Dhabi, the Capital of the United Arab Emirates. Particularly, this dissertation aims to investigate the principles of Projects Crisis and to examine several techniques that can be used in planning, controlling and mitigation stages to overcome the problem of Schedule delays and Cost overruns. Consequently, a combination of techniques would be proposed to accelerate schedules and optimize budgets.

The questionnaire comprises 2 parts as following :

1. General information about the studied development projects
2. Study Variable Characteristics.

We assure you that all the data you provide will be handled, displayed and analysed with strict confidentiality. The results of the analysis will only be used for the research purposes.

Your response is highly valuable for us and we will be grateful for your time and effort in completing this questionnaire. We will be glad to share our research findings with you if you indicate to get the research output.

Thanks and Regards,

Mohammad Halloum

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Table 7 : Survey 1

SURVEY ONE: PROJECT GENERAL INFORMATION ***Please tick one box for each question:***	
A. Authorities Participated *(please tick more than one if required)***:**	
(1) ADWEA	( )
(2) ADSSC	( )
(3) Etisalat	( )
(4) Abu Dhabi Municipality	( )
(5) Town Planning	( )
B. Project Initial Status:	
(1) Normal	( )
(2) Urgent	( )
(3) Important	( )
C. Project Location:	
(1) Abu Dhabi Central Region	( )
(2) Abu Dhabi Eastern Region	( )
(3) Abu Dhabi Western Region	( )
D. Project Budget:	
(1) Less than 40 million AED	( )
(2) 40 - 60 million AED	( )
(3) 60 - 80 million AED	( )
(4) 80 - 100 million AED	( )
(5) Greater than 100 million AED	( )
E. Project Duration:	
(1) Less than 9 months	( )
(2) 9 - 12 months	( )
(3) 12 - 15 months	( )
(4) 15 - 18 months	( )
(5) Above 18 months	( )
F. Number of Variation Orders issued:	
(1) None	( )
(2) 1	( )
(3) 2	( )
(4) 3	( )
(5) 4 and Greater	( )
G. The Percentage of the Cost Enhancement at The Project Completion:	
(1) As Planned	( )
(2) < 5%	( )
(3) 5% - 10%	( )
(4) 10% - 15%	( )
(5) Greater than 15%	( )
H. The Extra Time required to Complete the Project:	
(1) As Planned	( )
(2) < 5%	( )
(3) 5% - 10%	( )
(4) 10% - 15%	( )
(5) Greater than 15%	( )

PART TWO: Variable Characteristics
Please tick one box for each item:

SA: Strongly agree; A: Agree; *N: Neither agree nor disagree;* *D: Disagree; SD: Strongly Disagree*	**SA**	**A**	**N**	**D**	**SD**
A. Scope Definition					
1. The project scope was well defined at the start of the project.					
2. The identified scope was shared with all involved parties from the beginning.					
3. There was an identified scope variation process in place.					
4. All the variations have been processed accordingly.					
5. The project team was able to identify the cumulative impact in time and cost of the variations.					
6. Actual plans were tracked against estimated impacts for variations.					
7. The project plan had been adjusted to cater for variations.					
B. Roles and Responsibilities Identifications and Parties Coordination					
8. Roles and responsibilities were clearly defined.					
9. They were accurate reflection of what is really happening.					
10. There was a communication plan in place.					
11. It was being implemented.					
12. All key stakeholders had been identified?					
13. The stakeholders were always being kept up to date.					
14. There were frequent progress meeting to gather all involved authorities' representatives?					
15. Each authority shared data about its part of the projects with other authorities.					
16. Teams of consultant and contractor were being well managed.					
17. There was a sense of cooperation within the project teams.					

C. Initial Estimations					
18. There was an up to date risk plan in place.					
19. Stakeholders had been involved in developing the plan.					
20. There were mitigation strategies in place, and were they being monitored.					
21. Regular risk reviews were undertaken.					
22. The risks had been considered while estimating the project costs.					
23. The risks had been considered while estimating the project duration.					
24. The life cycle costs had been considered in the process of cost estimation.					
25. The Net Present Value had been considered in the process of alternatives assessment.					
26. There were considerations for estimating the duration of fuzzy activities.					
27. The planned schedule considered the time/cost optimization.					
28. The estimated costs were shared with all involved parties.					
29. The estimated duration was shared with all involved parties.					
D. Tracking and the Control Systems					
30. There were checkpoints for review by a management group to determine if the project is meeting organizational standards.					
31. There was a cost tracking system in place?					
32. The actual costs were being tracked properly.					
33. The cost tracking system was up to date.					
34. Costs were being reconciled against planned budget.					
35. Costs projections system was in place to measure the cost at the project completion.					
36. A suitably detailed schedule was in place.					
37. It was up to date.					
38. It reflected the current scope.					

39.	There were enough milestones being used to manage progress.					
40.	Time was being monitored throughout the project execution.					
41.	There was a solid and realistic plan for the remaining work.					
42.	The human resources were monitored during the stage of project execution.					
	E. Technical related Concerns					
43.	Each of the Authorities representatives' team had the necessary tools, skills and processes to undertake the project successfully.					
44.	The Consultants had the necessary tools, skills and processes to undertake the project successfully.					
45.	The contractors had the necessary tools, skills and processes to undertake the project successfully.					
46.	There were enough and sufficient resources.					
47.	The resources were being used efficiently.					
48.	There were no technical difficulties that never been faced in previous projects.					
	F. Contingency Planning					
49.	There was a contingency plan in place if the implementation fails to meet the deadline.					
50.	There was a timeframe to implement the plan.					
51.	There was a contingency plan in place if the implementation exceeded the budgets.					
52.	The plan had been signed off by all concerned.					
53.	The plan had been tested.					
54.	The impacts of a contingency plan were understood by managements of all parties.					
55.	There were back up activity acceleration plans introduced.					
56.	There was a penalty for late completion.					
57.	There was a bonus for early completion.					