Schedule Delay Identification and Assessment on Addis Ababa's Light Rail Transit Construction Project

ADDIS ABABA INSTITUTE OF TECHNOLOGY (AAiT) SCHOOL OF GRADUATE STUDIES GRADUATE PROGRAM IN RAILWAY ENGINEERING

A thesis submitted in partial fulfillment for the degree of Master of Science in civil and environmental engineering

Railway engineering stream

ROBEL ASSEFA

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ADDIS ABABA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

SCHEDULE DELAY IDENTIFICATION AND ASSESSMENT ON ADDIS ABABA'S LIGHT RAIL TRANSIT CONSTRUCTION PROJECT

By ROBEL ASSEFA

APPROVED BY BOARD OF EXAMINERS

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Chairman of the board	**Signature**

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ABSTRACT

Delay is generally acknowledged as the most common, costly, complex and risky problem encountered in construction projects. Because of overriding importance of time for both the owner (in terms of performance) and the contractor (in terms of money), it is the source of frequent disputes and claims leading to lawsuits. The primary concern of these arguments is answering the question of the extent of each contracting party's responsibility for the delayed projects and extra cost incurred. Consequently much has been done to avoid disputes related to delays.

The research reported in this thesis was initiated to investigate these issues by considering the case of Addis Ababa's LRT construction, towards developing a frame work for improving delay analysis. The methodology adopted in undertaking this research was the mixed approach involving a detailed review of the relevant literature followed by questionnaire survey and interviews to investigate the variables identified in more depth. The data collected were analyzed, with the aid of excel, using descriptive statistics approach.

The research has revealed that the LRT construction project underway is exposed to delay caused by delayed site handover and right of way, lack of coordination with the stakeholders, delayed external work due to public agencies and poor economic conditions resulting time and cost overrun and several claim requests. In addition it was found out in the literature that methodologies for analyzing delays are different in various ways leading to difficulties and disputes associated with delay analysis. Therefore, best practice recommendations for avoiding the causes of delays identified and a model for assisting the analyst in selecting an appropriate delay analysis methodology for any claim situation were provided.

Key Words: **Delay, Delay Analysis, Light Rail Transit, construction claim, right of way, cost overrun**

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List of abbreviations

AACRA	Addis Ababa City Roads Authority
CDCA	Computerized Delay Claim Analysis
CREC	China Rail Engineering Group Limited
CPM	Critical Path Method
CRD	Contractor Responsible Delays
DAM	Delay Analysis Methodology
DAT	Delay Analysis Techniques
DAMUDS	Delay Analysis Method Using Delay Section
ERC	Ethiopian Railways Corporation
ERA	Ethiopian Roads Authority
ED	Excusable Delay
IDT	Isolated Delay Type
LRT	Light Rail Transit
MAA	Multi Attribute Analysis
MAUT	Multi Attribute Utility Theory
ORD	Owner Responsible Delay
SMAA	Scoring Multi Attribute Analysis
SCL	Society of Construction Law

List of appendix

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It is with pleasure that I appreciate Ato Birhanu Alemu, project coordinator at Dynamic Planners PLC, for his positive attitude and permission off work during this study.

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DEDICATION

This research is dedicated to my heroes, a father of all qualities Ato Assefa Mengistie, a mother of perfection W/Ro Birhane G/Meskel and a life time teacher Finote Birhan.

CHAPTER ONE

Introduction

1.1 General background

Construction projects are sets of planned activities that are undertaken to create a unique engineering facility within a specified time and under constrained resources. The product's uniqueness entails the difference in output from one project to the other in some distinct characteristics. The specific time of project in turn indicates projects have finite time span through which they are executed. Achieving project objectives within the specified time and with limited resources require project management that applies knowledge, skill, tool and techniques of the activities (Project Management Institute, 2004).

The time and cost for performance of a project are usually of the essence to the employer and the contractor. This is because late completion of projects can deny employers the benefits that accrue through use of the project and may also expose them to serious financial and economic risks. On the contactor's side, delay in completion entails additional cost accruing from extended home office and site office overheads, labor and equipment standby costs and other intangible costs such as an opportunity cost if the delay is unjustifiable. Despite these effects, it is sadly all too common that most construction projects are not completed within the agreed contract period and for the price it was intended for.

The problem of delays in the construction industry is a global phenomenon. When delays are experienced, this is not necessarily an indication that the process or the management team is breaking down. Delays are often simply the results of an event which must be managed by a systematic process so as to anticipate the impacts of that event in advance, and to minimize the risk of further delays.

In most cases however, delay issues which ought to be managed in the course of a project are translated into claim situations and subsequently disputes (Kumaraswany and Chan, 1998). The disputes are often resolved through expensive forms of dispute resolution settings causing significant costs to all project stakeholders and to the society at large.

Consequently there has been much desire to reduce delay claim disputes and this has created considerable research interest among researchers and practitioners around the globe. Even though the world is concerned in studying the mechanisms to avoid disputes related to delays, what is done to even determine causes and effects of delays in our country is not satisfactory. Stimulated by this state, this research was initiated to determine the causes and effects of construction delays along with delay analysis methods and analysis methods selection by investigating the case of Addis Ababa's light rail construction project.

The city of Addis Ababa will soon open a new LRT line marking a milestone sustainable transportation for the community. Historically, Ethiopia owned a railway line in alliance with DJIBUTI "chemin de fer" which serves nearly 100 years covering a length of 780 Kms. This line was the only service provider for passenger and freight transportation to the eastern Ethiopia, as far as rail transportation is concerned, until it was abandoned due to its age and deterioration. Today a total of about 2000 Kms of national network and 34.25 Kms of Addis Ababa LRT line has been proposed and is now partially under implementation.

The city's metropolitan electric railway has a total length of 34.25 Kms, which is divided into the north-south line covering a length of 16.9Kms and east-west line covering 17.35Kms. These two lines share a common track of about 2.7KMs. The contract to the project was signed in September, 2009 between Ethiopian Railway Corporation (ERC) and China Railway Group Limited (CREC) with an EPC turnkey contract type where the contractor engineers, procures and constructs the project with a total sum of 475,000,000.00 USD. This huge project commenced in 2012 and is expected to be completed in January, 2015 with construction duration of three years. By mid 2014, the contractor is expected to complete 85% of the project.

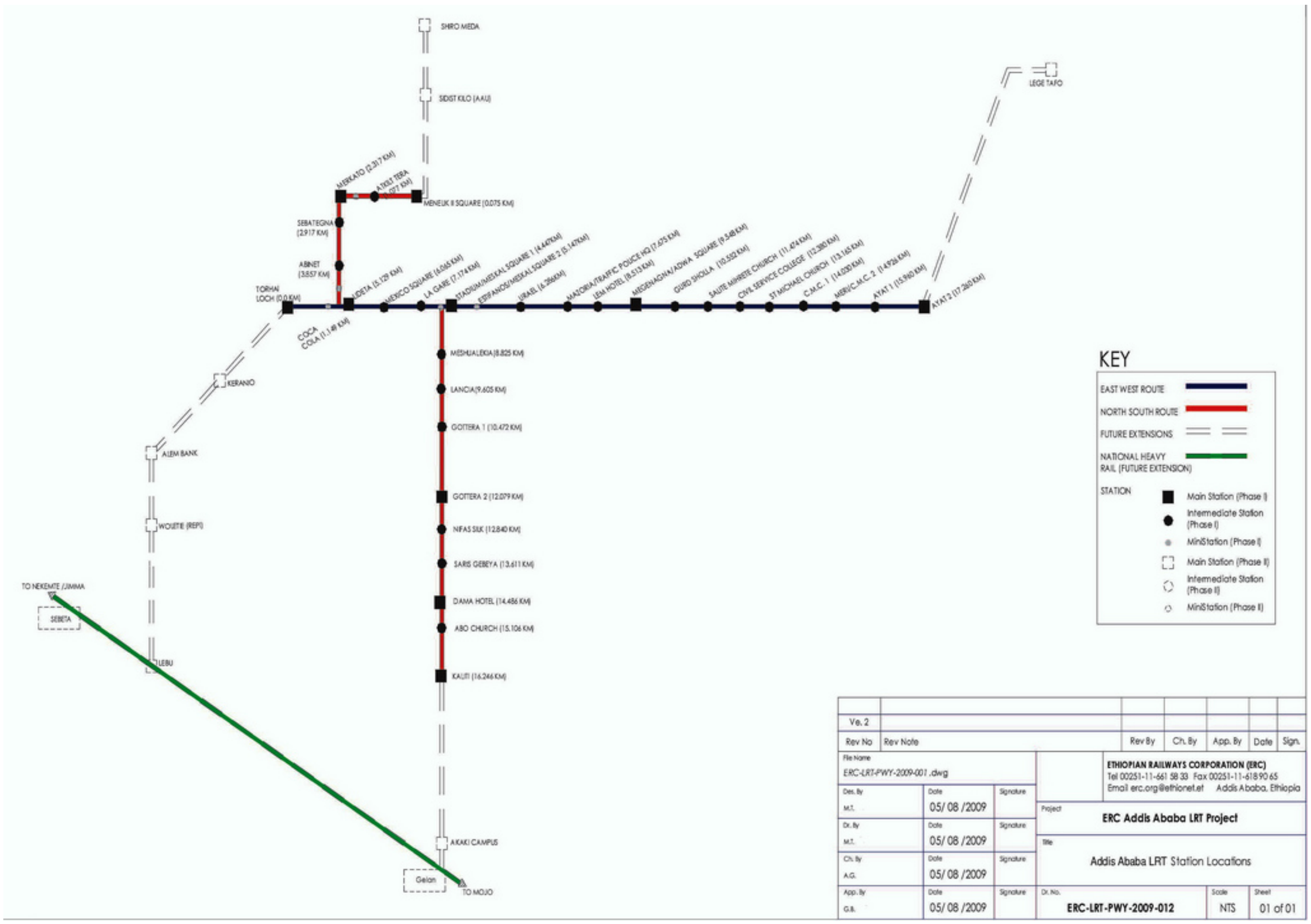


Fig 1.1 Addis Ababa LRT line routes and station locations (E-w and N-S), source: ERC home page

It is this thesis's objective to provide an understanding in minimizing delays for ERC's future projects and expansions.

1.2 Problem definition

The difference of construction industry from others is that the projects are large, built on site, unique and generally consume larger resources. This complexity requires close attention and follow ups. The lack of experience in managing such large projects in our country is costing us too much for employment of foreign contractors and professionals. In order to have our local contractors' participation in such large projects, there needs to have a complete package of project handling guideline. Railway industry is best known for its initial investment. This requires a closer attention towards the project during the construction period; therefore, effective management procedures should be incorporated to avoid deviations from the desired outcome.

Off all the challenges of construction management, the triple constraints are the most looked out for. Managing cost, schedule (time) and quality are the triple constraints which inter depend on each other (Abebe, 2003). When large projects deviate from their objectives (either in cost, completion time, performance, safety or environmental effects), the damage caused obviously transcends out of the contracting parties and affects the project stakeholders and the public at large. Emphasizing the completion time deviation factors as they are very common in our country's construction industry, lack of justified methodologies in quantifying and analyzing delays happens to be the greater challenge. Also the task of justifying and quantifying the effects of each delay event required for the proof of causation and quantum is well recognized as an extremely difficult undertaking.

This is because, not also the delays come from a variety of sources, they also have different effects and implications resulting in complex ramifications, creating considerable difficulty to practitioners in the claim resolution (Kumaaswany, 1997). A critical review of literature suggested that the reason for the continuing difficulty with delay claim resolution can be attributed to a number of problems including lack of uniformity in the application of delay identifying methodologies, lack of sufficient guidance from contacts and poor planning practice.

In the lights of these problems this research therefore, tries to determine delay causes and effects of the LRT construction and also to adopt an appropriate frame work for improving delay analysis and administration methods.

1.3 Objectives

In recognition to the above background, this research set out to investigate schedule delays occurred during the construction of the LRT and to recommend simplified and applicable method of a delay identifying and quantifying technique by studying the case of Addis Ababa's LRT construction. In pursuit of this aim, the main research objectives embrace the following

- To determine major contributing factors of delay on the project
- To determine effects of such delays on the project
- To identify and evaluate existing delay analysis methodologies
- To search or develop a framework for selecting schedule delay analysis methods
- To identify areas of further research and provide reference for future studies

1.4 Research questions

The main question that this thesis urges to answer is the identification of the occurrence of schedule delays on the construction of the city's LRT and quantification of impacts on the project. To come to such a generalized inquiry the following questions were raised along side

- Has the LRT construction project been exposed to schedule delays so far? If so, what were the major contributing factors to such delays?
- How best can claims related to delays be administered in the Addis Ababa LRT project?
- What is the existing delay analysis methodology, if there is any?

1.5 Scope and Limitations

Scope: in this study, the EPC turnkey project of the Addis Ababa LRT construction is considered. Events in construction projects may come out with either opportunities, threats or both. This research focuses only on time barriers or delays that defy the success of the project considered.

Limitations: in the study process, the following limitations were observed

- It was not possible to obtain local data from case study projects that can be used for applying extensive quantitative methods.
- By the time this research is carried out, the construction project of the LRT was not completed, hence no contract completion report of the project could be obtained
- There exists no organized system of delay analysis in the project, hence the research tried to approximate the methods to the existing techniques by defining each technique to the respondents understanding so that they can chose which ever technique they use

- The fact that the project is first of its kind, knowledge with respect to it is minimal together with sensitivity and uncertainty has caused participants in the research wary about giving actual data leading to information scarcity.

1.6 Thesis overview

In this thesis, the first chapter introduces the background information about the research and its objectives and the second chapter discusses about the literature reviewed in relation to the topics.

In the next chapter, the research methodology is described incorporating data collection and analysis methods, study approach and study design. The fourth chapter analyzes the research findings while in the fifth chapter conclusions and recommendations are given.

The last chapter cites all the reference materials used for the study. Also, relevant data and information about the thesis is given on the appendices.

CHAPTER TWO

Literature review

2.1 The concept of construction project management

To discuss project management, it is important to understand the concept of project. A \`project\` is a temporary endeavor undertaken to create a unique product, service or result (PMBOK, 2013). According to this book, the most distinguished feature of a project is a specific time frame. A project usually involves varied activities, which produce quantifiable and qualifiable deliverables that when added together, accomplish the overall objective. Every project is characterized by

- A boundary, limited/defined extent,
- Finite resource requirement , and
- Identifiable end.

If a project is defined in such a way, project management is then the application of knowledge skills, tools and techniques to project activities to meet project requirements. This is accomplished through the use of initiation, planning, execution, monitoring and controlling and closure process (PMBOK, 2013).

These processes have been organized into ten knowledge areas; these are Project Integration Management, Project Scope Management, Project Time Management, Project Quality Management, Project Human Resource Management, Project Communications Management, Project Risk Management, Project Procurement Management and Project Stakeholder Management (PMBOK, 2013).

These ten knowledge areas are applicable to every project management. But for a construction project management the following have been added (Construction extension to (PMBOK), 2000).

- Project safety management → describes the process required to assure that the construction project is executed with appropriate care to prevent accidents that cause or have the potential to cause personal injury or property damage.
- Project environmental management → describes the process required to ensure that the impact of this project execution to the surrounding environment will remain within the limits stated in legal permits.
- Project financial management → describes the process to acquire and manage the financial resources for the project and is more concerned with revenue source and analyzing/updating net cash flows for the construction project than in cost management. It consists of financial planning, control and administration and records.
- Project claim management → describes the process required to eliminate or prevent construction claims from arising and expeditious handling of claims if they do occur. It consists of claim identification, quantification, prevention and resolution.

Table 2.1 below describes the ten knowledge areas noted on (PMBOK, 2013).

Knowledge Areas	Project Management Process Groups: Initiating Process Group	Planning Process Group	Executing Process Group	Monitoring and Controlling Process Group	Closing Process Group
1 Project Integration Management	4.1 Develop Project Charter	4.2 Develop Project Management Plan	4.3 Direct and Manage Project Work	4.4 Monitor and Control Project Work 4.5 Perform Integrated Change Control	4.6 Close Project or Phase
2 Project Scope Management		5.1 Plan Scope Management 5.2 Collect Requirements 5.3 Define Scope 5.4 Create WBS		5.5 Validate Scope 5.6 Control Scope	
3 Project Time Management		6.1 Plan Schedule Management 6.2 Define Activities 6.3 Sequence Activities 6.4 Estimate Activity Resources 6.5 Estimate Activity Durations 6.6 Develop Schedule		6.7 Control Schedule	
4 Project Cost Management		7.1 Plan Cost Management 7.2 Estimate Costs 7.3 Determine Budget		7.4 Control Costs	
5 Project Quality Management		8.1 Plan Quality Management	8.2 Perform Quality Assurance	8.3 Control Quality	
6 Project Human Resource Management		9.1 Plan Human Resource Management	9.2 Acquire Project Team 9.3 Develop Project Team 9.4 Manage Project Team		
7 Project Communications Management		10.1 Plan Communications Management	10.2 Manage Communications	10.3 Control Communications	
8 Project Risk Management		11.1 Plan Risk Management 11.2 Identify Risks 11.3 Perform Qualitative Risk Analysis 11.4 Perform Quantitative Risk Analysis 11.5 Plan Risk Responses		11.6 Control Risks	
9 Project Procurement Management		12.1 Plan Procurement Management	12.2 Conduct Procurements	12.3 Control Procurements	12.4 Close Procurements
10 Project Stakeholder Management	13.1 Identify Stakeholders	13.2 Plan Stakeholder Management	13.3 Manage Stakeholder Engagement	13.4 Control Stakeholder Engagement	

Table 2.1 Project Management Process Group and Knowledge Area Mapping

Source: (PMBOK, 2013).

In addition, hopping to fill the gap of knowledge and even possibly review the applicability of the above areas under their context, twenty one knowledge areas were categorized into five groups by Wubishet, 2013.

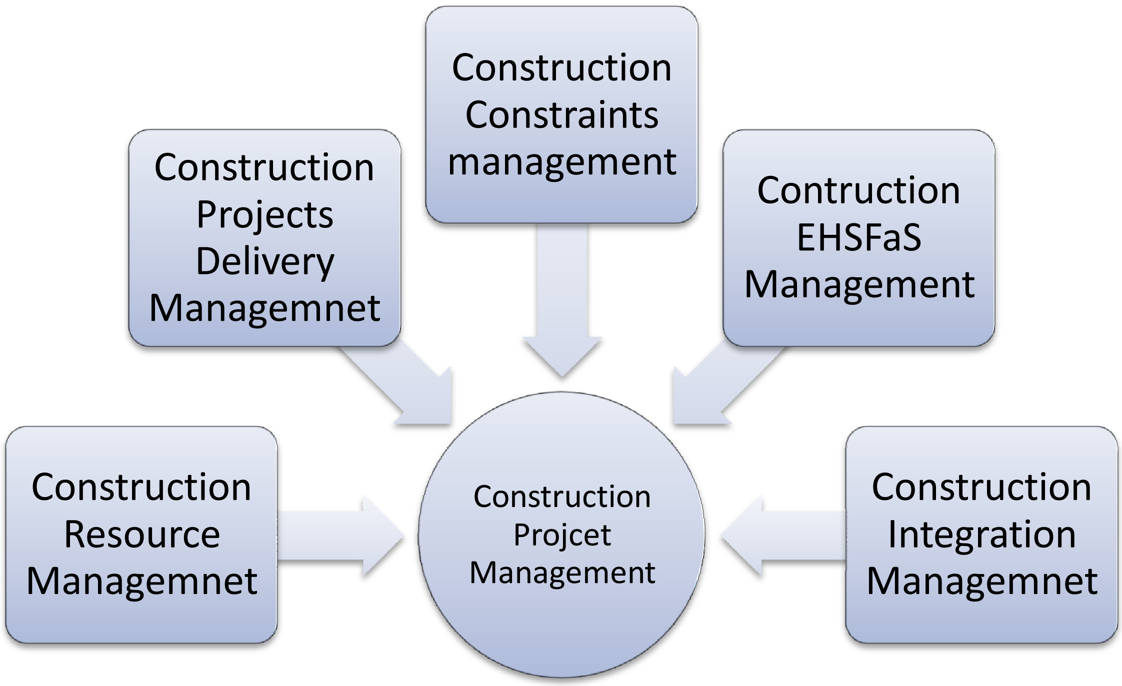


Fig 2.1 (CPMBoK) as proposed by Wubishet Jekale

(Source: ECoTMPA 4th national workshop magazine, 2013)

Further depiction of the above figure is presented as follows

I. Construction Project Delivery management
   a. Delivery
   b. Stakeholders
   c. Procurement
   d. Contract
II. Construction Constraints Management
   a. Scope
   b. Cost
   c. Time
   d. Quality

III. Construction Resource Management
   a. Finance
   b. Human
   c. Material
   d. Machinery and Plants
IV. Construction safety management
   a. Environment
   b. Health and Safety
   c. Fire and Security
V. Construction Integration Management
   a. Communication
   b. Front-End/ Feasibility
   c. Risks
   d. Changes
   e. Claims
   f. disputes

Since this thesis is dedicated to the schedule delay and time management of a construction project, these two terms shall be explained in a little more detail.

2.1.1 Project time management

Time management is a vital part of construction project management. (Westland, 2006) gives the following definition for time management: "time management is the process of recording and controlling time spent by staff on the project."

(Wideman, 1990) represents a wider definition for time management: "Time management is the function required to maintain appropriate allocation of time to the overall conduct of the project through the successive stages of its natural life cycle, that is, concept, development, execution and finishing by means of the processes of time planning, time estimating, time schedule and schedule control."

In Ethiopia, almost in all of the construction projects, we are used to seeing extensive delays leading to exceed of the initial time and cost budgeted. Time is essence of all construction contracts.

According to PMBOK guide 2013 edition, time management incorporates seven major processes;

- Plan Schedule Management
- Define Activities
- Sequence Activities
- Estimate Activity resources
- Estimate Activity durations
- Develop Schedule
- Control Schedule

But for the construction industry additional process are also required

- Activity weights definition → determining the relative and absolute weights for each project activity
- Progress curves development→ analyzing activity weights and project schedule to create progress curves
- Progress monitoring → monitoring project progress

2.2 Project schedule

The terms of project planning and scheduling are often mistakenly thought of as synonymous. However, as (Mubarak, 2005) indicates scheduling concentrates on the timing and sequence of operations in the project planning effort. Therefore, while project planning covers the issues of what is going to be done?, where?, how? and when?, The term of project scheduling covers only the issue of when?. (Trauner, Manginelli, Lowe, Nagata and Furniss, 2009) agree with Mubarak and define project schedule as "a written or graphical representation of the Contractor's plan for completing a construction project that emphasizes the elements of time and sequence". According to (Trauner, 2009), the project schedule should display all the construction tasks from the beginning of the project through completion, the time periods for each tasks, and the sequence of these tasks in a logical order.

(Oxley and Poskitt, 1996) define project scheduling as "the process of determining the actual time periods during which the activities are planned to take place: that is, start and finish dates for each activity". In order to determine the construction activities and their time periods, project planning should have been done before project scheduling. (Oberlender, 2000) claims that a successful project planning is more difficult to organize than scheduling .If the activities are identified in project planning, then scheduling the project will become relatively easy.

2.2.1 Project scheduling objectives

After a successful planning process, the schedule of the project is prepared. There are major objectives that are expected from good project scheduling. According to (Mubarak, 2005) there are eight important objectives of scheduling as noted below:

1. to calculate the project completion date.
2. to calculate the start or end of a specific activity.

3. to expose and adjust conflicts between trades or subcontractors.

4. to predict and calculate the cash flow.

5. to evaluate the effect of changes.

6. to improve work efficiency.

7. **to resolve delay claims.**

8. to serve as an effective project control tool.

A project schedule is viewed as a valuable project control tool for project managers to successfully conduct construction projects (Trauner, Manginelli, Lowe, Nagata and Furniss, 2009). (Trauner et al.,2009) further explain the basic purposes of a project schedule as effectively depicting the construction plan to the project participants, permitting management to control and measure the progression of the work, and finally accommodating the participants with information for timely decisions (Callahan et al.,1992) claim that the probabilities of on-time, on-budget, dispute free completion may be increased by means of a schedule and the purpose of the schedules is specified by the individual using the schedule. The authors further explain that the purpose to predict project completion for contractors is that they can arrange crew sizes, shifts or equipment to speed or slow progress. While, for architects or engineers the purpose is to determine how long design and construction will take for completion of the project. The authors add that subcontractors use the information of specific activities start and finish times to predict when they are needed at the site. Also, the activity completion dates are used by owners in order to decide when to deliver owner-furnished equipment and to coordinate partial occupancy. Another purpose of scheduling for contractors is to reveal and resolve conflicts between firms or subcontractors. Both for contractors and owners schedules are used to plan cash flow. (Callahan et al., 1992) also indicate that schedules are used for measuring delay and time extensions. If the schedules are regularly updated including work sequences, unanticipated delays, actual activity completion dates and change orders, then the owner and contractor can measure the affect of additional works and unanticipated delays, thus avoiding disputes.

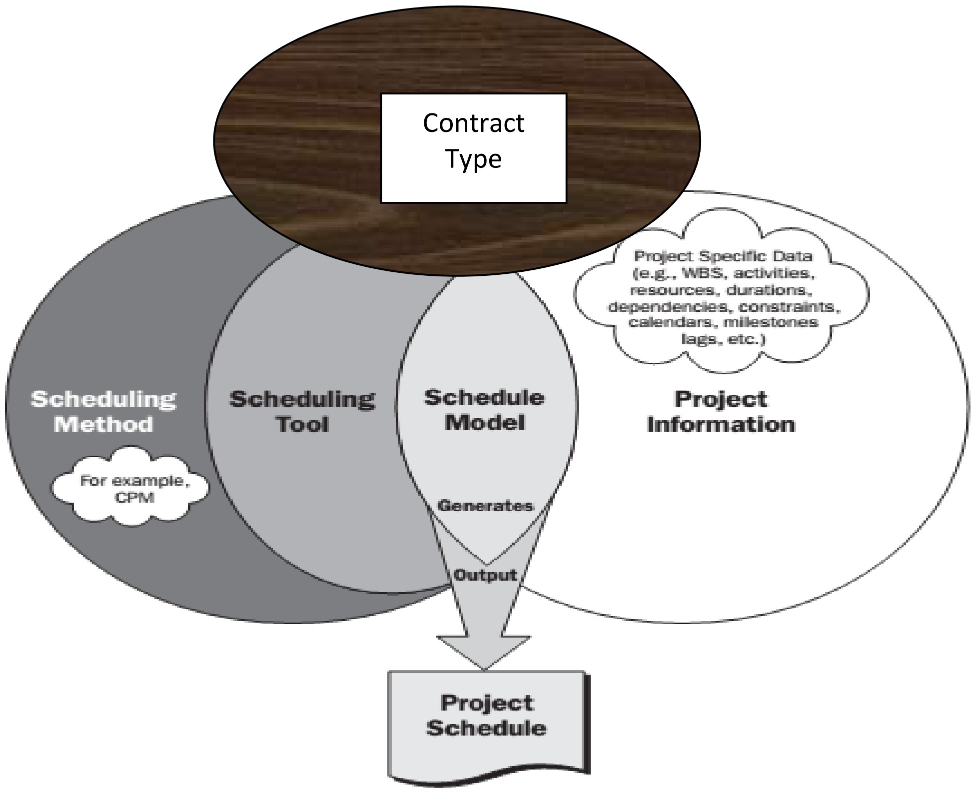


Fig 2.2 Scheduling overview (modified)

Source: (PMBOK, 2013).

As can be seen from the above figure, for a successful project schedule the interaction of scheduling techniques, tools, models and project information are necessary, governed by the context of the overall project as in contract type for instance.

The project schedule then can be presented in either of activity list, bar chart or network diagram.

2.2.2 Types of schedule impacts

According to Wickwire (2003) and Bramble (1990), types of schedule impacts are classified into five major groups. Namely:

1. Delays

Are the main concerns of this thesis therefore will be discussed in detail later, (sub topic 2.3).

2. Disruptions

A disruption can be defined as an impact that alters the contractor’s planned work sequence or flow of work expected at the time of bidding, which results in increased difficulty, cost, and/or time (Bramble, 1990 and Wickwire, 2003). When this occurs, the contractor cannot perform work in the manner anticipated during bid preparation, thus resulting in a schedule impact. Damages associated with disruption are likely to be increased labor costs due to inefficiency, the activation/deactivation of increased manpower, and additional equipment costs (Wickwire et al., 2003).

3. Changes

Another major type of potential schedule impact involves changes. When a contractor takes on any type of work that deviates from the original contract, or from the scope of work or plan of action reasonably anticipated under the contract, that results in an increase in performance time, the contractor may seek an adjustment (Bramble et al., 1990). Before determining the impact of the change on the schedule, the change must be identified as truly being a change from the original contract or merely a situation that should have been anticipated by the terms of the original agreement (Bramble et al., 1990). Changes can be broken down into three categories:

Directed Changes: A classic directed change order involving a directed written modification to the contract

- Directs the contractor to make specific changes to the work required by the project plans and specifications,
- Acknowledges that a change has been made, and
- Invokes the directed contract change order provisions.

The directed change to the contract should state the increase, or decrease in the case of a deletion, in total time for contract performance (Bramble et al., 1990 and Bartholomew, 2002).

Constructive Changes: An informal or constructive change lacks the formality of a directive authorizing a change in the work; “a change that is not acknowledged by the owner as such when it occurs, but which nonetheless is a change” (Bartholomew, 2002). The owner’s action or inaction has an impact on the contractor, taking the position that whatever the contractor is directed to do or is prevented from doing is not a change, but rather is required or prohibited by the original contract, as the case may be. The contractor then proceeds with the owner’s request for the constructive change, but then they must give prompt written notice of the constructive change to the owner. If courts rule that the contractor is correct in claiming a constructive change, the contractor will be awarded the necessary time extension (Bramble et al., 1990 and Bartholomew, 2002).

Cardinal Changes: A cardinal change is a change (either directed or constructive) that is clearly beyond the general scope of the contract, so extensive as to change the entire character of the work required under the contract (Bartholomew, 2002). Such changes are illegal in public contracts, for although the owner and contractor may agree on the change, such a large addition of work violates public bidding statutes guaranteeing free and open competition (Bramble et al., 1990).

4. Suspensions

A suspension of work is a written directive by the owner to stop all work on the project, either because the contractor has failed to perform in accordance with contract documents, or at the owner's convenience (Wickwire et al., 2003). Work will not continue until the owner has raised the suspension of work. A cost and time adjustment shall be made for any suspension of work ordered by the owner, as long as the contractor was not responsible for the suspension of work. As opposed to a pure delay, when an owner issues a suspension of work, the contractor is also entitled to equitable adjustment for profit (Wickwire et al., 2003).

5. Termination

Termination is a permanent stoppage of work of all or a portion of the contract and the contract is terminated. For a party to possess the right for termination, a termination clause must be specifically included in the contract. Most contracts allow the owner the right to terminate the contract, while some contracts grant the contractor this right.

There are two categories of termination, the first type being default termination, which gives the owner the right to terminate the contract when the contractor's performance is either:

1. Far behind a reasonable time schedule or
2. Results in work that fails to meet contract quality requirements or
3. When the contractor becomes financially insolvent. (Bartholomew, 2002)

The second type of termination, convenience termination, allows the owner to terminate the contract for its convenience, based on specific needs of the owner. For example, if the owner is unable to fund the remainder of the project and there is a termination for convenience clause in the contract, the owner is allowed to terminate the contract.

2.3 Delays

There are a number of definitions for schedule delays. Focusing on the construction project management approach, schedule delays can be "failure to complete a project either by the original or the stipulated or agreed contract period" (Abdulaziz and Abdul Naser, 2011).

Stumpf, (2000) defined delay as an act or event that extends the time required to perform the tasks under the contract. The international journal of project management summarized construction project delay as the exceedence of construction project completion time beyond the agreed completion time. All in all delay is to make something happen latter than expected. In relation with the participating parties of the construction project, (Aibinu and Jagboro, 2002) defined delay as a situation where the contractor and the project owner jointly or severally contribute to the non completion of the project within the agreed upon contract period. Even though these authors used different words and expressions, the general idea can be summarized as 'delay is the slowing down of work without stopping construction entirely which can lead to time overrun either beyond the contract date or beyond the date that parties have agreed upon for the delivery of the project, (Lo, Fung and Tung, 2006).

2.3.1 Types of Construction Delays

General types of construction delays should be clearly examined before schedule delay analysis begins. Schedule construction delays are categorized in many ways.

According to Trauner, 2009, there are four main groups of construction delays:

- Critical or noncritical
- Excusable or non-excusable
- Compensable or non-compensable
- Concurrent or non-concurrent

  This classification is explained in Fig 2.3 below

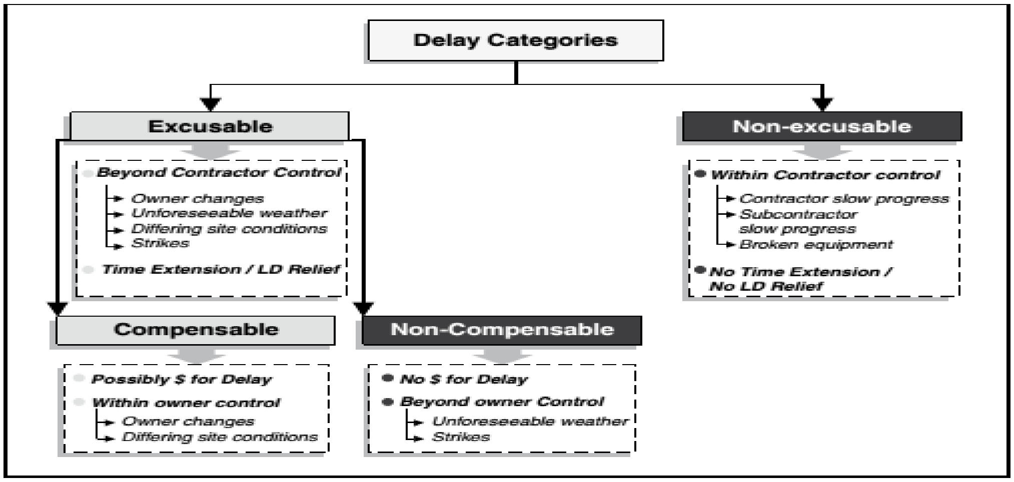


Fig 2.3 Delay classification (Source: Trauner et al., 2009)

Yang, Yin and Kao, 2007, classified delay following a logical process as shown in Fig 2.4 below. In this study, delay classification is given in a different manner, but similar to the concept of Trauner.

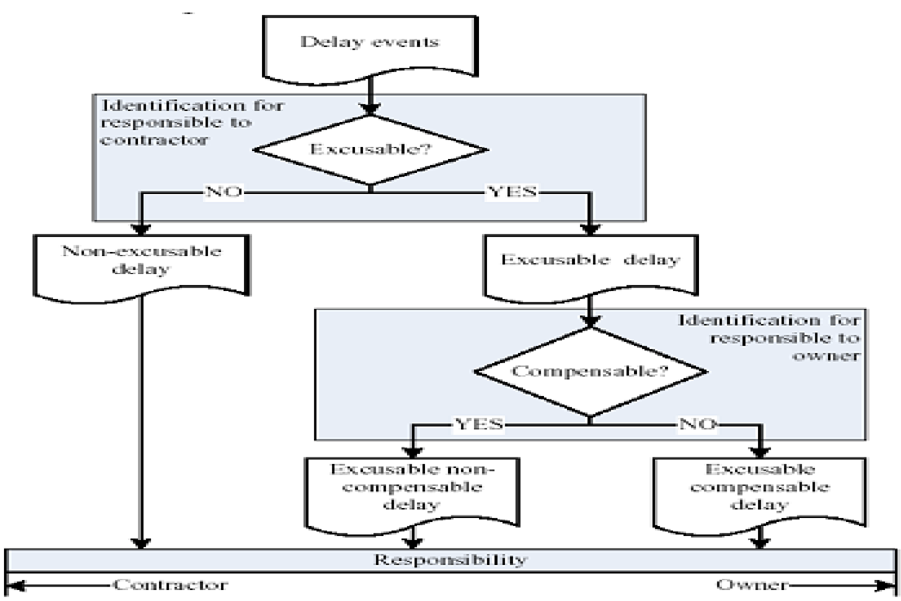


Fig 2.4 logical process of delay classification (Source: Yang, Yin and Kao, 2007)

Alaphbari, Kadir, Aziza and Ernawati (2007), grouped delays into four of the following broad groups

- Non excusable delays
- Excusable non compensable delays
- Excusable compensable delays
- Concurrent delays

And they generalized the categories into

- Excusable and non excusable
- Compensable and non compensable
- Concurrent

Whether or not delay is critical or non critical and concurrent or non concurrent should be determined in the process of analyzing delay effects on the project.

In another study, Kartam (1999), classified delay into three main groups based on their origin, timing and compensability

1. Delays classified based on their origin
    - Owner caused delays
    - Contractor caused delays
    - Third party caused delays
2. Delays classified based on timing
    - Concurrent delays
    - Non concurrent delays

3. Delays classified based on their compensability

- Excusable delays
- Excusable non compensable delays
- Non excusable delays

These classifications can be tabulated as follows

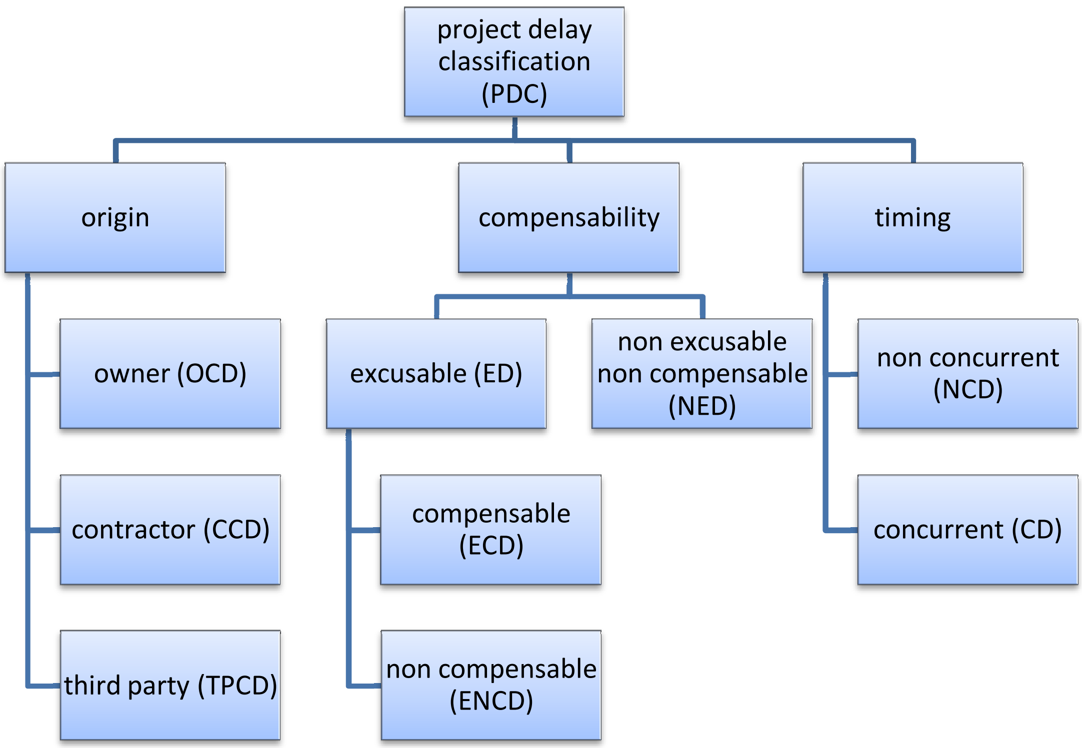


Fig 2.5 Kartam's delay classification (Source: Kartam, 1999)

2.3.2 Detailed classification

The previously highlighted delay types can be classified in detail as follows

A. Critical and non critical delays

According to (Trauner et al., 2009 and Callahan et al., 1992), the primary focus in any study of delays in a project is to see if the delay affects the progress of the entire project or the project completion date. The authors further state that delays which result in extended project completion are considered critical delays, and delays that do not affect the project completion date are known as noncritical delays. (Trauner et al., 2009) further claims that the issue of critical delays emerges from the Critical Path Method (CPM) scheduling. All projects have a critical path and if these critical activities on the path are delayed than the completion date of the project, it will be extended. The criteria determining the project completion date are as follows (Trauner et al., 2009).

- The project itself
- The contractor's plan and schedule (particularly the critical path)
- The requirements of the contract for sequence and phasing
- The physical constraints of the project- how to build the job from a practical perspective.

B. Excusable and non excusable delays

Construction delays are basically either excusable or non-excusable. (Callahan et al., 1992) and (Trauner et al., 2009) claim that whether a delay is excusable or non-excusable depends on the clauses in the contract. The authors note that standard construction contracts specify types of delay that will allow the contractor to an extension of time. For instance, in some contracts, unexpected or unusual weather conditions are not considered as excusable and so these contracts do not allow for any time extensions.

According to Trauner et al., (2009) an excusable delay, in general, is owing to an unforeseeable event beyond the contractor's or the subcontractor's control.

The authors further explain that delays resulting from the following issues are known as excusable:

- General labor strikes,
- Fires,
- Floods,
- Acts of God,
- Owner-directed changes,
- Errors and omissions in the plans and specifications,
- Differing site conditions or concealed conditions,
- Unusually severe weather,
- Intervention by outside agencies,
- Lack of action by government bodies, such as building inspection

In other studies, (Levy, 2006 and Kelleher, 2005) added more excusable delays to the above list as:

- Illness or death of one or more of the contractors,
- Transportation delays over which the contractor has no control
- Epidemics,
- Quarantine restrictions.

Mubarak (2005) defines non-excusable delays as "delays that are either caused by the contractor or not caused by the contractor but should have been foreseen by the contractor". But (Fugar and Agyakwah-Baah, 2010) claims Inexcusable delays (non-excusable delays) are caused solely by the contractor or its suppliers. The contractor is generally not entitled to relief and must either make up the lost time through acceleration or compensate the owner. This compensation may come from either liquidated damages or actual damages, provided there is no liquidated damages clause in the contract. Liquidated damages are generally expressed as a rate that is based on a forecast of costs the owner is likely to incur in the event of late completion by the contractor (Soon, 2010).

Non-excusable delays are common in various construction projects and cause considerable losses to project parties. It is widely accepted that construction project scheduling plays a key role in project management due to its significant influence on project success (Luu et al., 2009).

The common results of schedule delays include late completion of the project, increased cost, and disruption of work, loss of productivity, third party claims, disputes and abandonment or termination of contracts. Therefore, schedule delays in construction projects give rise to dissatisfaction in all the parties involved (Majid, 2006).

(Trauner et al., 2009) enumerate some examples of non-excusable delays as follows:

- Late performance of subcontractors,
- Untimely performance by suppliers,
- Faulty workmanship by the contractor or subcontractors,
- A project-specific labor strike caused by the contractor's unwillingness to meet with labor representatives or by unfair labor practices.

In another observation, (Mubarak, 2005) adds other examples to the above list as:

- Contractor cash-flow problems,
- Accidents on the site caused by the contractor's negligence or lack of preparations,
- Late delivery of the contractor's furnished materials and equipment.

As stated earlier, again, the contract is the determinant whether or not a delay is considered non-excusable. Therefore, (Trauner et al., 2009) warn contractors that before signing the contract it should be clearly understood which delays are defined as excusable and which as non-excusable.

C. Compensable and non compensable

In some studies, (Callahan et al., 1992, Kartam, 1999 and Mubarak ,2005) claim that an excusable delay can be classified as "excusable compensable" and "excusable non-compensable".

(Mubarak ,2005) states compensable delays are caused by the owner or the designer (engineer or architect). The contractor is typically entitled to a time extension or recovery of the costs related with the delay, or both. And (Fugar and Agyakwah-Baah, 2010) add compensable delays are caused by the owner or the owner's agents. An excusable, compensable delay usually leads to a schedule extension and exposes the owner to financial damages claimed by the contractor (Soon, 2010). In this case, the contractor incurs additional indirect costs for extended field office and home office overhead and unabsorbed home office overhead.

Examples of this type of delay would be the late release of drawings from the owner's architect and/or differing site conditions, changes in the work, access to the site.

Non compensable delays are caused by third parties or incidents beyond the control of either the owner or the contractor and are not attributable to any of the parties (Fugar and Agyakwah-Baah, 2010). They are delays which despite being excusable do not entitle the contractor to any compensation.

Authors such as (Barrie and Paulson, 1992 and Mubarak, 2005), point out that excusable non compensable delays are normally beyond the control of either owner or contractor such as unusual weather conditions, natural disasters, wars, national crises, floods, fires or labor strikes. They add that usually the contractor is entitled to a time extension, but not additional compensation. (Trauner et al. ,2009) emphasize that if a delay is compensable or non compensable basically depends on the issues of the contract. The contract determines the types of delays in detail and for which delay the contractor is entitled to time extension or monetary compensation.

D. Concurrent delays

Although this type of delays seems like a simple issue, still there is no clear definition of concurrent delays. concurrent delay includes a combination of two or more independent causes of delay occurring within the same time frame (Mubarak ,(2005)). Another definition made by (Callahan et al., 1992) is that "more than one delay contributed to the project delay, not that the delays necessarily occurred at the same time". According to (Trauner et al., 2009) concurrent delays are simply defined as "separate delays to the critical path that occur at the same time". (Levy, 2006) names this type of delays as overlapping delays. (Nguyen, 2007) also points out that simultaneous delays, commingled delays, and intertwined delays are other names used for concurrent delays.

(Levy , 2006) further indicates that concurrent delays may be generated by the contractor or by the owner, but if it happens that both parties are responsible, and these delays overlap then neither party can be able to retrieve damages. According to (Brian E Rawling) Concurrent delays could be caused by the delaying effects of events that were either excusable (i.e. the events for which the employer takes the risk of time and for which extensions of time should be granted to the contractor) or culpable (i.e. events for which the contractor takes the risk of time).

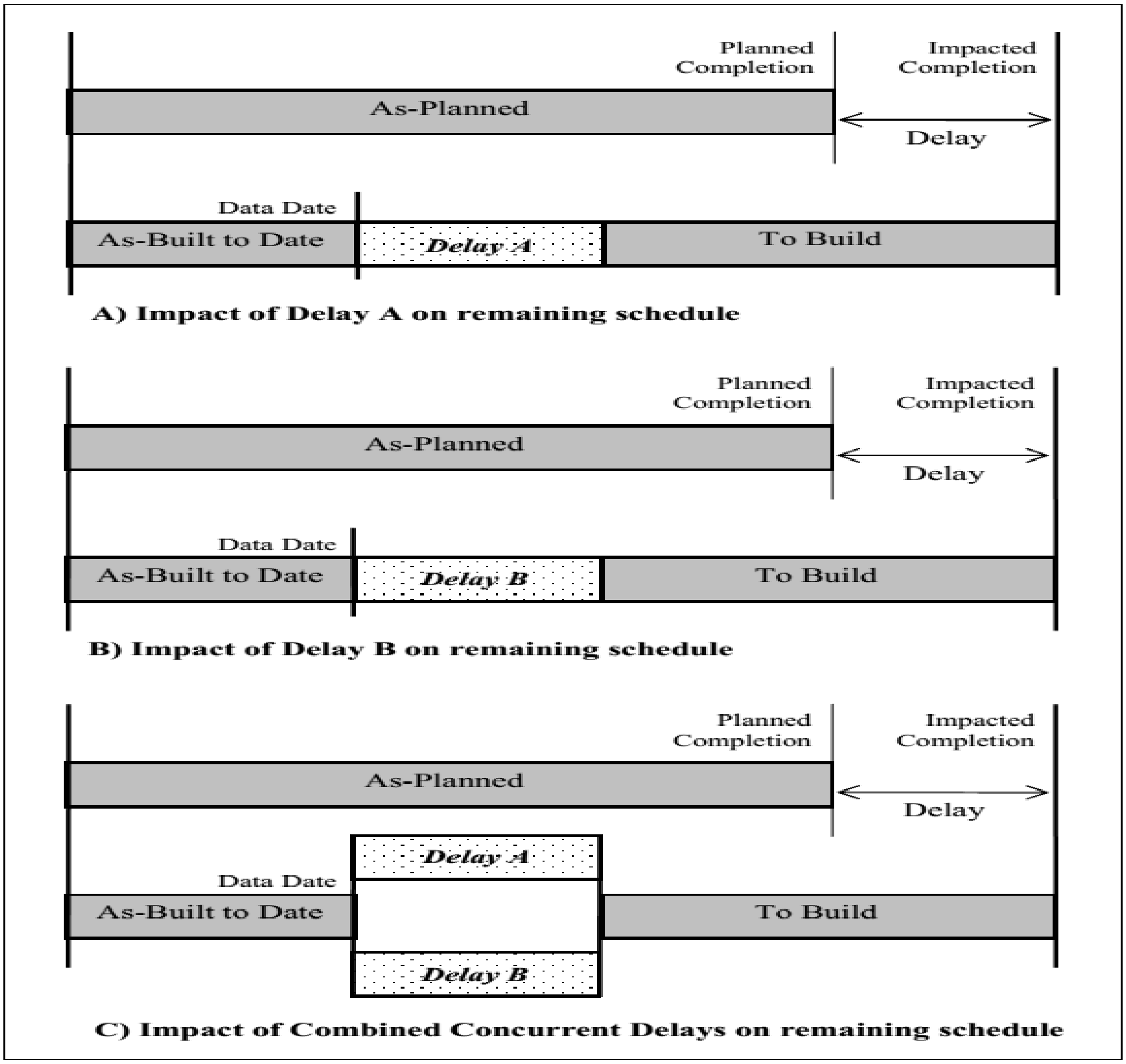


Fig 2.6 Concurrent Delays

Table 2.2 concludes the different perspectives on concurrent delays from previous studies. Concurrent delay analysis brings about many issues, since both owners and contractors view concurrent delays as a strong defense tool against each other. For example, owners use them to preserve their interest in order to get liquidated damages, however contractors use them to neutralize their inexcusable delays and avoid damage entitlement. Courts, practitioners, researchers are generally inconsistent in the subjects of definition and apportionment of concurrent delays.

All kinds of practitioners, especially contractors, contract administrators, and claims consultants have divergent opinions on concurrent delays. (Nguyen, 2007) As shown in the Table 2.2, general views regard concurrent delays as being similar to excusable delays. That means contractors are entitled only time extension.

Table 2.2: Divergent and inconsistent perspectives on concurrent delays

(Source: Nguyen, 2007)

No	Literature	Concurrent Delays		
		Excusable& Inexcusable	Excusable& Compensable	Compensable & Inexcusable
1	Ponce de Leon (1987)	Excusable	Compensable	Excusable
2	Reams (1989); Battikha and Alkass (1994)	Excusable	Excusable	Not Available
3	Arditi and Robinson (1995); Al-Saggaf (1998)	Inexcusable	Excusable	Not Available
4	Rubin (1983); Galloway and Nielsen (1990); Wiezel (1992); Alkass *et al.* (1995); Schumacher (1995); Galloway *et al.* (1997); Kartam (1999); Stumpf (2000); Reynolds and Revay (2001); Niesse (2004)	Excusable	Excusable	Excusable
5	Construction (1993); Baram (2000); Construction (2002)	Inexcusable	Excusable	Inexcusable
6	Kraiem and Diekmann (1987); James (1991); Kutil and Ness (1997); Finke (1999); Ness (2000); Bubshait and Cunningham (2004)	Excusable	Excusable	Excusable or Apportioning
7	Hughes and Ulwelling (1992); Wickwire *et al.* (2003)	Excusable	Excusable	Apportioning

Apportioning Concurrent Delays

Before a time impact analysis is performed, an understanding of concurrent delays is vital. The fact that two or more delays may occur at the same time and/or on separate parallel paths on the CPM network calls for methods to determine where time extension and compensation is warranted. In the event that two delays do occur at the exact same time on parallel paths of the CPM network, Figure below illustrates how apportioning of these delays may take place. It shows the four different concurrent delay scenarios that can occur between excusable delays, contractor responsible delays, and owner responsible delays. The general remedies that are commonly applied to these situations are listed on the right. The consensus of the figure is that any delay on the critical path acting concurrently with an excusable delay will warrant a time extension. In the event that both the contractor and owner cause a delay at the same time, the only remedy will be a time extension, without damages.

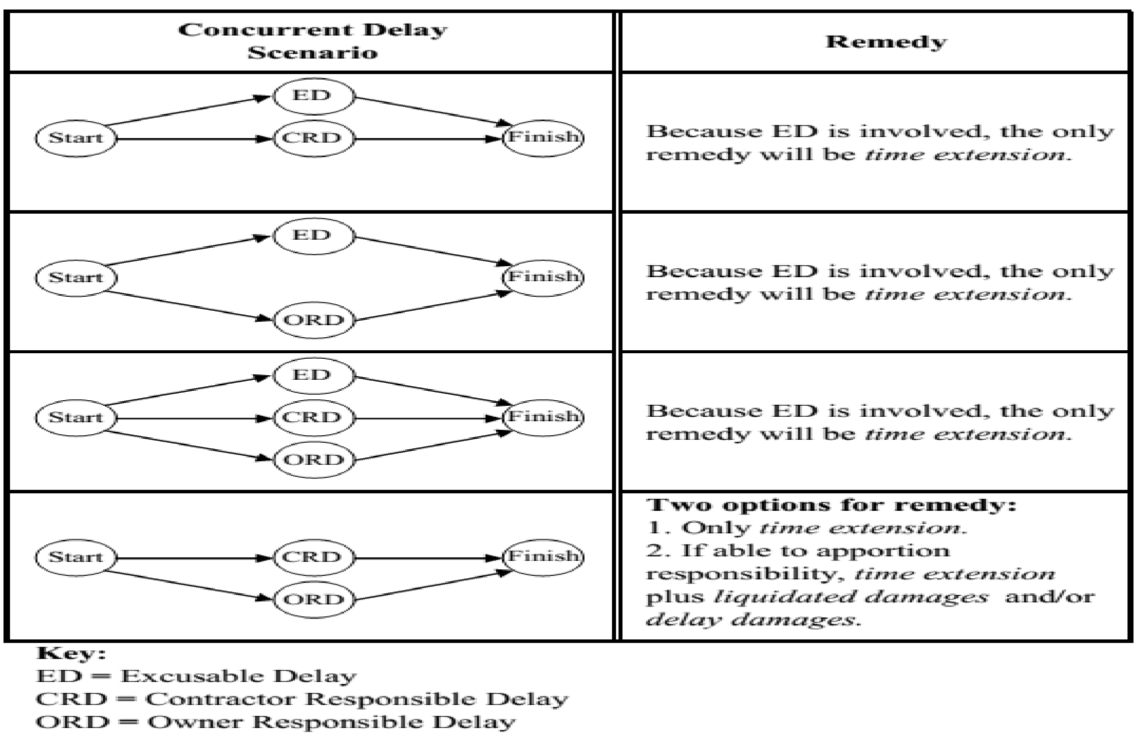


Fig 2.7: Apportioning Concurrent Delays (de la Garza 2006)

2.3.3 CAUSES OF DELAYS

Delays occur in every construction project and the magnitude of these delays varies considerably from project to project. Some projects are only a few days behind schedule; some are delayed by over a year. So it is essential to define the actual causes of delay in order to minimize and avoid delay in any construction project (Ahmedet al., 2003).

Mansfield, Ugwu and Doran , 1994, identified 16 major factors that cause delays and cost overruns in Nigeria. A questionnaire survey was carried out with contractors, consultants and client organizations in Nigeria. They found that the causes of delay and cost overruns in Nigerian construction projects were attributed to finance and payment arrangements, poor contract management, shortages in materials, inaccurate estimations and overall price fluctuations. (Assaf, Al-Khalil and Al-Hazmi, 1995) identified 56 main causes of delay in Saudi large building construction projects and established their relative importance. Based on the contractors surveyed, the most important delay factors were preparation and approval of shop drawings, delays in contractor's progress, payment by owners and design changes. From the view of the architects and engineers, cash problems during construction, the relationships between subcontractors and the owner's slow decision-making were the main causes of delay. The owners agreed that design errors, labor shortages and inadequate labor skill s were also important delay factors.

Mezher and Tawil , 1998, conducted a survey of the causes of delays in the construction industry in Lebanon from the perspective of owners, contractors and architectural/engineering firms. It was found that owners had more concerns regarding financial issues; contractors regarded contractual relationships as the most important; and consultants considered project management issues to be the most important causes of delays. (Chan and Kumaraswamy, 1996) surveyed the causes of construction delays in Hong Kong as seen by clients, contractors and consultants and examined the factors affecting productivity. The results of their research indicate that the five principal and common causes of delays are poor site management and supervision, unforeseen ground conditions, slow decision making involving all project teams, client-initiated variations and necessary variation of the work.

These causes were categorized into the following eight groups:

1. Project-related factors include project characteristics, necessary variations, communication among the various parties, speed of decision making involving all project teams and ground conditions.

2. Client-related factors include those concerned with client characteristics, project financing, their variations and requirements and interim payments to contractors.

3. Design team-related factors include design team experience, project design complexity and mistakes and delays in producing design documents.

4. Contractor-related factors include contractor experience in planning and controlling the project, site management and supervisions, degree of subcontracting and their cash-flow.

5. Materials-related factors include shortages, materials changes, procurement programming and proportion of off-site prefabrication.

6. Labor-related factors include labor shortages, low skill levels, weak motivation and low productivity.

7. Plant/Equipment-related factors include shortages, low efficiencies, breakdowns and incorrect selections.

8. External factors include waiting times for approval of drawings and test samples of materials and environmental concerns and restrictions.

Each of the above process and additional factors for the delay of construction projects were studied including the paper prepared by (Ramanothan, 2012) 'construction delays causing risk on time and cost' identifying several factors in which delay directly affects, such as, financier, projects, project attributes, owner, contractor, consultant, design, coordination, material, labor, environment, government relations… and the other paper of proceedings of the eastern Asia society for transportation studies, vol.5, pp 2282-2293,2005 summarizes reasons for delay in public work projects as

1. Technological factors Lack of management skills Constraints of construction technology to shorten project term

2. Unexpected factors unexpected geological condition Discovery of artifacts of cultural importance Natural disasters

3. Budgetary factors, inadequate budgetary resource for optimal project financing Lack of financial provisions for unexpected factors

4. Administrative procedures Complexities of negotiation with and consensus building among related public institutions Lack of standardized procedure regarding time span for individuals decision in the process of project planning and implementation

5. Other legal and regulatory factors Disincentive against shortening the project term Private contractors have to pay penalty for the delay but also have to return the saved cost if term is shortened

6. Factors related to stakeholders Land acquisition Consensus building among concerned citizens Activism to oppose project implementation

Frimpong and Oluwoye, 2003, identified the significant factors that cause delay and cost overruns in the construction of groundwater projects in Ghana. The results of the survey indicated that all three groups felt that project financing, economic and natural conditions and materials are the four major causes of delay and cost overrun. It was shown that consultants, owners and contractors agree substantially on the ranking of the categories of delay and cost overrun factors. It was also shown that all three groups surveyed ranked the project financing category of delay and cost overrun factors highest, while the labor category was ranked lowest.

Baldwin and Manthei, 1971, researched into the reasons for schedule delays in building projects in the United States of America. They cited seventeen (17) delay factors: weather, labor supply, subcontractors, design changes, shop drawings, foundation conditions, material shortage, manufactured items, sample approvals, jurisdictional disputes, equipment failure, contracts, construction mistakes, inspections, finances, permits and building codes. Other factors which were not in their original list but were mentioned by the respondents included labor management relations, strike, poor organization, scheduling, coordination, deteriorating quality of workmanship, productivity, lack of skills in craftsmen, quality of training, delivery delays and the high cost of financing. Their findings concluded with weather, labor supply and the sub-contractors as the three major causes of construction delays

Arditi, 1985, researched into the reasons of schedule delays in publicly funded construction projects for the period 1970-1980 in Turkey. They identified twenty three (23) reasons for the construction delays. Their findings concluded that the delays were due to shortage of materials (e.g., steel and cement), difficulty in receiving payments from agencies (e.g., payment not made on time; no advance payment; expensive surety bonds; insufficient public agency budget), contractor's difficulties (e.g., shortage of liquid funds; hard to get loans; hard to get credit purchase), organizational characteristics of contracting companies and public agencies (e.g., ill defined duties and responsibilities; site manager lacks authority; inadequate and slow decision-making mechanism; multitude of bureaucratic obstacles; high turnover in technical personnel).

Al- Ghafly, 1995, identified that, the schedule delay occurred frequently in medium and large size projects, and considered severe in small projects. There were many important causes of schedule delay related to owner involvement, contractor performance, and the early planning and design of the project. The most important causes were financial problems, changes in the design and scope, delay in making decisions and approvals by owner, difficulties in obtaining work permit, and coordination and communication problems.

Ogunlana, 1996, concluded that the problems of the construction industry in developing economies can be nested in three layers: problem of shortages or inadequacies in industry infrastructure, mainly supply of resources; problems caused by clients and consultants; and problems caused by incompetence of contractors. They were classified source and causes of delays into six groups: Owners related delay factors, designers related delay factors, inspector related delay factors, contractors related delay factors, resources suppliers related delay factors, and other factors.

Noulmanee, 1999, investigated causes of schedule delays in highway construction in Thailand. According to their findings, schedule delays might be caused by all parties involved in projects. They identified that the main causes come from inadequacy of subcontractors, organization that lacks of sufficient resources, incomplete and unclear drawings and deficiencies between consultants and contractors. They suggested that schedule delay can be minimized by discussions that lead to understanding.

Odeh and Battaineh, 2002, carried out a survey to identify the most important causes of schedule delays in construction projects with traditional type of contracts. They classified the causes of delays into the following eight (8) major groups: Client related, contractor related, consultant related, material related, labor and equipment related, contract related, external related delay factors. Results of the survey indicated that interference, inadequate contractor experience, financing and payments, labor productivity, slow decision making, improper planning, and subcontractors were among the top ten most important factors.

Assaf and Al-Hejji, 2006, studied the causes of schedule delays in large construction projects in Saudi Arabia. In their study, they identified that seventy three (73) causes of schedule delay exist in Saudi construction projects. Schedule delay factors were grouped into nine (9) major categories with different levels of importance to different parties. These groups were owner related, consultant related, design team related, materials related, labor related, contractor related, project related, external related, and plan/equipment related delay factors. According to survey results, 76% of the contractors and 56% of the consultants indicated that average of schedule delay is between 10% and 30% of the original duration. The most common cause of delay identified by all the three parties was ''change order''. Surveys concluded that 70% of projects experienced schedule delay and found that 45 out of 76 projects considered were delayed. They found that the most important causes of schedule delay as seen by contractors were: delay in progress payments by owner, late in reviewing and approving design documents by owner, change orders by owner during construction, delays in producing design documents, late in reviewing and approving design documents by consultant, difficulties in financing project by contractor, mistakes and discrepancies in design documents, late procurement of materials, inflexibility (rigidity) of consultant, slowness in decision making process by owner.

El Razek, 2008, conducted a survey to identify the main causes of delay in construction projects in Egypt from the point of view of contractors, consultants, and owners. They identified thirty two (32) causes of schedule delay which were grouped into nine (9) groups to fit the Egyptian construction industry. These groups were: Financing, materials, contractual relationships, changes, rules & regulations, manpower, scheduling and control, equipment, environment related causes. Their findings indicated that the most important causes are: financing by contractor during construction, delays in contractor's payment by owner, design changes by owner or his agent during construction, partial payments during construction, and non-utilization of professional construction/contractual management.

Han, Sungmin, Kim, Young, Park and Lee, 2009, studied that the causes of delay in Korean mega projects are classified into five categories: insufficient planning; difficulties in acquiring right of way; inefficiency of project management and monitoring system; conflicts between organizations; and strong public resistance. All of the direct or indirect participants tend to maintain different interests in the same project, making it extremely difficult to properly align them for project success. The sheer size and complexity of the project can easily lead to inefficiency and low productivity. Even though these causes, normally found in Korean mega projects, can be repetitive in any construction project, they tend to bring poorer results than those of smaller projects in both size and complexity.

Odeh and Battaineh, 2002, found that contractors and consultants agreed that owner interference, inadequate contractor experience, financing and payments, labor productivity, slow decision making, improper planning, and subcontractors are among the top ten most important causes of construction delay in Jordan.

Asnaashari, 2009, presented the result of an investigation into the main factors which cause construction delay in Iran. The results reveal that most of construction projects in Iran are subject to delay. Cash constraints, shortage of resources, high inflation rate, delay in payments, and disputes in the supply chain are the top causes of delay in the Iranian construction industry.

Ahmedet , 2003 and Alaghbari, 2005, mentioned the possible following factors causing delays in construction projects in Malaysia:

Contractor caused	Consultant caused	Owner caused	External factors
• Delay in delivery of materials to site • Shortage of materials on site • Construction mistakes and defective work • Poor skills and experience of labor • Shortage of site labor • Low productivity of labor • Financial problems • Coordination problems with others • Lack of subcontractor's skills • Lack of site contractor's staff • Poor site management • Equipments and tool shortage on site	• Absence of consultant's site staff; • Lack of experience on the part of the consultant • Lack of experience • Delayed and slow supervision in making decisions • Incomplete documents • slowness in giving instructions	• Lack of working knowledge • Slowness in making decisions • Lack of coordination with contractors • Contract modifications • Financial problems	• Lack of materials on the market • Lack of equipment and tools on the market • Poor weather conditions • Poor site conditions • Poor economic conditions • Changes in laws and regulations • Transportation delays • External work due to public agencies

Table 2.3: factors causing delays in construction projects in Malaysia

2.3.4 EFFECTS OF DELAYS

There has been a considerable and continued interest on the effects of construction delays. The information available is diverse and widespread. Despite the necessity for such research, little work has been described in the literature concerning public projects.

A study by (Aibinu and Jagboro, 2002) reveals six effects of delay on project delivery in Nigerian construction industry which are: time overrun, cost overrun, dispute, arbitration, total abandonment and litigation. (Sambasivan and Soon, 2007) disclose the same effects of delay in Malaysian construction industry. (Haseebet, 2011) identify effects of delays in Pakistan construction industry as clash, claims, total desertion and slowing down the growth of the construction sector. (Ramabodu and Verster, 2010) identify critical factors that cause cost overruns in construction projects as changes in scope of work on site, incomplete design at the time of tender, contractual claims (extension of time with cost), lack of cost planning and monitoring of funds, delays in costing variations and additional works. These critical factors in turn are the delay factors. (Chileshe and Berko, 2010) indicate that causes cost overrun in Ghanaian road construction sector are delay in monthly payments to contractors; variations; inflation, and schedule slippage. Again, these explain the causes of delays and the effect of cost overrun. The consequences of delay are different for different parties. The general consequences are the loss of wealth, time and capacity. For owner, delay means the loss of income and unavailability of facilities. For contractor, delay means the loss of money for extra spending on equipment and materials and hiring the labor and loss of time.

Geraldine John, 2012, determined a number of effects to construction projects. Their results indicate five highly ranked effects as time overrun, cost overrun, negative social impact, idling resources and disputes. These results are more less the same as those obtained by (Aibinu and Jagboro, 2002) in Nigerian construction industry and (Sambasivan and Soon, 2008) in Malaysian construction industry. On the other hand, medium ranked effects include: arbitration, delaying by the client to return the loans and poor quality of work due to hurry.

They, (Geraldine, 2012), summarized the effects according to their survey results into the following fourteen categories and ranked them accordingly.

1. Time overrun: project's duration difference between its original contract time and its overall actual contract time.

2. Cost overruns: a percent difference in cost between the final cost of the project and the contract award amount

3. Negative social impact: the influence on the public due to untimely completion of the construction

4. Idling resources: zero productivity of resources and equipments as a result of delaying activities

5. Disputes: adverse relation between the contracting parties

6. Arbitration: claim resolution between the parties involved in the delayed projects as an alternative to using court system

7. Delaying by the client to return the loans: whenever the project is financed with loan, delays will push the last returning date of the loan

8. Poor quality of work due to hurry: when trying to compensate for the delayed activities, accelerating will bring about quality compromise

9. Delaying in getting profit by clients: the productivity or profit of the project will be delayed if the construction end date is delayed

10. Bankruptcy: the state of being legally unable to pay off debts

11. Litigation: claim resolution, involving lawsuit

12. Create stress on contractors: not accomplishing of the contract will definitely cause the contractor to stress about matters to resolve the situation

13. Total abandonment: when excessive deliance, the project might be terminated and abandoned

14. Acceleration losses: trying to compensate to the delays occurred, activities will be accelerated causing additional costs

2.3.5 Schedule delays in railway constructions

Aswathi and Thomas, 2013, developed a delay analysis system for a railway construction project in India, the contribution of which was to develop methodology for analyzing and quantifying the impact of delay factors in construction projects. They studied the railway construction department of Kayamkulan in which the railway track doubling work was considered.

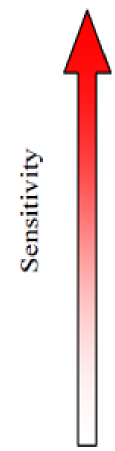
Activity	Description	Duration (month)		
		Ideal	Actual	Delay
A	Land acquisition	2	18	16
B	Rail barricading of different sections and milages (a structure setup across a route of access to obstract passage)	4	23	19
C		9	48	39
D		8	39	31
E		6	36	30
F		6	22	16
G		6	32	26
H		9	15	6
I	collecting and stacking of ballast	6	20	14
J		6	25	19
K		6	26	20
L	telecommunication, acm, FOB and platform shelter	6	14	8
M		5	36	31
N	track linking	6	16	10
O	commissioning	2	2	0

Table 2.4: Major activities of doubling work (modified)

The authors found out that almost all the associated works in that project were delayed. They collected questionnaires and conducted interviews to gather information. The construction project implemented/used critical path method scheduling and the authors used this information as an input of the delay analysis system. As a result they determined the contractor was the main party responsible for the delays and among the sub categories the project management stood first.

They quantified the possible duration of the construction project using simulation model and applied a sensitivity analysis to identify sensitivity in project duration due to the variation in the influence value of each delay factor affecting the project. As a result the researchers came up with the following causes of delay in accordance of sensitivity.

- Delay in material delivery
- Financial problem
- Delay in issuing change order
- Shortage of manpower
- External works
- Slow site clearance
- Difficulty in financing project by contractor
- Delay in progress report
- Low skill of man power
- Waiting time for approval of design and test of materials
- Improper construction methods and;
- Delay in delivering site



In conclusion, they stated that their research has introduced a new methodology to analyze and quantify the impact of delay factors by developing a delay analysis system (simulation method).

In another study, (Nathaniel Efron and Megan Read, 2012) conducted a qualitative and quantitative research on tunnels including railway lines and studied causes of cost escalations. They determined geology, labor cost and market competition and bidding process were major causes of delays and hence cost escalations.

According to ICRA Lanka and IMACS, industry report on Sri Lanka (2011), key issues faced by players (contractors, consultants and clients) of highway and railway construction are

- High cost of construction materials
- Lack of funds
- Low supply of high grade steel
- Lack of skilled workers
- Land acquisition delays
- Frequent changes in regulations

This, in turn caused delays of implementation of construction.

McKinsey and company, inc. (2009), classified causes of delays in major infrastructures such as railways, highways, hydropower constructions etc. into two major components;

1. Challenges in the tendering phase leading to the delay of project implementation: which further are caused by

    - Poor quality of planning and engineering design
    - Inappropriate use of contracts
    - Slow and centralized pre tendering approval process

2. Challenges in the construction phase leading to delivery delays, cost overruns and disputes: which further are caused by

    - Land acquisitions
    - Ineffective dispute resolution process
    - Weak performance management
    - Insufficient availability of skilled and semi skilled manpower
    - Weak risk management skills

- Lack of best-in-class procurement practices

Generally, the literatures reviewed indicate that land acquisition and funding shortages are the main causes of delays in the railway construction sector. The fact that funding shortages may cause delays in rail projects of US was reported by CNBC, (2014).

2.3.6 Construction Project Delays in Ethiopia

Delays are endemic to the construction projects in Ethiopia. By examining 15 completed projects in different region of the country, the delay encountered in most projects range from 20.66% to 500% of original contract time. Project delays are the major causes of claims for time extension and associated cost (ABDISSA, 2003).

In his research, the author collected reports of construction projects in Ethiopia using questionnaires and summarized them in tables.

In addition, the author tried to justify the extent of construction delays in Ethiopia by referring a report of Ethiopian Road Authority on September 2001, as shown on table 2.5 below. The authority reported the progress status of road civil works projects under construction industry news. The projects were funded by different funding agencies such as IDA, EU, ADF, the government of Japan, the government of Germany and the government of Ethiopia. The report includes completed projects, projects on progress and projects at tender stage but the author included on the thesis only four completed and fifteen projects on progress from the report. From nineteen projects, delays ranging from 11.11% to 173.33% were reported. The delay percent is calculated as the ratio of delay to contract time.

$$\text{That is } \%\text{delay} = \frac{\text{Delay} * 100}{\text{Contract time}}$$

No.	Project name	Contract time (month)	Delay (Month)	Contractor	Consultant	%Delay	Remark
1	Awasharba-Gewane	30	52	Keangnam	ICT	173.33	On progress
2	Addis-Ghion-Jima	36	51	Dragados g&p	DIWI&TYPSA	141.67	On progress
3	Semera-Elidar	36	50	ERA	TCDE	138.89	On progress
4	Gewane-Mille	30	39	LTA/CCC/BB	Shelladia	130.00	On progress
5	DireDawa-Harar	30	38	CRBC	PANAF.	126.67	On progress
6	Debremarkos-Merawi	36	39	Wanbeo	BVA/CC	108.33	On progress
7	Addis - Gohatsiyon	42	42	Kajima	CPCNKJV	100.00	On progress
8	Woldia-Alemata	36	30	China Wanbao	Dar AL Handas	83.33	On progress
9	Betemariam-Wukro	36	25	China Wanbao	BCEOM	69.44	On progress
10	Awash-Hirna	36	24	CRBC	CES	66.67	On progress
11	Kulubi-Dengego	30	18	Keangnam	Scot Wilson	60.00	On progress
1 2	Mille-Assab contract (1)	36	16	SOGEA	DIWI	44.44	Completed
13	Ginte-Metema	12	4	ERA	TCDE	33.33	On progress
14	Mille-Assab contract (3)	36	9	SOGEA	DIWI	25.00	Completed
15	Mojo-Awasharba	36	9	Keangnam	Carl bro.int.	25.00	On progress
16	Indesellassie-Humera (Sec.2)	33	6	SUR	TCDE	18.18	On progress
17	Addis-Mojo-Awassa	40	6	Dragados g&p	DHV	15.00	On progress
18	Mille-Assab contract (2)	41	6	SOGEA	DIWI	14.63	Completed
19	Chida-Sodo	36	4	Salini	Gauffi	11.11	Completed

Table 2.5: percentage delays in Ethiopia

(Source: - EACE Bulletin Vol.3 No. 1, September 2001)

The additional costs in some of the projects were due to indirect and overhead costs, loss of productivity and cost associated with extensions of various bonds.

The most common causes of delays and their associated costs, according to Abdissa (2003), were:

i) Shortage of spare parts

ii) Untimely payment

iii) Poor planning and control

iv) Increase in scope (design changes/extras)

v) Differing soil and site conditions

vi) Limited access to the site (partially or totally) not ready for work to progress

vii) Unusual and long rainy weather condition

viii) War and instability

ix) Poorly equipped contractors and

x) Public sector agencies lack of motivation, and lack of experience in project management.

Most of the delays were concurrent delays. That is to say that delays occurred by contractor, owner and third party at the same time. Some delays are sole responsibility of either contractor or employer. The overlapping of the causes of delays makes difficult to identify which portion of delay is which party's sole responsibility. Poor record keeping of events makes the problem even worse. It is obvious that delays result in additional cost to both the owner and the contractor (ABDISSA, 2003).

2.4 SCHEDULE DELAY ANALYSIS

The characteristics of delay factors and their level of impact vary from project to project, ranging from a few days to years. They have significant financial, environmental and social impact in construction projects; therefore, it is vital to investigate the causes of delay and analyze their impact.

In the study of (Ndekugri, Braimah and Gameson, 2008), delay analysis (DA) is defined as 'the task of investigating the events that led to project delay for the purpose of determining the financial responsibilities of the contracting parties arising from the delay'. The authors further pointed out that the techniques which have been developed for analyzing construction delays are referred to as 'delay analysis methodologies, (DAM) or delay analysis techniques, (DAT)'. The objective of delay analysis is to calculate the project delay and work backwards to try to identify how much of it is attributable to each party (contractor, owner, or neither) so that time and/or cost compensation can be decided. Questions that need to be answered here often include

- What was supposed to happen?
- What did actually happen?
- What were the variances?
- How did they affect the project schedule? (Schumacher, 1995) and (Wickwire, Groff, 2004)

2.4.1 Tools of quantification of delay impacts

Schedule analysis is used in order to identify delays and to measure the net impacts of delays on a project. Basic tools which are used in the schedule analysis are known as bar chart schedules and critical path method schedules. (SONGÜLI, 2010)

1. Bar charts

(Callahan, 1992) defines bar charts as "a collection of activities listed in a vertical column with time represented on a horizontal scale". Bar charts show duration, start and finish times of project activities in chronological order. Henry L. Gantt developed bar charts during World War I. This tool is widely preferred since it is simple, easy to prepare and has an easily understandable format.

However, bar charts have many limitations. (Wickwire, Driscoll, Hurlbut, and Hillman, 2003) give a detailed list of disadvantages of this tool:

- Size limits a bar chart in what it can graphically present
- Bar charts do not show the interrelationships or interdependencies of one bar to another
- Bar charts do not show the available float or contingency time, nor can they show the delay impact of one bar on another
- Bar charts are not capable of accurately distributing or controlling manpower and project costs.
- Adding more detail to the bar chart makes it harder to read, understand, and maintain.

Consequently, bar charts cannot show the logical relationships among activities. When there are continuous relationships between many activities, a bar chart becomes difficult to prepare schedule correctly (Callahan et al., 1992).

2. Critical path method

In project management, the Critical Path Method (CPM) is a planning, scheduling and controlling tool and using this tool properly facilitates the completion of projects timely.

(Wickwire et al., 2003) describe CPM as "a graphic representation of the planned sequence of activities that shows the interrelationships and interdependencies of the elements composing a project." At first, CPM was introduced as a planning tool; however, later additional function of CPM appeared as proving delay claims. This function is the result of the ability of CPM as showing the picture of the project and changes. Critical path is defined as the path with the longest duration. All activities lying on the critical path are called critical activities.

CPM can help to establish:

- How long your complex project will take to complete;
- Which activities are "critical," meaning that they have to be done on time or else the whole project will take longer to complete

2.4.2 Basic techniques of analyzing schedule delays

The various DATs have varying capabilities in providing sound answers to these questions. The techniques can be grouped under non-Critical Path Method (CPM)-based techniques and CPM-based techniques. They have been reported by different authors in the literature using different names, with the most common techniques being: "as-planned vs. As-built", "impacted as-planned", "as-planned but for", "collapsed as-built", "window analysis", and "time impact analysis"

Common name	**Alternative names used by different authors**
Non critical path method based techniques	
S-curve global impact technique	**Dollar-to-time relationship** (Trauner, 1990)
Net impact	**Bar chart analysis** (Lucas, 2002) **As-built bar chart** (Bordoli and Baldwin, 1998)
Critical path method based techniques	
As-planned Vs as-built	**Adjusted as-built critical path** method (Leary and Bramble, 1998) **Total time** (Zack, 2001) **Impacted as-built critical path method** (pinnell, 1998)
As-planned but for impacted as-planned	**What if** (Schumacher, 1995) **Baseline adding impacts** (Bordoli and Baldwin, 1998) **As- planned-plus delay analysis** (Zack, 2001) **As-planned critical path method** (pinnell, 1998)
Collapsed as-built	**But for** (Schumacher, 1995; Zack, 2001 and Lucas, 2002) **As-built but-for** (Pickavance, 2005) **As-built subtracting impacts** (Bordoli and Baldwin, 1998) **As-built minus analysis** (Chehayeb et al., 1995) **As-built less delay analysis** (Zack, 2001)
Window analysis	**Contemporaneous period analysis** (Schumacher, 1995; Zack, 2001 and Lucas, 2002) **periodic update analysis** (Chehayeb et al., 1995)
Time impact analysis	**End of every delay analysis** (Chehayeb et al., 1995) **Chronological and cumulative approach** (Wickwire and Groff, 2004)

Table 2.6: Names of existing delay analysis methodologies (DAMs) (Source: Ndekugri, Braimah, Gameson, 2008)

a) As-planned versus as-built (Total time) method

Basically, the main concept is that the as-planned versus as-built method compares two schedules, which is why it is also called "the total time method or net impact method". In this method the assumption is that one party (contractor) causes no delays and other party (owner) causes all delays. In this manner, the method displays the net impact of all claimed delays on project's finish date (Nguyen, 2007). The difference between the as-planned and as-built completion dates is the amount of time for which the claimant will request for compensation. The critical path is determined once in the as-planned and again in the as-built schedule. (Braimah, 2013).

According to (Ndekugri et al., 2008), the main advantage of this method is that it is inexpensive, simple and easy to use or understand, on the other hand its disadvantages are failure to consider changes in the critical path and incapability of managing complex construction delays.

According to (Braimah, 2013) the limitations of this methodology are:

- it does not scrutinize delay types and this makes it easy for it to be manipulated and distorted to reflect either the position of the claimant or the defendant;
- it ignores the dynamic nature of the critical path and any changes in schedule logic
- No attempt is made to determine the individual impact of each delay on the project completion. All delays, including delays on non-critical path, were summed up and their net effect calculated.

b) Impacted as-planned (What-if) method

The other names of this method are "what-if" or "adjusted-baseline" method. According to (Trauner et al., 2009), in this method the analyst specifies the as-planned schedule, and inserts into this schedule the changes which caused project delays. These changes are the only determined delays recorded during construction process which may have affected the project duration. The amount of delay equals the difference in completion dates between the schedules before and after the impacts. The period between the completion date presented on the as-planned program and the one on the impacted as-planned program is regarded as delay to which a contractor is entitled to an extension of time as a means of an excusable delay activity.

(Trauner et al., 2009) point out the major weaknesses of this method as follows: firstly the impacted schedule does not show the project activities as they occurred, secondly the decision of placing which changes or impacts into the schedule is greatly subjective, and finally, and also most significantly, it does not reflect the dynamic nature of construction project and the critical path. The authors also add that some analysts like this approach because of being simple and clean, however, this method is greatly inaccurate. According to the authors by using the first schedule, this method freezes the critical path at the beginning of the project, thus the real changes in the critical path will not be identified. Nonetheless, (Nguyen, 2007) claims that the what-if method is more reliable than the total time method since this method distinguishes between the types of delays.

According to (Braimah, 2013) the limitations of this methodology are:

- It uses fixed as-planned schedule to analyze delays out of context and time
- The original baseline program may not be a realistic model on which to base the whole analysis;
- It has the potential of failing to consider the delays of all parties especially that of the claimant ("i.e.", being one-sided);
- Potential disputes over the adequacy of the as-planned schedule, because it is not economically possible, nor does it makes sense, to schedule the entire project in detail at its inception

C) As-Planned But for

Braimah, 2013, this method entails injecting the as-planned schedules with all the delays of a particular party to form an adjusted schedule. The completion date of this adjusted as-planned schedule compared with the actual completion date gives the amount of delay for which the other party is responsible.

A contractor using this method would identify and add all non-excusable delays to the as-planned schedule, whereas the owner would add all excusable delays. The advantage of this method is that it can be performed quickly because there is no need to consider actual progress of the work.

The limitations of this method include the following:

- It does not take into account any changes in the critical path schedule during the course of the project
- It assumes that the planned construction sequence remains valid during the project duration
- Owner's point of view and contractor's point of view may yield different results resulting in disputes.

d) Collapsed as-built (But-for) method

In principle, this method is a form of "but for" which does not use the as-planned as a baseline schedule, but rather uses the as-built schedule (and thus also referred to as "as-built but for" technique). Another method of analysis is the collapsed as-built method, also called "the subtractive as-built or but-for method". In this method, the analyst studies all contemporaneous project documentation and prepares a detailed as-built schedule instead of an as-planned schedule as mentioned in the what-if method. The analyst subtracts or removes activities which affected the project from the as-built schedule (Trauner et al., 2009). The authors point out that if subtracting activities from the as-built schedule has an impact on the new schedule's end date, then the difference in time between the as-built and the collapsed as-built end dates is thought to be the delay caused by the subtracted or removed activities. In the study of (Trauner et al., 2009), two different variations of this method are explained such as "unit subtractive as-built and gross subtractive as-built" methods. This technique and the "as-planned but for" could give similar results if the planned logic remains unchanged in the course of the project.

Finally, according to the authors, this method has many serious problems and their three primary weaknesses are explained as follows:

- "It requires the analyst to construct a CPM network diagram based on as built information.
- It is extremely subjective and highly amenable to manipulation.
- With very little effort, the analyst can create an as-built schedule that supports a predisposed conclusion."
- In collapsing the schedule, the analyst is typically forced to insert after-the-fact logic ties which may not reflect the thinking of the executor of the schedule during actual performance.
- The removal of the delays from the schedule could result in an unrealistic as-built but-for schedule, particularly when the schedule sequence has been so much impacted by those delays.
- Adjusting the collapsed schedule to suit what the contractor is likely to follow requires experience and sound judgment beyond the capability of most analysts.
- It ignores the circumstances at the time of the delay and the dynamic nature of the critical path.
- The identification of the as-built critical path requires great deal of effort on judgment and schedule manipulation.

- The use of as-built information to prepare the as-built schedule is subjective and highly amenable to manipulation.

e) Window analysis (Contemporaneous period analysis) method

Window analysis method is also called the contemporaneous period analysis and snapshot method. In contrast to previous methods which analyze construction delays by taking into consideration the whole project, window analysis method analyzes delays within certain time periods individually (Nguyen, 2007).

This technique is based on CPM scheduling. In this method, the basic concept is that the total project duration of CPM schedule is divided into digestible time periods or windows (e.g., monthly) and the delays that occurred in each windows of time are analyzed successively by focusing on the critical paths (Hegazy and Zhang, 2005). The authors indicate that the selection of boundaries of window sizes is specified with major project milestones, significant modifications in the critical path, occurrence of major delay events and dates for the issue of schedule revisions. These factors identify the number of windows and boundaries of these windows for the entire project.

The study of (Kaoa and Yangb, 2009) compares windows-based delay analysis methods to determine their advantages and limitations. The differences in terms of the perspectives of use prerequisite, functional capability, analytical process and accuracy of analysis results are reviewed in terms of a simulated case.

Windows-based delay analysis methods are grouped in the study of (Kaoa and Yangb, 2009) as follows:

1. Windows analysis
2. Modified windows analysis
3. Delay analysis method using delay section
4. Daily windows delay analysis

In the research of (Hegazy and Zhang, 2005), the major drawbacks of traditional windows analysis are summarized below:

> "First drawback: While the as-built is the key to accurate delay analysis, it is widely recognized that it is manually done after the fact (after the project ends) and not as the events evolve, due to the difficulty in site-data recording. Accordingly, the as-built schedule may be subjected to errors and omissions that hinder accurate delay analysis.
>
> Second drawback: With the window span being in the form of weeks or months, the focus is on the critical path(s) that exists at the end of the window time. Thus, the technique does not consider the fluctuation that occurs in the critical path(s) as events evolve on site.
>
> Third drawback: As a consequence of the above point, the technique loses sensitivity to the time at which the owner/contractor cause project delays within the window. Also, it loses sensitivity to the events of speeding or slowdowns within the window.
>
> Fourth drawback: The delay representation of existing software systems makes the application and automation of the windows technique a difficult task."

On the other hand, the authors evaluate the above drawbacks as the desired objectives of their proposed method which is called "the daily windows delay analysis". According to the authors, the proposed method views the fluctuation day-by-day in critical path and so reaches correct and repeatable results to allocate project delays between the parties involved. The authors claim that this proposed method is a simple and practical alternative with its automated and computerized nature compared to a traditional window analysis which demands extensive effort. In another study of (Hegazy and Menesi, 2008), the authors proposed a different variation of delay analysis called "delay analysis under multiple baseline updates". This model which is based on a daily window size considers multiple baseline updates in order to accurately apportion delays and accelerations among project parties.

Opposite to (Hegazy and Zhang, 2005), (Ndekugri, Braimah, and Gameson, 2008) argue that the main strength of window analysis method is its capacity to take care of the dynamic nature of critical path scheduling. According to the authors, this method is used successively for each of the windows to specify the impacts of all other delays on project completion. (Nguyen, 2007) also claims that many researchers, experts, courts as well as boards generally approve window analysis method as the most suitable choice.

f) Time impact analysis (Modified as-built) method

(Nguyen, 2007)) indicates that the time impact analysis method (TIA) is one of the most reliable techniques presently. (Alkass, Mazerolle, and Harris, 1996) state that this method is a variation of the window analysis technique, also in this method, the analyst focuses on a specific delay or delay activity, whereas in the window analysis the analyst focuses on time periods (also known as window or snapshot).

This method analyzes the impacts of delays chronologically, starting with the first delay, by incorporating each delay (sometimes using a fragment- or subnet-works) into an updated CPM schedule. The analyst determines the amount of project delay resulted from each of the delaying activity successively by calculating the difference between the project completion date of the schedule after the addition of each delay and that prior to the addition (Ndekugri, Braimah, and Gameson, 2008).

(Alkass et al., 1996) note that this method is incapable of analyzing potential concurrent delays. The effect of concurrent delays is not immediately dealt with in this method since delaying events are analyzed separately. According to (Ndekugri, Braimah, and Gameson

2008), another drawback of the method is that it is time consuming and costly to operate, especially in situations with many delaying activities.

Despite some of the above mentioned drawbacks, (the Society of Construction Law, 2002) recommends this method. Time Impact Analysis is the most appropriate method for specifying the amount of time extension that the contractor should have been given at the time that an excusable risk appeared. However, in order to apply this method successfully, the daily records and diaries should be noted very meticulously and accurately. Otherwise, the analysis will not give correct results.

According to (Braimah, 2013) the limitations of this methodology are:

- It may not be practical or realistic to use if there are an overwhelming number of delay causing events.
- Periodic updates may not exist which may then require the analyst to perform highly laborious analysis of project records to create updates.
- The analysis requires intensive effort and is time consuming.

2.4.3 Other schedule delay analysis techniques

The study of (Nguyen, 2008) presented a new schedule delay analysis technique named as "FLORA which could control the dynamics of float, logic, and resource allocation in the analyses". The authors further indicate that this method examines both the direct impact of delay and also its secondary effect. On the other hand, (Alkass, 1996) conducted a study to discuss different delay analysis techniques which are currently being used in the construction industry. The authors also presented a new delay analysis method called the Isolated Delay Type (IDT). According to the authors, this new technique can be used as a standalone module for delay analysis or can be integrated within a computer system for delay analysis and construction claims preparation called "Computerized Delay Claims Analysis (CDCA)". In another field observation, (Kim, Kim, and Shin, 2005) made a study of delay analysis methods and introduced a new method called the "delay analysis method using delay section" (DAMUDS) in order to eliminate inadequate accounting of concurrent delay and time-shortened activities.

In the research of (Oliveros, and Fayek, 2005), the fuzzy logic model which combines daily site reporting of activity progress and delays with a schedule updating and forecasting system for project monitoring and control is introduced. Another research of (Lee, Ryu, Yu, and Kim, 2005) proposed a method for analyzing construction schedule delay in terms of lost productivity. They emphasize the necessity of a logical method for analyzing delays occurred by lost productivity in order to measure the delay time correctly. In the study of (Shi, Cheung, and Arditi, 2001), a different method which is not established on critical Path analyses are proposed for computing activity delays. The authors define this technique as "Construction Delay Computation Method" and add that this method may be combined with any delay analysis system in order to advance the process of delay analysis. (Kartam, 1999) has presented a generic methodology for analyzing and resolving delay claims which has been developed and successfully used by the author. The developed methodology has brought into question of while several techniques for analyzing delay claims there are, how much adequate these techniques.

Generally, In analyzing the delay activities of the schedule, the analysis method should be selected according to the appropriateness of the technique. However, determinants in selection of the technique depend on the availability of possible as-built information such as: project daily reports and diaries, meeting minutes, pay requests/estimates, inspection reports by the designer or owner, official correspondences, memos in the files, construction photographs taken at the site, and etc. The skill level of the analyst, relevant contract clauses, the nature of the schedule delays and the available time are the other determinants for choosing a delay analysis method. (SONGÜL, 2010))

2.4.4 Relevant Issues not Addressed by Existing delay identification techniques

In addition to the different results that existing DATs produce when applied to the same set of delay claims data, there are other relevant issues that have the potential of affecting the results but are often not taken into consideration in the techniques applications. These issues include: resource loading and leveling requirements, resolving concurrent delays, and delay pacing strategies.

1. Resource Loading and Leveling Requirements

The basic assumption underpinning traditional CPM program that resources are unlimited does not hold in reality as resources tend to be limited in most practical situations (Woodworth, Shanahan, 1988). It is thus quite important for baseline programs to be resource-loaded so as to ensure both reliable task duration and network logic, especially when many tasks require the same resources at the same time (Kuhn, 2007). Without such loading, the program to be used for delay analysis would not show realistic float values in its non-critical activities, and would thus affect the outcome of the analysis; especially for cases involving time extensions claims resolutions (Nosbisch and Winter, 2006). Therefore, a resource loading or leveling consideration in delay analyses is quite crucial to ensuring accurate and trustworthy results (Pickavance, 2010), except for the collapse as-built technique as it does not rely on baseline programs.

It is noteworthy that the need for analysts to take resource allocations into account in their delay analyses is becoming an increasingly vital requirement. (Wickwire, 2002) reviewed legal decisions in the US and noted that "in any analysis of project delays, the contractor is required to take into account realistic resource leveling". Although the incorporation of resource loading effects in the analysis represents a more accurate and rigorous assessment of delay claims, there is very little research on how this consideration can be incorporated in the existing techniques. There is thus the need for further research into this aspect of programming to help enhance the resolution of delay claims in practice.

2. Resolving Concurrent Delays

The identification and apportionment of concurrent delays remains a contentious technical subject. More debilitating is the fact that there is no uniformly accepted definition among practitioners as to what it concurrent delay itself means. A reliable approach for analyzing concurrent delays would involve using dynamic multiple time periods or windows, as this is capable of tracing changes in the critical path (Society of Construction Law (SCL), 2002). However, in such mode of analysis, identifying the concurrency and the type of concurrent delays within a given period will be dependent on the length of time chosen for the analysis period. Therefore analysts using different time intervals are bound to interpret a given concurrent delay situation differently. To enhance amicable settlement of claims, analysts would have to agree on the analysis time interval to be used, which can either be based on dates at which program updating occurred or the occurrence of key project events such as project milestone or major changes in the program. The legal aspects of concurrent delays concerning the kind of remedies to be offered to parties have also continued to remain a highly contentious issue. (Scott, 2004), for example, found that UK practitioners hold dissenting views to the SCL's recommended remedies (Society of Construction Law (SCL), (2002), which stipulate that, for employer and contractor delays occurring concurrently, the parties should share the responsibility between them and extension of time without costs also awarded. In addition, existing case laws that could offer some guidance on the remedies do not speak in harmony (Martin, 2002). This lack of consensus or clearly defined rules/methods for dealing with remedies of concurrent delay types poses great difficultly to practitioners in delay claims resolution. There is therefore the need for research into the underlying principles that governs the legal resolution of concurrent delays to establish clear guidelines for dealing with all possible concurrency situations. Employers may subsequently incorporate these in their contracts for it to guide claim parties during delay claims resolutions.

3. Pacing Delays

(Zack, 2000) defined this as "deceleration of the project work, by one of the parties to the contract, due to a delay to the end date of the project caused by the other party, so as to maintain steady progress with the revised overall project schedule". The thinking behind pacing delay is that it is sensible for a party to slow down the working pace if a delay by other party makes it unnecessary for hard or fast working, as often memorably argued, "Why hurry up and wait". It enables the contractor or the employer to mitigate or avoid cost that otherwise would have been incurred had the work been done faster. However, there are difficulties in exercising the right to pace delays, which can affect the delay analysis process. For instance, float ownership, will determine whether a particular contractor-caused delay could be a potential employer's defense of concurrent delay or otherwise. Furthermore, as argued by (Zack, 2000), pacing delays tends to minimize compensable delay and this makes it imperative to consider its effect in delay analysis process to ensure fairness in the apportionment of delay responsibility. Further studies are thus needed to offer assistance on how to resolve these issues.

2.4.5 Introducing model for selecting appropriate delays analysis technique

The findings reported in the previous literatures with respect to delay analysis methods suggest that there is no industry wide agreement in which methodology should be employed in delay claims.

Unfortunately the contractual agreement signed between ERC (the owner) and CREC (the contractor) to build the city's light rail transit does not specify the method that should be adopted to perform delay analysis; either in the course of the project or after. But considering the number of acceptable delay analysis methods available for use, such specifications should be important. As the contract type is EPC TURNKEY, it just specifies the cause of delays so as to award the contractor with time extension or money compensation.

Any delay due to:

a) Additional work referred to in the Contract,

b) Suspension of work (without any default or negligence on the part of the Contractor),

c) Any act or default on the part of the Employer,

d) Any act or default on the part of the Employer's other sub-contractor working on Site(s) or,

e) Any Force Majeure event,

f) Any exceptional adverse weather conditions, such as rainstorm or other special circumstance of any kind whatsoever which may occur, other than through a default of the Contractor,

g) Any cause of delay referred to the Contract will fairly entitle the Contractor to an extension of time for the completion of the Works.

If the delay is due to the Employer, except;

a) Suspension of work (without any default or negligence on the part of the Employer).

b) Any act or default on the part of the Contractor,

c) Any act or default on the part of the Contractor's Sub-Contractor working on Site(s) or,

d) Any Force Majeure event,

e) Any exceptional adverse weather condition, or other special circumstance of any kind whatsoever which may occur, other than through a default of the Employer,

The Employer shall compensate the Contractor on a mutually agreed basis for extra cost. ((ERC turnkey contract for AA E-W and N-S phase 1) LRT project, particular conditions, sub clause 8.7, 2009)

The above clause states certain causes will award the contractor with time extension and some will award the contractor with money compensation. The contract states there should be a mutual agreement but doesn't specify the analysis methodology. Claim experts and analysts therefore usually adopt their own delay analysis methods for proving or disproving the claims based on their accumulated experience, expertise and intuitions (Kumaraswany and Yogiswaran, 2003). This will call for disputes mainly because the various delay analysis methods produce different results when applied to a given claim situation.

As (Bubshait and Cunningham, 1998) put it, the only solution for this problem is the recommendation that the best methodology for any situation should be selected based on a number of criteria. However, apart from the fact that the criteria vary from analyst to analyst, they are qualitative, subjective and imprecise in nature making their use in methodology selection open to challenge. There are no standard guidelines or approaches that can help analysts in this to insure a more objective selection process.

Inspired by the need to address this problem several researches tried to develop models of analysis; the one introduced here in after is the model developed by (Braimah, 2008); was found to be applicable to the situation of our country.

The model is intended to serve as a tool assisting analysts in identifying their choice of delay analysis methods. Apart from delay claim letters, as seen on the questionnaire and interview surveys, most analysts will always prefer simple and inexpensive methods than complex and expensive ones. The as planned VS as built method was the preference than other standard mechanisms for its simplicity. But the decision to select the best methodology cannot be resolved by using simple decision rules. It rather requires the use of a decision model which enables analysts to trade off the available selection factors against the various delay analysis methods. Hence, for adopting delay analysis models, reliable decision making tools should be selected.

Decision making is the process of making a correct decision by choosing the one alternative from among those that are available. Deciding delay analysis is governed by the availability of possible as built information, skill level of the analyst, relevant contract clauses, and the nature of schedule delays and available time (SongÜl, 2010). In order to come up with the relating factors and governing decisions, multi-criteria decision making was introduced over the years. The following table summarizes characteristics of different decision making tools.

Technique	Nature of input data	Nature of output
Scoring multiattribute analysis	Interval and ordinal but subjective	Numeric score and ranks and hence rank amongst alternatives
Multi-attribute utility theory	Raw data is often qualitative, utility achieves interval data	Numeric score and ranks and hence rank amongst alternatives
Multiple regression	Interval predictive	Numeric; further value
Linear programming	Value judgement on the importance of an over-all objective	Maximisation of objective function
Cluster analysis	Multivariate	Group membership/group characteristics
Multivariate discriminant analysis	Multivariate	Group membership/group characteristics

Table 2.7: **Characteristics of decision-making tools (Holt, 1998; Greening and Bernow, 2004)**

Considering the governing factors and the above characteristics of decision making tools, the most suitable to use is the multi-attribute analysis. Multi-attribute analysis is a decision making tool which can either be scoring multi-attribute analysis (SMAA) or multi-attribute utility theory (MAUT), each shall be discussed below

A. Scoring multi attribute analysis: this is a technique for evaluating multi-criteria decision problems to identify the best decision alternative from several well defined alternatives (Finlay, 1994). (Anderson, 2005) have spelt out the analysis involved in the technique in clear steps as follows

   i. Develop a list of criteria to be considered, which are relevant for evaluating each decision alternative
   ii. Assign a weight to each criterion that describes the criterion relative importance. Let Wi=weight of criterion i, which may be a function of sole practitioners experience, group consensus opinion and analysis of data. (Holt, 1998)
   iii. Assign a rating for each criterion that shows how well each decision alternative satisfies the criterion. Let Rij= rating for criterion i and decision alternative j.
   iv. Complete the score of each decision alternative, Sij= $\sum \omega \iota$Rij, Sij is the score of decision alternative
   v. Order the decision alternative from the highest to the lowest to provide the scoring model's ranking of the decision alternatives. The decision alternative with the highest score is the recommended decision alternative.

B. Multi attribute utility theory (MAUT): it is similar to SMAA, except it uses 'utility' to quantify the subjective components of the attributes. It refers to measures of desirability or satisfaction of an attribute of the alternative under consideration.

   MAUT is expressed mathematically as: Sij= $\sum \omega \iota$Uij, where Uij represents the abstract equivalent expressed in utilities for the ith attribute of the jth alternative.

The wide attribution of Multi-attribute analysis (MAA) tools in one form or the other by a number of researchers in the construction industry is an indication that the tools are particularly suitable for construction decision problems. Examples of such applications include the use of SMAA for the analysis of design/build contract evaluation (Janssens, 1992) and the use of MAUT for the selection of an item of plant (Haris and Mc Caffer, 1991).

The fact that SMAA is well defined and easily understood tool, especially with regard to the application of the attributes and selection criteria, make its use more suitable than MAUT (Greeing and Bernow, 2004).

The following figure indicates the MAA process of decision making

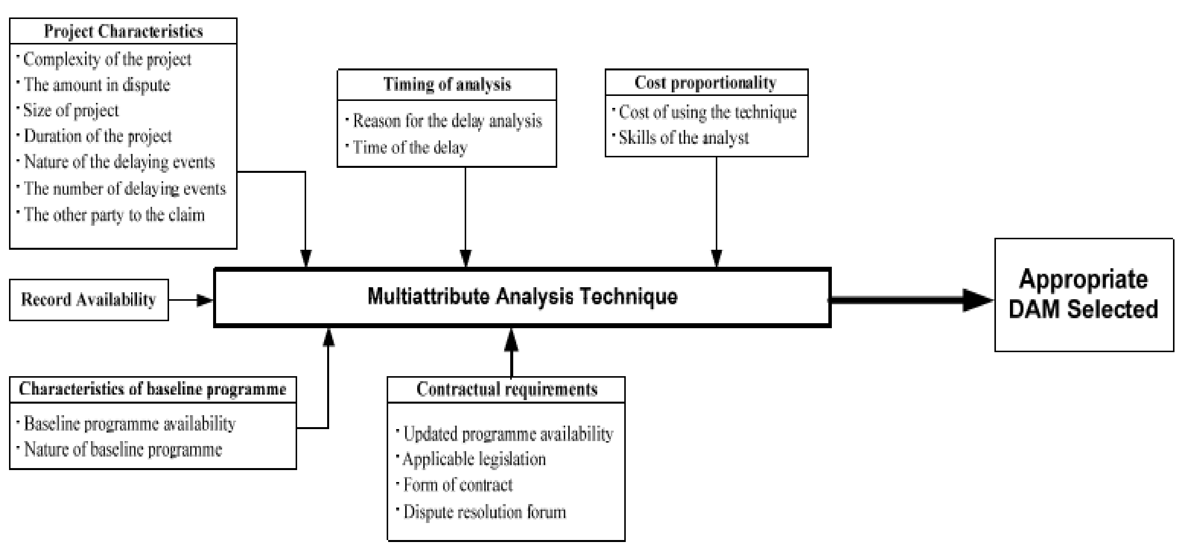


Fig.2.8 MAA process of decision making

2.4.5.1 Construction of DAM selection model

According to (Kepner and Tregoe, 1975), there are seven factors that are essential in decision making. These factors, in their order of consideration, are: establish the overall objectives which are essential or desirable; classify the objectives according to importance; establish alternatives choices; evaluate the outcome for each alternative; choose the best alternative as the preliminary decision; re-evaluate the decision and assess the adverse possibilities of that choice and finally, set up contingency plans to control the effects of the final decisions. Tuning this framework to the problem of DAM selection coupled with the procedure set out for SMAA, Figure 2.9 is proposed as the flow chart describing the procedure involved in developing the model.

2.4.5.2 Identification of DAMs and selection criteria

This requirement was achieved via literature review on DAMs in the previous chapters. These chapters highlighted the existing methodologies for analyzing delays and the relative importance of the criteria for selecting the appropriate one for any given claims circumstances. The most commented upon DAMs are As-planned Vs as-built, impacted as-planned, Collapsed as-built and the Time impact analysis/Window analysis. The model was therefore designed for selecting a methodology from among these. The generic selection factors (or criteria) are: Project characteristics, Contractual requirements, Characteristics of baseline programmed, Cost proportionality, Timing of the analysis and Record availability.

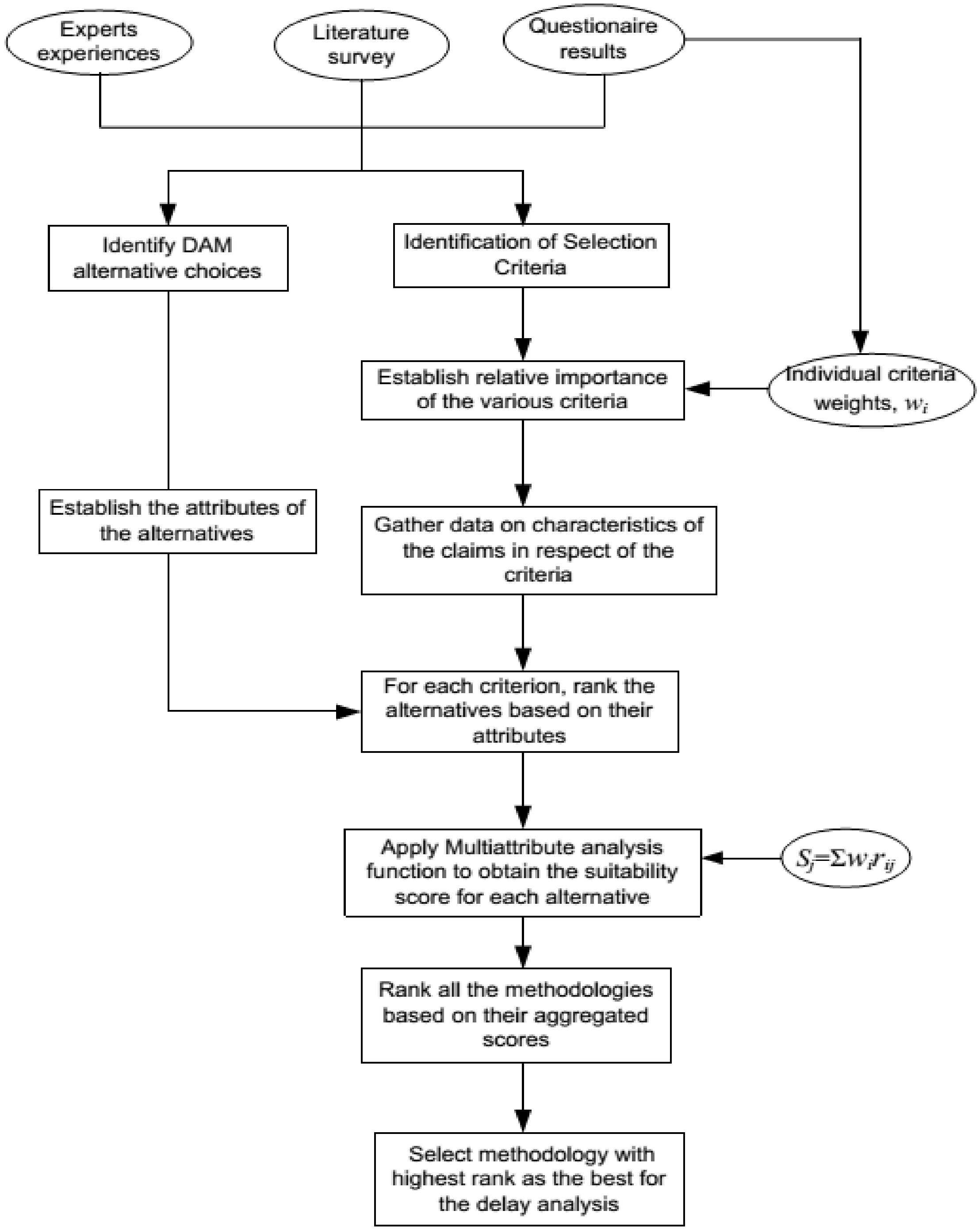


Fig. 2.9: flow chart model for the selection of DAM

The basic steps followed in the above model are summarized by Nuhu Braimah, 2008 as follows

1. ***Gathering data on selection criteria***

To be able to rank the competing methodologies against the various selection criteria, data in respect of these criteria will have to be gathered and analyzed. The sources of this data are the claims itself, the contract document, project as-built records and other project documentations.

2. ***Rating of DAMs in respect of the selection criteria.***

This step involves rating the suitability of the various methodologies successively against each criterion in reflection of the extent to which the method is suitable to use given the criterion under consideration, using a scale of 0-1; "1 for very suitable" and "0 for not suitable". The various methodologies have different attributes which have to be determined against the selection criteria to facilitate their rating. Some of the criteria have sub-criteria that can be attributed to them so to assign rates to such criteria; each sub-criterion would have to be considered and assigned a rank.

For such criteria, the score can be calculated mathematically as:

$$SCX_j = scx_{1j} + scx_{2j} + \dots scx_{nj} \quad \text{................Eq. 1}$$

Where SCX_j = criteria score for methodology j;

$scx_{1j\dots\dots nj}$ = sub-criteria scores attributable to criteria X for methodology j. These are equally weighted with the constrain that $\sum scx_{nj} \leq 1$.

The problem, however, with the rating here is the fact that some of the criteria are intangible and also have different units of measurement making it difficult to evaluate them. Therefore to facilitate the rating process, the means or approaches by which each of the selection criteria could be evaluated has been presented as follows.

Records availability

Table 2.8 shows the type of project information required for the use of the various DAMs. To rate a methodology, the question to ask is: ***Is there enough project information for the use of this methodology?*** Using Table 2.8 as a guide, the percentage of information available for the proper use of the methodology is calculated to represent the methodology's suitability rating on this criterion.

Record	As Planned vrs As Built	Impacted As Planned	Collapsed As Built	Window analysis
Outline of delay events	✓	✓	✓	✓
Start dates of delay events	✓	✓	✓	✓
Finish dates of delay events	✓	✓	✓	✓
Activities affected by delays			✓	✓
Duration of delay events	✓	✓	✓	✓
Original Planned completion date (or as extended)	✓	✓		✓
Actual completion date	✓		✓	✓
As-Planned critical path(s)	✓	✓		✓
As-built critical path	✓		✓	
Updates critical or near critical path(s)				✓
Update or Schedule revision dates				✓
Activity list with logic and lag	✓	✓	✓	✓

Table 2.8: Important project information required for the application of DAMs

Base line availability

Some methodologies require baseline program for their implementation while others do not. The question here is: ***Is there a baseline program***?

If **yes**, score "1" for methodologies that need this program for implementation.

If **No**, score "0" for such methodologies

Nature of baseline program

It is not enough for a baseline program to be just available; the program would have to be reliable in terms its completeness (i.e. showing all project activities), activity durations, details and relationships. These sub-criteria are defined in Table 2.9 below. The question to ask in rating a methodology is: ***Does the baseline program satisfy all these sub-criteria?*** A methodology is then rated by calculating the percentage of sub-criteria that are adequately catered for by the baseline program.

	As Planned vrs As Built	**Impacted As Planned**	**Collapsed As Built**	**Window analysis**
Baseline programme available	✓	✓		✓
Nature of Baseline programme				
Available in CPM	✓	✓		✓
Includes all relevant activities	✓	✓		✓
Reasonable activity durations	✓	✓		✓
Reasonable activity relationships	✓	✓		✓
Activities defined in appropriate detail	✓	✓		✓

Table 2.9: Main programming requirements of DAMs

Updated program availability

Table 2.10 outlines important program updates required by the various DAMs. The question here is: ***Are these program updates available?*** A methodology is then rated as the percentage of updates that are available for its use.

Table 2.10 Relevant programs updates for DAMs application

Updated programmes availability	**As Planned vrs As Built**	**Impacted As Planned**	**Collapsed As Built**	**Window analysis**
Intermediate regular programme updates available				✓
Final updated programme available (as-built programme)	✓		✓	✓

Applicable legislation

The contract may be governed by certain legal procedures or rules which are required to be followed by the disputing parties when resolving disputes. This can constrain the methodology to be used. So in rating a methodology, the question is: ***Is the use of the method affected by certain legal procedures or rules which ought to be followed in the claims settlement process****?* If **Yes**, rate the methodology 0.0, otherwise rate it 1.0.

Form of contract

Most of the contracts used in our country do not state the methodology to be used for analyzing delays. However, certain contractual provisions may constrain the methodology to adopt; typical of which are provisions regarding relief (in the form of time extensions) from liquidated damages for employer risk events. The question here is thus**:** ***What are the terms of contract in relation to entitlement to extensions of time as a result of delay events that are at the employer's risk?*** On this, most forms of contract can be classified into two:

(a) Contracts that provide that the contractor is only entitled to time extension for delays that actually cause delay to completion and

(b) Contracts that provide that the contractor is only entitled to time extension for the likely effect of the delays.

Retrospective DAMs are suitable for case (a) and so should be rated 1.0 if the contract stipulates so and 0.0 for prospective methods. Opposite rating should be accorded in case (b).

Dispute resolution forum

Delay claims have been settled in negotiation, mediation, adjudication, arbitration or litigation. The Analysts experience with these forums will give some information as to the extent of acceptability or reliability of various DAMs in their use in these forums. So the question to ask is: ***Is the methodology used/adopted in the previous forums likely to settle the disputes?*** If **Yes** or not known, rate it 1.0, otherwise rate it 0.0.

The reason for the delay analysis

Table 2.11 shows the capabilities of the methodologies in proving important delay claims issues. The question that will facilitate rating here is**: *What are the issues of entitlement to be proved in the dispute?*** Using Table 2.11 as a guide, a methodology is rated as the percentage of claims issues that it is capable of proving. For example a rate of 1.0 should be accorded if it is capable of proving all these issues.

Claims issue	As Planned vrs As Built	Impacted As Planned	Collapsed As Built	Window analysis
Extension of time	✓	✓	✓	✓
Prolongation cost	✓		✓	✓
Acceleration effects				✓
Disruption effects				✓

Table 2.11 Capabilities of DAMs in proving common delay claims issues

Time of the delay

The time of occurrence of the disputed delay event(s) relative to the current stage of the project determines whether a retrospective or prospective methodology should be used. The question to ask is: ***Is the methodology being used to assess delay before its actual occurrence?*** If **yes**, then prospective methodology is appropriate and thus should be rated 1.0 and retrospective methods 0.0. Opposite rating should be allotted if the delays are being analyzed after they have occurred.

Project characteristics criteria

These criteria include complexity of the project, the amount in dispute, size of project, duration of the project and number of delaying events. More sophisticated methods are warranted for instances where these characteristics are assessed to be high.

Figure 2.10 compares the suitability of the various DAMs against several project characteristics criteria. To rate a methodology for each of these criterion, a number on the 1-10 scale is first selected in reflection of the characteristics of the project in dispute. A vertical should then be drawn through this number and the methodology that falls in line with this vertical or very close to it will be the most suitable method with a rate of 10/10 = 1.0. The other methods are rated in proportion to their relative positions to this vertical.

Scale	1	2	3	4	5	6	7	8	9	10
	Very insignificant		Insignificant		Moderate		Significant		Very significant	
Size of project (in terms of contract sum)	<£500k		£500-£10m		£11m-£49m		£50m-£100m		>£100m	
Duration of project	<6 months		<6-12 months		<1-3 years		<4-6 years		>6years	
Number of delay events	<5		5 – 10		11- 20		21–50		>50	
Amount in dispute	<50k		50k-199k		200k-499k		500k-1m		>1m	
Complexity of project (in terms of activity relationships)	Very low		Low		Moderate		High		Very High	

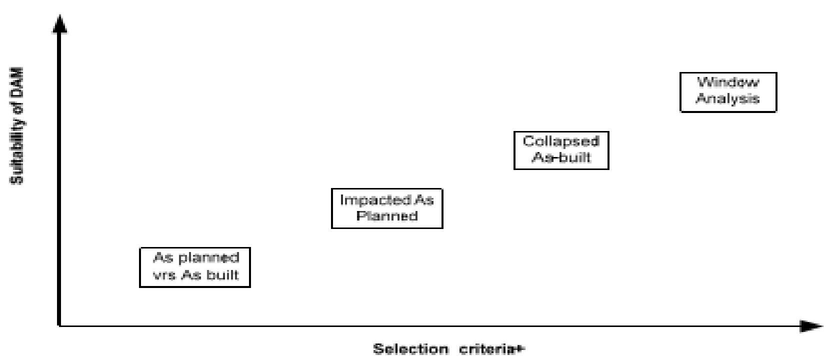


Figure 2.10 Suitability of DAMs against project characteristics criteria

Nature of delaying events

The nature of the delays experienced also makes the use of certain methodologies more appropriate than others. The sophisticated methods are capable of dealing with more complex situations than the simplistic ones. The capabilities of the various DAMs in dealing with typical characteristics of delays are shown in Table 2.12 to rate a methodology, the question is: ***Which of these characteristics best describe the delays encountered?*** Using Table 2.12 as a guide, the percentage of delay characteristics that a given methodology is able to handle is calculate to represent the suitability score for that methodology.

Characteristics of the delay	As Planned vrs As Built	Impacted As Planned	Collapsed As Built	Window analysis
Delays occurred concurrently with others				✓
Delays caused much changes in construction logic				✓
Cause of delay is clearly definable	✓	✓	✓	✓
Delay caused productivity losses				✓
Delay caused acceleration				✓
Delays limited to specific definitive activities	✓	✓	✓	✓

Table 2.12 Capabilities of DAMs in dealing with important characteristics of delays

The other party to the claim

Experience with the other party in previous claims matters or in prior settlement of the claims in question could inform the analyst of the extent to which the various DAMs are suitable to use. The question to ask in rating each methodology is thus: ***Has the methodology been used in prior settlement of claims dispute with the other party with success?*** If **Yes**, rate the methodology 1.0, otherwise rate it 0.0.

The skills of the analyst

Analysts are likely to incline toward the methodology which they are more knowledgeable and abreast with than those that they have very little experience with its use. Therefore the question to ask here is: ***Does the analyst have the required knowledge and skills for implementing the methodology being rated?*** If **yes** rate 1.0, or else rate 0.0.

Cost of using the technique

To rate a methodology on this criterion, the question to ask is: ***Is the expense involved in using the methodology within what is budgeted for?*** If No, rate the least expensive method 1.0 (as it's the most suitable) and the most expensive as 0.0. Figure 2.10 provides a guide on the cost of using available DAMs relative to each other.

3. Computing suitability scores for the methodologies

Having rated the methodologies against each of the selection criteria, the next stage is to compute their respective total suitability scores using the equation: Sij= SwiRij where the terms have their usual meanings as defined before. These scores can be obtained easily by tabulating the individual scores for each criterion as indicated in Table 2.13. The fourth column of this table shows the weights (*wi*) of the various criteria as calculated by normalizing importance ratings responses obtained from the questionnaire survey. Column 5 shows their respective ratings. The total suitability score for each methodology is obtained by summing up all the entries in Column 6

4. Selecting the most appropriate methodology

Following the computation of the total suitability scores for each DAM, the next step, which is the last, is to rank the various methodologies based on their total scores. The methodology with the highest score and ranks highest should thus be selected as the most appropriate methodology for the delay analysis.

Table 2.13 Computation of suitability scores of DAM

Group Factor	Selection Factor	Rank index	Weight	Rating	Score
Record availability	Record availability	97.5	1.0	Rd_1	$1.0xRd_1$
Baseline programme characteristics	Baseline programme availability	84.1	0.86	Rb_1	$0.86xRb_1$
	Nature of Baseline programme	71.5	0.73	Rb_2	$0.73xRb_2$
Contractual Requirements	Updated programmes availability	69.8	0.72	Rc_1	$0.72xRc_1$
	Applicable legislation	36.5	0.37	Rc_2	$0.37xRc_2$
	form of contract	59.2	0.61	Rc_3	$0.61xRc_3$
	Dispute resolution forum	54.4	0.56	Rc_4	$0.56xRc_4$
Timing of the analysis	Reason for the analysis	61.8	0.63	Rt_1	$0.63xRt_1$
	Time of the delay	62.0	0.64	Rt_2	$0.64xRt_2$
Project characteristics	Project complexity	65.8	0.67	Rp_1	$0.67xRp_1$
	The amount in dispute	73.1	0.75	Rp_2	$0.75xRp_2$
	Size of the project	50.9	0.52	Rp_3	$0.52xRp_3$
	Duration of the project	45.1	0.47	Rp_4	$0.47xRp_4$
	Nature of delaying events	64.6	0.66	Rp_5	$0.66xRp_5$
	Number of delaying events	66.1	0.68	Rp_6	$0.68xRp_6$
	The other party to the claim.	44.7	0.46	Rp_7	$0.46xRp_7$
Cost Proportionality	Cost of using method	58.0	0.59	Rs_1	$0.59xRs_1$
	Skills of the analyst	65.3	0.67	Rs_2	$0.67xRs_2$
				Total score	$S_j = \sum w_i r_{ij}$

Limitations and Capabilities of the model

A major limitation of the model is the fact that the rating of the methodologies against each of the selection criterion requires many subjective decisions. To minimize this subjectivity and ensure that the model generates reliable results it is suggested that the analysts consult with relevant parties to discuss rating issues and agree on the rate to be assigned for each methodology. Another important concern is the need for analysts to consider all the selection factors in the model, although in some claims cases not all factors will be applicable or relevant. Notwithstanding these limitations, the model provides analysts with a comprehensive framework for selecting the right DAM for any claims situation. By this, they can justify their choice of a methodology to their client or tries-of-fact in a rational and balance manner. For better understanding the model is applied to the LRT case study scenario.

CHAPTER THREE

Thesis methodology

This chapter addresses the research methodology adopted for capturing the data needed to achieve the aim and objectives of the research. It is organized in sections covering research designs and methods adopted; scope of the literature reviewed; data collection methodologies adopted; and methods used in analyzing data.

3.1 Research design and methods adopted

A study design is a means of providing a plan of frame work for data collecting and analysis. The nature of the research topic, its aims and objectives and the resource available largely determine its design (Gill and Johnson, 2002; Creswell, 2003)

The basic questions that needs to be addressed in this thesis were identified from the objectives, these questions are

- Has the LRT construction project been exposed to schedule delays so far? If so, what were the major contributing factors to such delays?
- How best can claims related to delays be administered in the Addis Ababa LRT project?
- What is the existing delay analysis methodology, if there is any?

These criteria determine the methodology adopted in carrying out this research. As a result of the diversity in the types and sources of data required for answering these questions, the study used data which are qualitative and quantitative in nature. From the two main categories of design; observational and experimental, the study was found to be observational for the minimum intervention of the researcher. Several literatures related to the aims and objectives of the research were reviewed to provide sufficient explanation about delay and delay related issues by considering past and present events in relation to the case of construction of the LRT. This further classified the research design into descriptive explanatory case study.

3.2 Population and Sampling

The population selected was based on the participants' experience in the construction industry especially in the railway sector. Since the number of available sources was very limited, the total population (twenty in number) was used in the questionnaire survey and off of these, four participants were selected for a follow up interview. These four were selected based on their current participation in handling the LRT project and claims in relation to the project.

3.3 Data collection methodologies adopted

Any research uses either or both of primary and secondary data. The primary data is the original information collected by the researcher for a specific purpose and secondary data is information collected by others. This study makes use of both the primary and secondary data. The secondary data were obtained from internal and external sources. Internal sources such as ERC's and CREC's reports, designs, schedules' contractual documents and other legal documents.

Apart from observation, questionnaire was used as a primary information collecting tool. The survey was designed to ensure that it elicits useful responses to the questions raised. This was achieved by making sure the questions were easily readable and understandable by the respondents, short, well organized and few.

In view of the nature of feedbacks, it was resolved that the questionnaire be designed to contain both open ended and closed ended questions. Having their own advantages and disadvantages, combining them (open and closed) was essential by reducing or eliminating the disadvantage of each whilst gaining their advantage. The questionnaire therefore contains multiple choice questions requiring ticked-box responses and open ended questions. Provisions were also made for respondents to contribute in free text forms any further comment or views they have in respect of each question. A copy of the final version of the questionnaire is indicated in the appendix. In order to reinforce the results of the questionnaire, interview and data from archival reports were collected.

3.4 Data analysis

The questionnaire surveys and interviews were analyzed in relation to the theoretical propositions. The fact that the number of respondents is few didn't allow the use of extensive descriptive statistics. Instead, tabular presentation followed by discussions and reports is used. The analysis is conducted in perspective with the research objectives and follows the topics of causes of construction delays, delay exposition of the LRT and delay claim administration.

Furthermore, the previously adopted model for selecting delay analysis technique was applied to the case of the LRT.

CHAPTER FOUR

Analysis and findings

4.1 Introduction

These surveys employed a questionnaire and an interview in collecting data on schedule delay and delay claims on the LRT construction project from employing, contracting and consulting organizations of the LRT project. The questions contained in the questionnaire were informed by the review of the literature reported on chapters one and two. Further clarification on the method of delay analysis and identification was required, and so, few key persons on project management and claim administration were selected for an interview. This chapter presents the results and analysis of the responses to individual questions in the lights of comments made on delay and delay analysis by researchers and experts and is produced by grouping the questions under the following headings.

Heading Group

1. Survey responses
2. Characteristics of the respondents and organization
3. Causes of construction delays
4. Delay exposition of the LRT
5. Delay claim administrations

4.2 Survey responses

Out of the 20 questionnaires sent out a total of 18 questionnaires were returned and which only 14 were properly completed that could be used for analysis. For the others (non returned questions), respondents stated that either they are not risking their jobs for privacy or confidentiality reasons or have little experience in delay and delay claim analysis. This results a response rate of 70%. Out of these 20 participants, 4 of them were again selected for a follow up interview in which all of them participated.

4.3 Characteristics of the respondents and their organization

Table 4.1 shows the distribution profile of the respondents' organization in terms of type, size and designation. Here, it is important to note that the contracting group was not willing to accept any questionnaire.

Table 4.1: Respondents organizational profile

no	type of organization	percent
1	Ethiopian Rialways Corporation	71.43
2	SWEROAD (consulting firm)	28.57

Table 4.2: Respondents designation

no	Designation	percent
1	Project Engineer	28.57
2	Contract Engineer	28.57
3	Quantity surveyor	35.71
4	sociologist	7.15

Consulting firms were not well represented. This low response is probably because they are not willing to give out information or do not actively carry out most of the decisions on delays and delay related claims due to the contract type.

With regard to the size of the respondents, as the survey indicates a narrow range of spectrum, it was due to the specificallity of the research topic and the newlines of the considered construction project.

The designation of the respondents shows a relatively wider Varity of professionals which are relevant to the schedule delay analysis. The respondents have been acting as senior project managers, quantity surveyors, contract administrators and sociologists.

Table 4.3 below shows the experience of the respondents in percent both in the construction and railway sectors with regard to a number of relevant functions.

Table 4.3: Experience of respondents in the construction in general and in railway sectors

function	years of experience				
	0	1 to 3	4 to 6	7 to 9	>10
in the construction sector					
site management			2	1	1
claim preparation		1	1	1	
contract management		1		3	
planning and programming			2		1
estimating and measurment			3	2	
in the railway sector					
site management		4			
claim preparation		3			
contract management		4			
planning and programming		3			
estimating and measurment		5			

As can be seen the average years of experience in the railway sector on all of the relevant functions is 1-3 years. This suggests that most/all of the respondents were participating in the sector since the start of the LRT construction project (3 years already) and thus were ideally suited to comment on the issues dealt within the survey.

4.4 Perception o the respondents on Causes of construction delays in Ethiopia

Delays in construction projects are a universal phenomenon. They are almost always accompanied by cost and time overrun. Construction project delays have a debilitating effect on parties (owner, contractor and consultant) to a contract in terms of a growth to adversarial relationships, distrust, litigation, arbitration, cash flow problems, and a general feeling of apprehension towards each other. To investigate the extent to how much construction is susceptible to delay in Ethiopia, respondents were asked to mark their level of agreement with the question

'Do you think construction is often susceptible to delay in our country, Ethiopia?'

Using three options, yes, no and I don't know. Table 4.4 shows the result; which suggests 100% of the respondents from either construction or consulting firms are in agreement with the question.

Table 4.4: construction's susceptibility to delay in Ethiopia (respondents' perception)

options given	employer		consultant	
	percent	cummilative	percent	cummilative
yes	100	100	100	100
No	0	100	0	100
I don't know	0	100	0	100
total	100		100	

An important consideration in the design of a frame work for improving construction delays is identifying the reasons that often cause such delays in the industry. In this respect respondents were asked to rate the frequency by which a number of reasons have each been the cause of delays, using four points scale (high, medium, low and rare). Participants were also asked to add to the list any other reasons they consider relevant. Table 4.5 shows a summary of the results.

Table 4.5: Cause of construction delays in Ethiopia (respondents' perception)

no	Cause	Frequency checked				Grade*	Rank
		high	medium	low	rare		
1	Financial problems	14				56	1
2	Contractor's ability	10	3	1		51	2
3	Managerial problems	7	2	5		44	3
4	Consultant's weakness		12	2		40	4
5	Government's construction policy	2	6	5	1	37	5
6	Design difficulty	1	6	7		36	6
7	Lack of awarness and understanding	1	6	6	1	35	7
8	Natural causes	2	3	8	1	34	8

(*, grade is given by multiplying the number of responses with the corresponding credits high= *4, medium= *3, low= *2 and rare= *1)

Participants added corruption and unclear/conflicting contractual agreement to the above list.

As can be observed from the table, the three most likely causes of delay in Ethiopia are financial problems, managerial problems and contractors' ability. These issues therefore require more attention in researches aimed at reducing construction delays.

4.5 Delay exposition of the LRT

In order to strive for better development prospects, Addis Ababa, as a capital of Ethiopia, launched the urban rail traffic projects at the beginning of 2008, and initially planned two light rail lines, namely E-W and N-S corridor. (China railway group limited (2009))

Since its commencement in 2012, LRT construction of Addis Ababa has shown a major progress. As mentioned earlier, almost all constructions in Ethiopia are susceptible to delay. To confirm the validity of this idea as a justification, or otherwise for the need to seek current progress of the LRT project, respondents were asked

'Has the LRT construction project been exposed to delay so far?' Table 4.6 shows the result

Table 4.6: proposition that if the LRT project has been exposed to delay so far

option	employer	consultant
	percent	percent
Yes	90	100
No	10	
total	100	100

The results suggest that more than 85 percent of the respondents agree the LRT construction is exposed to delay so far. This implies delay continues to pose great challenge for construction projects. Thus there is much to study on this area.

Respondents were also asked how they identified the delay and 90 percent of the respondents who said yes answered to the options provided. They were also asked to add to the list other options.

Table 4.7 summarizes the response as to how the participants determined/identified the delay.

delay identifying options	%age of respondents checking*
standard mechanisms **	
as planned VS as built	21.40%
impacted as planned	7.15%
As planned but for	
Collapsed as built	
Window analysis	
Time impact analysis	7.15%
Due to delay claim letters	64.29%

* respondents were allowed to check multiple options
** explanation for each of the standard mechanisms were provided

the respondents considered or identified the project to be delayed because they were handed over delay claim letters by the contractor. In addition, as the table shows, standard mechanisms mainly as planned Vs as built methods were also used.

The extent or volume of delay encountered so far on the project's completion date was also asked. Given 5 point scale (where '0-2.5%' = very low, '2.5-5%'= low, '5-7.5%'= medium, '7.5-10%'= High and '>10%'= very high), table 4.8 below shows the respondents result. It suggests more than half of the respondents think the delay encountered so far is at a medium extent on the overall project's end date. But there's also a probability of it being either low or very high according to the responses.

Table 4.8: extent of delay so far on the project's end date

	delay extent				
	0 to 2.5% (very low)	2.5 to 5% (low)	5 to 7.5% (medium)	7.5 to 10% (high)	>10% (very high)
Percentage checked		14.29%	57.14%		7.14%

Here also, causes of such delays were asked. The respondents were given a list of causes based on sources of literature under major grouping of the major participating parties. (Contractor's, consultant's, owner's and external factor's responsibilities)

In this respect, respondents were asked to rate the frequency using four point scale (high, medium, low and negligible). Participants were also asked to add to the list any other reasons they consider relevant. Tables below show summary of the results.

Table 4.9: Cause of delay in the LRT construction, contractor's responsibility

	cause	frequency checked				Grade*	Rank
		High	Medium	Low	Negligible		
1	Financial problems	8	3	1		43	1
2	Poor site management		10	2		34	2
3	Delay in delivery of materials on site	9	3			33	3
4	Shortage of materials on site		9	3		33	3
5	Equipments and tools shortage on site		6	6		30	5
6	Construction mistakes and defective works		5	7		29	6
7	Poor skill and experience of labour		2	10		26	7

* grade is given by multiplying the number of responses with the relevant credits
high= *4, medium= *3, low= *2 and negligible= *1

Respondents also added the LRT contractual agreement (with it being turnkey), as a cause for delays. The result suggests that the three most likely causes of delay by the contractor are delay in delivery of material on site, poor site management and shortage of material on site. Therefore, in future railway constructions or expansions the above points should be addressed properly.

Table 4.10: causes of delays in the LRT construction project, consultant's responsibility

	cause	frequency checked				grade*	rank
		high	medium	low	negligible		
1	Incomplete documents	1	10		1	35	1
2	Delayed and slow supervision in making decisions		8	3	1	31	2
3	absence of consultant's site staff		3	8	1	26	4
4	lack of managerial experience and supervisory personnel		7	5		31	2
5	lack of experience on the part of the consultant as a company		2	10		26	4

(* grade is given by multiplying the responses with the corresponding credits)

Table 4.11: cause of delay in the construction of LRT, owner's/ employer's responsibility

	cause	Frequency checked				Grade	Rank
		High	Medium	Low	negligible		
1	site hand over and right of way	8	3	1		43	1
2	financial problems (delayed payments, financial difficulties and economic problems)	8	3	1		43	1
3	slowness in making decisions	2	7	3		35	5
4	lack of coordination with contractors	4	4	4		36	3
5	contract modifications (replacment and addition of new work to the project and change in specifications)	1	10	1		36	3
6	Lack of working knowledge		3	9		27	6

(* grade is given by multiplying the responses with the coresponding credits)

Table 4.12: Causes of delays in the LRT construction, External factors

cause	frequency checked				grade*	rank
	High	Medium	Low	negligible		
1 external work due to public agencies (road, utilities and public service)	9	3			45	1
2 transportation delays	9	2	1		44	2
poor economic conditions (currency, inflation..)	6	5	1		40	3
3 lack of material, equipment and tools on the market		4	8		28	5
4 Poor site condition (location, ground)		5	7		29	4
5 change in laws and regulations		4	5	3	25	6
6 poor weather condition		1	11		25	6

(* grade is given by multiplying the responses with the corresponding credits)

From the results, table 4.10 shows the causes of delays on the project where the consultant takes the responsibility. Incomplete documents, delayed and slow supervision in making decisions and lack of managerial experience and supervisory personnel were the main causes selected by the participants.

Table 4.11 summarizes causes of delays derived by owner/employer. Site handover and right of way, financial problems (delayed payments, financial difficulty and economic problems) and lack of coordination with contractors were the leading causes. Between November 2012 and August 2013, the contractor (CREC) wrote 12 letters to the employer (ERC) regarding delay claims.

All the claimed delays were due to delay on land handover. On the letters it was noted the delayed site handovers would delay the project schedule by 106 days.

Table 4.12 summarizes participants' response to causes of delays by external factors and external work due to public agencies (road, utilities and public services), transportation delays and poor economic conditions (currency, inflation rate..) were the main causes pointed out.

Similar to delayed land handovers, external work due to public agencies were also the leading cause for delay. Between May 2013 and July 2013, the contractor wrote several letters concerning variations and delay claims due to relocation on elevated structures, drainage line relocation, river line relocation, future utilities crossing and other public utility factors. This indicates the major role external works and public agencies play in delaying the project.

In general, from the three tables; delayed site handover, delayed decision making and lack of coordination with public utilities are the leading causes, therefore require attention in future railway constructions and expansions.

To finalize the survey about delay exposition of the LRT, the agreeing respondents were asked to describe the effects delays on the project. In this respect the, the general responses were

- Time overrun and cost overrun
- The delay made the contractor to claim about 6 months of extension
- Loss of political and economical value towards the project
- Several arbitrations, adverse relations and attitudes between the participating parties.

The Other 10% of the respondents argue the LRT project was not exposed to delay so far. Upon request for their reason for such opinions, they claimed that the government is giving enough attention not to let any delays and the contractor's experience and ability will not cause any delays to the project.

Even though, the above points were raised, the majority of the respondents believe that the project faced delay so far. Therefore, it was possible to understand the LRT project was exposed to delay from the information gathered by the questionnaire.

To elaborate on this subtopic interviewees were asked the same question. As a start interviewees were asked to describe about the general overview of the LRT construction project underway including the current status. Even though some disparities on the responses were observed, interviewees marked that about 80% of the project is expected to be completed by now and about 70% of it is done showing 12% of delay. They added, even if these delays happened; the project is still in the green zone.

The interviewees were asked to point out the causes of the delays and responses were similar to the questionnaire survey. Trying to put the causes along with the project schedule; the following causes were pointed out

- Initially the project contract was signed in 2009 and project commencement was on 2012 lagging by about three years
- After the project starts, site handover and right of way problems were faced and are still posing a great challenge on the project
- Integrating the LRT design with the city's master plan was started after the LRT construction proceeded and this took extra time
- Demolishing public utilities happen to be the critical concern
- Reworks at some junctions; lideta, mexico, 22, Urael and wiha limat
- Incomplete technical provisions including design drawings and details

Similar to the above points, delayed interim payments, delay in demolishing drainage pipes, delayed land acquisition and house demolishing delays were the common causes of delay as stated on the latest progress report (progress report of June 1,2014 to June 30, 2014).

Table 4.13: delay causes as of June 1, 2014 (source: progress report of June 1, 2014 to June 30, 2014)

Delay cause	description
Under pass execution by AACRA	AACRA should complete the under pass access construction and it is not completed yet (megenagna).
Traction substation of the whole line	Right of way problems, land have not been handed over to the contractor
Traction substation of the whole line	The overhead power cables at certain mileages are not demolished yet
culverts	The culvert work has not been completed and submitted by AACRA
designs	Solutions for entrance and exit schemes of certain stations has not been approved yet

The primary intension of the interview was to understand the methodologies in analyzing delays and delay claims. As the interviewees put it; apart from the master schedule, which they track the critical activities to compare with the actual work done, there is no standard method set to justify delays. Comparing the critical activities of the schedule with the actual constructed activities can be reported as an 'as planned Vs as built method of analysis' even though there were no direct steps followed.

Fig. 4.1 Delayed underpass construction by AACRA at Megenagna

4.6 Delay claim administration

The issues to be dealt with as far as the analysis of claims on delay are concerned; they are complex, requiring an understanding of contract law, contract forms, contract administration, project planning techniques and an appreciation of how construction activity typically takes place. (Scott et al., 2004)

This Multy-disciplinary nature suggests that a variety of people with various expertises would have to work together in a team to ensure adequate analysis and settlement of delay claims. So as to assure delay claim decisions were passed so far, respondents were asked if their company made a decision on any delay claims.

All the respondents who believe the project was delayed, answered delay claim decisions were made. As shown in the table below, out of the delay claims raised by the contractor, all of them (100%) were declined. i.e, were awarded with neither time extension nor monetary compensation.

Table 4.14: Delay claim decisions

participants	delay claims decisions passed on	% of claims compensated (money)	% of claims excused (time extension)	% of claims declined
consultant	yes	none	none	100
owner	yes	none	none	100

Respondents were also asked which software they used to justify delays so as to award responsibility and 58.3% of them use Ms Project, 75% of them use primavera and 58.3% of them use Microsoft Excel. Here it is important to note that respondents were allowed to check multiple options

About the delay claim administration methods; interviewees stated, even though the contractor filed several claim letters concerning delay activities, the contractual agreement settles most of the arguments. They added; even though there were no standard mechanisms followed to manage delay claims, 're-claiming or de claiming' is the technique applied so far. That is, when the contractor claims on owner caused delays, the client re claims the contractor for delays and incomplete works caused by the contractor. These points justify the need to develop certain criteria or standard towards selecting delay identification and analysis methods.

4.7 Application of the model to the LRT case study

The project is a 475,000,000.00 USD contract for the construction of new ADDIS ABABA east-west and north-south (phase 1) light rail transit project. The project consists of a considerable amount of construction work with scope over 277 major activities (EPC contract agreement, 2009). This involved the construction of light railway tracks; at grade, elevated and underground junctions and stations; signaling and communication lines; depots and other sideway constructions. The agreed contract duration for the project is 3 years.

In order to justify the previously established model, one of the several claims requested by the contractor is adopted. It is to be noted that even though the scenario below was claimed and denied, it is used here to only justify the model and there was no such procedure whatsoever on the LRT project underway. Therefore, for the purpose of understanding, the contractor's claim is used. It is also believed by the researcher, to state dates or factual claim letter references, is inappropriate.

As was seen on the questionnaire and interview analysis, the project is being delayed mainly because of delayed site handover and relocation or demolition of drainage lines, power cables or poles. These causes are sole responsibilities of the owner according to the particular conditions of contract sub clause 2.1 stating 'the employer is responsible for clearing expropriation cost of any utilities (underground, above ground and at the surface) and buildings within the right of way'.

Following these problems, the contractor issued claims for extension of time of 184 days plus loss and expense of 3.5 million USD. Both the consultant and the client declined the claim stating there had been a revision in the master schedule negating the relevance of the claim. The objections were concrete, and so the contractor agreed to the terms of the client and the consultant by resolving the claimed date and money. But as stated earlier, this scenario was created as a justification for the application of the model only hence; it is used here in after by considering this section with some important assumptions.

There is no clear data as to what method the contractor followed to determine the delayed days and claim for time extension and money compensation. Also say the master schedule was not revised, as the reason for the claims declination of the previous paragraph, and the claims were true. In this case there is a large probability of the owner's analyst adopting different delay analysis methodology from the contractor's causing different results. It is certain that one of the methodologies used will be the most appropriate for the case, but to reach to such an agreement the obstacles are

1. The contract didn't provide for the use of specific methodology for the analysis of delay claims. It however stipulated that for the contractor to be entitled to extension of time or be compensated with money, delay events that are at the employers risk should actually cause project delay.
2. In compliance with contract specifications, a base line program in CPM network format was prepared and submitted to the employer by the contractor. But the baseline program did not include all the major city's requirements namely integrating with the city's and ACCRA's master plan.

For illustration purposes, the model was applied to the scenario to select the best methodology among the available methods; as planned Vs as built, impacted as planned, as planned but for, collapsed as built, window analysis and time impact analysis. The main steps stated previously in developing the model are followed here to the window analysis method.

1. **Rating of window analysis against selection criteria:-** The rating is done by first comparing each selection criteria to the corresponding attribute of the window analysis method.

a. **Records availability**: - table 2.8 shows all the information required for the implementation of the various delay analysis methods. In our case, most of the information required for applying window analysis method is available except the program update. On the scale of 0-1 the suitable rate in respect of this criteria is R_{rec} = 10/11=0.91
b. **Base line programming availability:-** window analysis requires the use of baseline program, and it is available in our case. Therefore on the scale of 0-1, the suitability rating of the method for this criteria is R_{bas}=1.0
c. **Nature of baseline programming:-** table 2.9 outlines important baseline programming requirements. The baseline program of this case study satisfies all the requirements. Eg five out of five and hence, R_{nab}=5/5=1.0
d. **Updated Program availability:-** table 2.10 outlines important program updates required for the use of some delay analysis methods. For this case study, one of the requirements was not satisfied, i.e, regular program updates. Therefore R_{upa}=1/2=0.5
e. **Applicable legislation:-** it is assumed in this case study that no legal procedures or rules were required to be followed by the disputing parties which could have affected the use of window analysis. It is therefore very suitable to use this methodology and R_{app}=1.0
f. **Form of contract:-** the terms of the contract require that the delay analysis be based upon the actual effect of the delays on the project completion date (particular conditions of contract part 2, sub clause 8.7). Therefore, the methodologies suitable for use should be retrospective (considering the past events), example of which include the window analysis method. Thus R_{fmc}=1.0
g. **Dispute resolution forum:-** in this case study, it is assumed that window analysis method is one of the acceptable for use in adjudication. Therefore, the methodologies suitability rating on this criterion using the scale of 0-1 is R_{drf}=1.0
h. **Reason for the delay analysis:-** table 2.11 shows the capability of the methodologies in proving important delay claim issues. Since window analysis is capable of proving all the entitlements, it is rated very suitable. That is, R_{rda}= 1.0
i. **Time of the delay:-** the time of the delay relative to the current stage of the project requires that a retrospective analysis of delay be performed but not prospective analysis. Window analysis is retrospective methodology and so rated very suitable on 0-1 scale R_{tmd}=1.0

j. **Complexity of the project: -** Fig 2.10 compares the suitability for the various delay analysis methods against a number of projects characteristics criteria. On project complexity of this case study, the scale number that best describes is 10. A vertical through this number falls in line with the window analysis method, making it more suitable method in respect of these criteria and thus rated R_{cxp}=10/10=1.0
k. **Amount of dispute:-** as in complexity of the project, window analysis is to be most suitable because the amount in disputed is 1.5 million>1 million hence, R_{amd}=1.0
l. **Duration and size of the project:-** based on the classification set out in Fig 2.10, the example project is considered very large in size and moderate in duration. Therefore R_{sz}=1.0 and R_{dvt}= 3/6=0.5
m. **Number of delay events:-** the number of delays in our case study is 12, as stated in questionnaire analysis which is less than threshold with window analysis is most suitable to use. Therefore, R_{nde}=12/50=0.6
n. **Nature of delaying events: -** referring to table 2.12, window analysis is capable of dealing with issues of concern in this example. Therefore, window analysis is very suitable to use and so rates highest on the 0-1 scale; R_{nad}=1.0
o. **The other party to the claim: -** It is assumed in this example that there was no prior unsuccessful settlement of the claims in which window analysis was employed. It was therefore, very suitable to use this methodology and thus rates R_{opc}=1.0
p. **The skill of the analyst:-** assuming the analyst is very skilled in the use of window analysis, the methodology is suitable to employ so rated R_{ska}=1.0
q. **Cost of using technique:-** since the cost of resolving the claims was not budgeted for in the contract, the most suitable methodology for this study will be one which is least expensive to use. Fig 2.10 shows that the window analysis is the most expensive method and thus ranks least on the scale of 1-10. R_{cst}=1/10=0.1

2. **Window analysis suitability scores: -** table below shows suitability score of window analysis for each of the selection criterion obtained by multiplying each of the rating for the criteria and their corresponding weightings. The total sum of all this scores is 10.03.

Table 4.15: suitability scores of window analysis

group factor	selection factor	weight	rating	suitability score
record availability	record availability	1	0.91	0.91
baseline program characteristics	baseline program availability	0.86	1	0.86
	nature of baseline program	0.73	1	0.73
contractual requirements	updated programs availability	0.72	0.5	0.36
	applicable legislation	0.37	1	0.37
	form of contract	0.61	1	0.61
	dispute resolution forum	0.56	1	0.56
timing of the analysis	reasons for the analysis	0.63	1	0.63
	time of the delay	0.64	1	0.64
project characteristics	project complexity	0.67	1	0.67
	the amount in dispute	0.75	1	0.75
	size of the project	0.52	1	0.52
	duration of the project	0.47	0.5	0.235
	nature of delaying events	0.66	1	0.66
	number of delaying events	0.68	0.6	0.408
	the other party of the claim	0.46	1	0.46
cost proportionality	cost of using method	0.59	1	0.59
	skills of the analyst	0.67	0.1	0.067
	total suitability score			**10.03**

3. **Selecting the most appropriate methodology: -** the above procedure should be repeated for the remaining methodologies to determine their suitability score, and the methodology with the highest total score will be the most suitable methodology.

4.8 Summary

This chapter has presented the results of a questionnaire and interview surveys of owners/employers and consultants aimed in establishing an understanding to schedule delay identification and impact assessment. A summary of the findings of the survey is as follows.

a) All of the respondents agree construction is susceptible to delay in Ethiopia. Also, majority agree that financial problems, managerial problems and contractor's ability are the main causes.
b) From delay claim letters submitted by the contractor, more than 85% of the respondents believe the LRT project is exposed to delay.
c) Majority of the respondents grouped the delays occurred so far in the medium level and believe that delayed delivery of materials on site, delayed site handover, delayed decision making and external work due to public agencies, Right of way problems, incomplete designs, city master plan integration and demolishing or relocating public utility crossing problems were the major causes stated by the participants.
d) All of the respondents, who believe the project was delayed, agree delay claim decisions were passed by and none of the claims made by the contractor were excused or compensated. There was no justified method followed to quantify or analyze the delays and hence a method should be adopted or developed.
e) A model developed by (Nuhu Braimah, 2008) was adopted for the case of the LRT project and it should be used by ERC for future reference after it is validated by scholars.

CHAPTER FIVE

Conclusions and Recommendations

It is well documented that claims related to project delays are now a major source of disputes in the construction industry. Consequently, there has been much desire to reduce or completely avoid this problem and this has created considerable research interest among researchers and practitioners.

Despite such attempts, delays and their analysis continues to pose great challenge to project parties. It is this reason that stimulates to investigate the current status of the LRT construction concerning delays and analysis methodologies. This was achieved through the use of questionnaire surveys distributed to the owner and the consultant and subsequent interviews with the contracting parties. The purpose was to use the result from this investigation and that from review of the literature to determine the causes and effects of schedule delays on the LRT construction and develop a framework for improving delay analysis. The major findings and conclusions from the previous chapters and recommendations for further researchers are reported below.

5.1 Research findings and conclusions

Drawing from the primary data collected and the literature review, the main research findings obtained in respect of the research objectives are as follows

1. From archival reports, questionnaires and interviews, construction delay in Ethiopia is mostly caused by financial problem, managerial problems and local contractor's limited ability.

2. According to the responses the LRT construction project under way is exposed to delay to (about 7.5% according to the questionnaire responses and about 12% according to interviews) of the total completion time and the method of identification of delay is not justified apart from delay claim letters and as built progress reports.

Delay identification in construction is performed by one or more of the following methods

- As planned Vs as built
- As planned but for
- Collapsed as built
- Window analysis
- Time impact analysis

The following causes are identified as causes of delay on the project so far

- Delay in delivering material on site, poor site management, shortage of material on site, incomplete documents (design drawings and schedule updates) as contractor's responsibility
- Incomplete documents, delayed and slow supervision in making decisions as the consultant's responsibility
- Delayed site handover and right of way, financial problems (delayed payments) and lack of coordination with the contractor and the public utility providers as the owner/ employer responsibility.
- External work due to public agencies (road, utilities and public services), transportation delays and poor economic condition (currency and inflation rate) as external factors.

3. Delay analysis and claim administration have no justified method or arrangement so far on the LRT project contract. All the delay claims by the contractor are denied by declaiming the contractor for the delays he is responsible.

4. Time overrun, cost overrun, loss of political and economical value towards the project, several arbitrations between the contracting parties are the effects of the delay encountered so far.

5. A number of methodologies for analyzing delays (DAMs) have been reported in the literature. Not only are these reported to by different terminologies amongst practitioners and researchers, they also differ based on their mode of application, the type of programming technique and baseline program used. This differences contribute to the difficulties and dispute associated with delay analysis.

5.2 Recommendations

Based on the findings of the research, the following recommendations were proposed

- Master plan integrations and utility crossings relocation were the major delaying factors. Therefore, prior to commencement of work, provisions should be made for a meeting between the stakeholders for a joint assessment of the project
- A turnkey system of contract should not be adopted for future expansions and projects of railway because it is not economical and stakeholders should share the risks equally.
- Qualified, experienced and motivated staff always benefits the employer. Therefore ERC should expose the employers to the project more often; also sustainable and continues trainings, assessments and motivational plans should be prepared
- The employer should request a provision in the contract for the contractor to submit a fully resource loaded baseline program in an appropriate format reflecting the true intention of the contractor.

- Provisions should be made in the contract for the keeping of records that will provide adequate evidence on the causes of delay and their impacts. Such records should include
  - Site progress reports (factual and frequent, i.e not for the payment purpose only)
  - Job cost report
  - Drawings and other necessary information requested and dates received
  - Records on actual working conditions
- The contract should require the accepted baseline program and all subsequent updates be submitted with each program update being accompanied by a detail progress report describing any changes in the project activities, their logic (flow) and duration which are inconsistent with the previous progress report enabling the employer check the accuracy of updated programs
- The previously adopted model for determining the best method of delay identification methods by Nuhu Braimah, 2008 should be used by ERC for future delay disputes after being validated by scholars.
- ERC should incorporate claim experts, mainly familiar with delay claims, in its organizational structure under contract administration team.

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Part 1

Personal information

1. Name ______________________________(optional)
2. Workplace/organization ____
3. Position/work title ____
4. Address (optional)
    a. Mob. ______________________________
    b. E-mail _____________________________

5. Work experience

a. in the construction sector

1-3 years ☐ 3-6 years ☐ 6-9 years ☐ more than 10 years ☐

b. in the railway sector

1-3 years ☐ 3-6 years ☐ 6-9 years ☐ more than 10 years ☐

Part 2

General Information

delay is the slowing down of work without stopping construction entirely which can lead to time overrun either beyond the contract date or beyond the date that parties have agreed upon for the delivery of the project. All the questions below will refer back to the above given definition.

1. Do you think construction is often susceptible to delay in our country (Ethiopia)?

Yes ☐ No ☐ I do not know ☐

a. If your answer is 'Yes', what do you think is the cause (check/rate in order of recurrence)

	High	medium	low	rare
▪ Contractors' ability	☐	☐	☐	☐
▪ Design difficulty	☐	☐	☐	☐
▪ Financial problem	☐	☐	☐	☐
▪ Natural causes	☐	☐	☐	☐
▪ Lack of awareness/understanding	☐	☐	☐	☐
▪ The government's construction policy	☐	☐	☐	☐
▪ Consultants' weakness	☐	☐	☐	☐
▪ Managerial problems	☐	☐	☐	☐

- If other, please specify ____
____

Part 3

Specific Information

(For engineers, project managers, contract administrators, claim experts and construction supervisors of ERC, CREC, LRT and SWEROAD)

1. Has the LRT construction project been exposed to delay so far?

Yes ☐ No ☐

I. If your answer is 'Yes' then How did you identify/know there was a delay?

i. By implementing standard mechanisms/techniques

- ☐ ***As planned Vs as built/total time*** (calculating the difference between as planned schedule and the as built schedule)
- ☐ ***Impacted as planned (what if) method*** (inserting changes that cause project delays into the as planned schedule to calculate the amount of delay)
- ☐ ***As planned but for*** (injecting the as planned schedules with all the delays of a particular party to form an adjusted schedule and calculating the difference with the actual completion date)
- ☐ ***Collapsed as built (but for) method*** (collapsing the as built schedule by removing activities which affect/delay the project and calculating the difference in time between the as built and the collapsed as built end dates)
- ☐ ***Window analysis*** (analyzing delays that occurred in each window of time/monthly for instance/ than considering the whole project)
- ☐ ***Time impact analysis*** (calculating project delay from each of delaying activities successively by determining the difference between the project completion date of schedule after the addition of each delay and that prior to the addition)

ii. Due to delay claim letters ☐

iii. Other, please specify ____

a. how do you evaluate (in percent) the extent or volume of delays so far on the overall project's end date

0-2.5% ☐ 2.5-5% ☐ 5-7.5% ☐ 7.5-10% ☐ more than 10% ☐

b. What do you think cause those delays ***(rate/check in order of their effect on the overall project)***

Contractor's responsibility	high	medium	low	negligible
Delay in delivery of material on site	☐	☐	☐	☐
Shortage of materials on site	☐	☐	☐	☐
Construction mistakes and defective works	☐	☐	☐	☐
Poor skill and experience of labor	☐	☐	☐	☐

	high	medium	low	negligible
○ Financial problems	☐	☐	☐	☐
○ Poor site management	☐	☐	☐	☐
○ Equipments and tool shortage on site	☐	☐	☐	☐
○ Coordination problems with others	☐	☐	☐	☐

○ Other, please specify ____

____

• Consultant's responsibility	high	medium	low	negligible
○ Lack of experience on the part of the consultant (as a company)	☐	☐	☐	☐
○ Delayed and slow supervision in making decision	☐	☐	☐	☐
○ Incomplete documents	☐	☐	☐	☐
○ Absence of consultant's site staff	☐	☐	☐	☐
○ Lack of experience of managerial and supervisory personnel	☐	☐	☐	☐

Other, please specify ____

• Owner's responsibility	high	medium	low	negligible
○ Lack of working knowledge	☐	☐	☐	☐
○ Slowness in making decision	☐	☐	☐	☐
○ Lack of coordination with contractors	☐	☐	☐	☐
○ Contract modifications (replacement and addition of new work to the project and change in specifications)	☐	☐	☐	☐
○ Financial problems (delayed payments, financial difficulties and economic problems)	☐	☐	☐	☐

- Site handover and right of way ☐ ☐ ☐ ☐
- Other, please specify ____
____

- External factors

	high	**medium**	**low**	**negligible**
Lack of material, equipment and tools on the market	☐	☐	☐	☐
Poor weather condition	☐	☐	☐	☐
Poor site condition (location, ground…)	☐	☐	☐	☐
Poor economic conditions (currency, inflation rate,…)	☐	☐	☐	☐
Change in laws and regulations	☐	☐	☐	☐
Transportation delays	☐	☐	☐	☐
External work due to public agencies (road, utilities and public services)	☐	☐	☐	☐

- Other, please specify ____
____

c. What were the effects of the delays on the project?

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II. If your answer to question number 1 is 'No' then why do you think so?

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____

2. Which scheduling software does your company use?

- ☐ Ms Project
- ☐ Primavera
- ☐ Con.Mis
- ☐ Custom made (please elaborate) ______________________________
- If other, please specify ___________________________________

3. Has your company made a decision on any delay claims so far?

Yes ☐ No ☐

a. If your answer is 'Yes' then,

- How many percentile of the delay claims were awarded with money (compensated)

  100-75% ☐ 75-50% ☐ 50-25% ☐ 25-5% ☐ none ☐
- How many percentile of the delay claims were awarded with time (excused)

  100-75% ☐ 75-50% ☐ 50-25% ☐ 25-5% ☐ none ☐
- How many percentile of the delay claims were declined (not excused)

  100-75% ☐ 75-50% ☐ 50-25% ☐ 25-5% ☐ none ☐
- Other, please elaborate ___________________________________

b. If your answer is no, why do you think so?

____
____
____
____
____

Part 4

General opinions/recommendation

1. What is your general opinion about the LRT construction project regarding construction practice and delay in Ethiopia?

2. What is your company's strategy towards time management and zero delay performance?

THANK YOU SO MUCH!!!!

Appendix B

Interview question 1

Interviewee - ,___________________

Interviewer:- ***Robel Assefa, student***

1) General overview of the LRT (current status)

2) Role in the LRT construction (as a company), any difficulties in handling this role so far?

3) Contractual agreement type (comment on the lump sum contract), disadvantages, advantages or comments for future use?

4) Any delayed activities? If so

- Cause, effect, analysis method and percentage amount
- Problems encountered during the analysis

If not

- Recommendation for ERC on national rail network

5) Any delay claims? If so

- **Can I have the detail document?**
- What procedures you used for the analysis and what were the decisions (some examples If possible)

6) Recommendations for future use on

- Operation
- Construction methodology and material handling
- Administration, contracting and supervision
- Personnel and professionals uprising

In relation to delayed construction hand over

- Equipment and workmanship
- Local contractors and on time delivery
- Supervision and technical methodology
- Personnel and professionals uprising
- Quality and cost

In relation to technology transfer

7) Anything you want to add about the LRT construction, use, ….?

Interview question 2

Interviewee - ____

Interviewer:- ***Robel Assefa, student***

1) General overview of the LRT (current status)

2) Why is a claim expert required on a specific project?

3) Any delayed activities? If so

- Cause, effect, analysis method and percentage amount
- Problems encountered during the analysis

If not

- Recommendation for ERC on national rail network

4) How is claim administered in construction (general overview?)

5) How were claims related to delays administered? (LRT construction)

6) Recommendations for future use on

In relation to delayed construction hand over:

- Operation
- Construction methodology and material handling
- Administration, contracting and supervision
- Personnel and professionals uprising

In relation to technology transfer:

- Equipment and workmanship
- Local contractors and on time delivery
- Supervision and technical methodology
- Personnel and professionals uprising
- Quality and cost

7) Anything you want to add about the LRT construction, use, ….?

Thank you for your precious time.