Doctoral theses at NTNU, 2018:2018:97

Youcef ZIDANE

“Need for Speed” Insights into the Concept of Time in Managing Large-Scale Projects

Focus on the Concept of "Time" in its Two Dimensions – i.e., Quantitative Time as Chronos, and Qualitative Time as Kairos

NTNU
Norwegian University of Science and Technology

Doctoral thesis

Youcef ZIDANE

Doctoral theses at NTNU, 2018:2018:97

NTNU
Norwegian University of Science and Technology
Thesis for the Degree of
Philosophiae Doctor
Faculty of Engineering

NTNU

ISBN 978-82-326-2984-8 (printed ver.)
ISBN 978-82-326-2985-5 (electronic ver.)
ISSN 1503-8181

NTNU
Norwegian University of Science and Technology

Youcef ZIDANE

“Need for Speed”
Insights into the Concept of Time in Managing Large-Scale Projects

Thesis for the Degree of Philosophiae Doctor

Trondheim, March 2018

Norwegian University of Science and Technology
Faculty of Engineering

NTNU
Norwegian University of
Science and Technology

NTNU
Norwegian University of Science and Technology

Thesis for the Degree of Philosophiae Doctor

Faculty of Engineering

ISBN 978-82-326-2984-8 (printed ver.)
ISBN 978-82-326-2985-5 (electronic ver.)
ISSN 1503-8181

Doctoral theses at NTNU, 2018:2018:97

Printed by NTNU Grafisk senter

In the name of God, the Most Gracious, the Most Merciful

To the memory of my Dear Father,

To my lovely Dear Mother.

"Yemma tedda ḥafi, Tekna ɣef uzemmur, Tgezzem tiẓgi, Iɣli-as w-amzur, Talwit ur itt tufi, Tidi tettcaṛcuṛ, Tferfer-as temẓi, Tessaram amur. Tifexsa deg-iḍaṛṛen, Ṭerḍiqent i usemmiḍ, Iẓri-s di lemḥan, Ur ğin ur tesfiḍ, M-id lliɣ allen, Am aggur deg iḍ, Yemma xas tertem, Yiwen ur itt yerkiḍ. Yemma am tafiɣert, Iddarayen uruz, Mi s teɣli tezmert, As ɛalqen leḥruz, Ad d teffeɣ di taddart, Ur d teskan telluẓ, Yemma am tzezert, Mmis mi getthuz. Sakdeɣ di yemma, Tergagid tasa-w, Lqed- s yekna, Tḥenced ɣer tama-w, Assa nemwala, Tulesiyi-d arraw, Selmeɣ tanafa, Tefliyi-d aɛlaw."

— Tagrawla

Preface

"This thesis is one giant step for a man, one tiny leap for mankind."
— *Emrah Arica*

This Philosophiae Doctor's dissertation is the completion of my three years (during the period 09.2014 – 09.2017) of research at the Norwegian University of Science and Technology, in the Faculty of Engineering, Department of Mechanical and Industrial Engineering (previously Department of Production and Quality Engineering), in Trondheim, Norway. This Ph.D. research work is part of the "SpeedUp" research project. "SpeedUp" focuses on large complex projects, and the main objective of "SpeedUp" is to develop strategic, tactical and operational measures that can help reduce execution time in large projects. This is done in close cooperation with SINTEF, which is the largest independent research organization in Scandinavia. Moreover, with major players in construction, both private and public (ÅF Engineering, Statsbygg, Bane NOR, Defense Materials, Oslo Kommune, OPAK and WSP Norge). The goal is to test whether it is possible to reduce the total execution time by at least 30% compared with the 2013 level. The SpeedUp research project is part of the "BIA project" (Brukerstyrt innovasionsarena). It is funded by the Research Council of Norway, Project Norway (Prosjektnorge) and industrial partners (ÅF Engineering, Statsbygg, Oslo Kommune, WSP Norge, OPAK, Forsvarsmateriell, Bane NOR, Bunde Gruppen, Statens vegvesen). The project also involves other academic collaborations, such as the Construction Industry Institute (CII) in Austin, Texas, USA, California University and the Lean Construction Institute, both in California, USA and Aalto University in Helsinki, Finland.

This Ph.D. project was financed by the "SpeedUp" research project; however, there was no bias or any conflict of interest in gathering data from other sources. Of course, the selection of the problems addressed in the research reported in this dissertation is directly influenced by the "SpeedUp" research project, along with my experience gained in managing medium- to large-scale engineering projects in telecommunications infrastructures. Many other Ph.D. candidates have been involved directly or indirectly within the "SpeedUp" research project. Each one has chosen the problems to work with, and a methodology to achieve his/her research objectives. My choice as written in this dissertation, which consists of ten chapters, is to work with the concept of time and timing in managing these large-scale projects; or in other words, investigate how to achieve better efficiency and effectiveness. I was pragmatic in my research philosophy, with pragmatism here meaning that the exact position on a positivism and interpretivism continuum is determined by the research questions. After shaping the research objectives and formulating the research questions, there was an openness and tolerance regarding the sources of the data and the types of methods used. I am deeply grateful for the financial support received from the Research Council of Norway, the support of the "SpeedUp" research project, "ProsjektNorge" and NTNU, as well as the support I received from SINTEF during my Ph.D. research work. I am also grateful to those organizations, especially from Algeria, that gave me their full trust, along with access to their data and their employees, in allowing me to conduct surveys, case studies and interviews, and to check their internal documents.

— *Youcef J-T. ZIDANE. Trondheim, September 2017.*

Acknowledgements

"... And, when you want something, all the universe conspires in helping you to achieve it."
— Paulo Coelho

Although I am solely responsible for any errors, the writing of this dissertation would not have been possible without the guidance and help of many people. First and foremost, I appreciate enormously the help, support, advice and encouragement of my supervisors from NTNU, Associate Professor Bassam Hussein and Professor Bjørn Andersen, during the research period and the writing of this dissertation – without their help and continuous support, feedback and guidance, this dissertation would never have been completed within this short period. Staying with NTNU, I am very grateful to Professor Nils Olsson, who kept giving me hints, support and feedback regarding many issues related to my Ph.D. I must not forget to thank Professor Ole Jonny Klakegg for his feedback and input, and Professor Knut Samset for his time and interesting courses. My thanks also go to Associate Professor Cecilia Haskins for her very interesting course and her feedback, and to Professor Amun Bruland, Professor Olav Torp, Professor Jørn Vatn, Associate Professor Bjørn Otto Elvenes and Professor Asbjørn Rolstadås, as well as to Tonje B. Hamnes and Rune Brose. I am very grateful to Kari E. Dahle for all her great help and support, and to other Ph.D. candidates Saad, Anette, Sjur, Harald, Pavan, Amin. From SINTEF, I would like to thank Agnar Johansen for the opportunity to undertake this Ph.D. Thanks too to Siva for his help and to Elisabeth Holden, who supported me during my stay period in SINTEF's office. Still from SINTEF, many thanks to Emrah Arica, Sara, Jan Alexander, Andreas, Rimmert, Linda and many others. From Aalto University in Finland, I am extremely grateful to Professor Ahola Tuomas for his precious advice and for helping me shape my research questions, and also for sharing with me several interesting papers and other Ph.D. dissertations. I would like to thank Professor Karlos Artto for giving me very constructive criticism on my research questions. Many thanks to Professor George Jergeas from the University of Calgary in Canada for all his input, for sharing useful articles and books, and for putting me in touch with other researchers from his network. From CII Texas, my thanks go to both Professor Stephen Mulva and Hyeon-Yong Park, and many, many thanks too to Mr. J. Ø. Gudmundsson, Ms. Astrid Torsteinson, Ms. Margit Hermundsgård, Mr. T. Tekebayashi, Mr. S. Tazawa, Mr. I. Takeshi, Ms. M. Igarashi, Miss M. Takahashi. I am infinitely sorry if I have forgotten you or anyone else who helped me to achieve these results. There are many people who, consciously or unconsciously, have contributed to the thoughts and production of this work. That is why I must not forget all those who participated in the surveys, the case studies and the interviews, including all the people around me who helped me directly and/or indirectly. Many people from Algeria and Norway were involved too – thank you very much! And **I hope I have conveyed your meaning accurately- if not, *mea maxima culpa***. Thanks to my brother James for his support, and to all my family. Of course, all my love and limitless, endless and infinite thanks go to my lovely dear mother for her continuous moral support and for all that she has done and still does for me, from the day I was born to the day I am writing these words. Last, but never least, exclusively, all thanks and praise be to my God Almighty Alone.

— Youcef J-T. ZIDANE. Trondheim, September 2017.

Table of Contents

List of Figures

List of Tables

List of Equations

List of Abbreviations

- **2/3/4G** — **2/3/4G**eneration
- **ADM** — **A**rrow **D**iagramming **M**ethod
- **AOA** — **A**ctivities **O**n **A**rrows
- **AON** — **A**ctivities **O**n **N**odes
- **BoQ** — **B**ill **o**f **Q**uantity
- **CCPM** — **C**ritical **C**hain **P**roject **M**anagement
- **CE** — **C**oncurrent **E**ngineering
- **CPM** — **C**ritical **P**ath **M**ethod
- **CTA** — **C**ycle **T**ime **A**nalysis
- **FT** — **F**ast **T**racking
- **GERTs** — **G**raphical **E**valuation and **R**eview **T**echnique**s**
- **GPM** — **G**raphical **P**lanning **M**ethod
- **ICT** — **I**nformation and **C**ommunication **T**echnologies
- **JIT** — **J**ust-**in**-**T**ime
- **KPI** — **K**ey **P**erformance **I**ndicator
- **LBM** — **L**ine of **B**alance **M**ethod
- **LCA** — **L**ife **C**ycle **A**ssessment
- **LCM** — **L**ife **C**ycle **M**anagement
- **LCT** — **L**ife **C**ycle **T**hinking
- **LDs** — **L**iquidated **D**amages
- **LM** — **L**ogic **M**odel
- **LPS** — **L**ast **P**lanner **S**ystem
- **LSEP** — **L**arge-**S**cale **E**ngineering **P**roject
- **LSM** — **L**inear **S**cheduling **M**ethod
- **NPD** — **N**ew **P**roduct **D**evelopment
- **NTCP** — **N**ovelty **T**echnology **C**omplexity **P**ace
- **ORI** — **O**verall **R**anking **I**ndex
- **OTD** — **O**n-**T**ime **D**elivery
- **PD** — **P**roject **D**uration
- **PERTs** — **P**rogram **E**valuation and **R**eview **T**echnique**s**
- **PESTOL** — **P**roject **E**valuation on **S**trategic, **T**actical and **O**perational **L**evels
- **PLC** — **P**roject **L**ife **C**ycle (Span)
- **PLM** — **P**roduct **L**ifecycle **M**anagement
- **PMBOK** — **P**roject **M**anagement **B**ody **o**f **K**nowledge
- **PMI** — **P**roject **M**anagement **I**nstitute
- **RQ** — **R**esearch **Q**uestion
- **RSM** — **R**epetitive **S**cheduling **M**ethod
- **TTD** — **T**ime **T**o **D**elivery
- **TTM** — **T**ime **T**o **M**arket
- **TTMPs** — **T**ools, **T**echniques, **M**ethods & **P**hilosophie**s**
- **VE** — **V**alue **E**ngineering

List of Papers

No	Title Authors	This author's contribution	Status
1	**Barriers and Challenges in Employing of Concurrent Engineering within the Norwegian Construction Projects**		
	Youcef Zidane Kjersti Bjørkeng Agnar Johansen Susanne Van Raalte	Lead author, idea, literature study, data collection, complete analysis and sole contribution to the text.	*Procedia Economics and Finance* 2015, V. 21, pp.494-501.
2	**Time-thieves and Bottlenecks in the Norwegian Construction Projects**		
	Youcef Zidane Agnar Johansen Bjørn Andersen Erfan Hoseini	Presented the paper at the Nordic Conference on CEO 2015.	*Procedia Economics and Finance* 2015, V. 21, pp.486-493.
3	**Project Evaluation Holistic Framework – Application on Megaproject Case**		
	Youcef Zidane Agnar Johansen Anandasivakumar Ekambaram	Lead author, idea, literature study, data collection, analysis and sole contribution to text.	*Procedia Computer Science* 2015, V. 64, pp.409-416.
4	**When Stakeholders Shape Successes or Bring Failures – A Case Study of an Algerian Megaproject**		
	Youcef Zidane Agnar Johansen Anandasivakumar Ekambaram Linda Cathrine Hald	Lead author, idea, literature study, data collection, complete analysis and main contribution to text.	*Procedia Computer Science* 2015, V. 64, pp.844-851.
5	**Problems Associated with Defining Project Success**		
	Bassam A. Hussein Saad Bin Saleem Ahmad Youcef Zidane	Contribution to the literature study and took part in the discussions.	*Procedia Computer Science* 2015, V. 64, pp.940-947.
6	**"The Fast and the Fantastic" Time-Cost Trade-Offs in New Product Development vs. Construction Projects**		
	Youcef Zidane Asbjørn Rolstadås Agnar Johansen Anandasivakumar Ekambaram Pavan Sriram	Lead author, idea, literature study, complete analysis and sole contribution to text.	APMS 2015 Tokyo, Japan, Sept 7–9, 2015, Proceedings, Part I. Springer 2015 ISBN 978-3-319-22756-6, pp.589-597.
7	**The Black Swan – Knowing the Unknown in Projects**		
	Sara Hajikazemi Anandasivakumar Ekambaram Bjørn Andersen Youcef Zidane	Presented the paper at the IPMA world congress 2015.	*Procedia Social and Behavioral Sciences* 2016, V. 226, pp.184-192.
8	**Categorization of Organizational Factors and Their Impact on Project Performance**		
	Youcef Zidane Bassam A. Hussein Johann Ørn Gudmundsson Anandasivakumar Ekambaram	Lead author, idea, literature study, data collection, analysis and main contribution to text.	*Procedia Social and Behavioral Sciences* 2016, V. 226, pp.162-169.
9	**"Need for Speed": Framework for Measuring Construction Project Pace – Case of Road Project**		
	Youcef Zidane Bjørn Andersen Agnar Johansen Saad Bin Saleem Ahmad	Lead author, literature study, data collection, complete analysis and main contribution to text.	*Procedia Social and Behavioral Sciences* 2016, V. 226, pp.12-19.
10	**PESTOL – Framework for «Project Evaluation on Strategic, Tactical and Operational Levels»**		
	Youcef Zidane Agnar Johansen Bassam A. Hussein Bjørn Andersen	Lead author, idea, literature study, data collection, analysis and main contribution to text.	*International Journal of Information Systems and Project Management* IJISPM 2016, V. 4, No. 3, pp.25-41.

No	Title		
	Authors	This author's contribution	Status
11	**Defining Project Efficiency, Efficacy and Effectiveness**		
	Youcef Zidane Nils O.E. Olsson	Lead author, idea, literature study, data collection, analysis and main contribution to text.	*International Journal of Managing Projects in Business* IJMPB 2017, V. 10, No. 3, pp.621-641.
12	**"Superfast!" Managing the Urgent: Case Study of Telecommunications Infrastructure Project in Algeria**		
	Youcef Zidane Ole Jonny Klakegg Bjørn Andersen Bassam A. Hussein	Lead author, idea, literature study, data collection, analysis and main contribution to text.	*International Journal of Managing Projects in Business* IJMPB 2018.
13	**Top Ten Universal Delay Factors in Construction Projects**		
	Youcef Zidane Bjørn Andersen	Lead author, idea, literature study, data collection, complete analysis and main contribution to text.	*International Journal of Managing Projects in Business* IJMPB 2018.
14	**Causes of delays in Major Norwegian Projects and Their Remedies**		
	Youcef Zidane Bjørn Andersen	Lead author, idea, literature study and contribution to text.	*Journal of Modern Project Management* JMPM 2018, V. 5, No. 3, pp. 80-91.
15	**Significant Factors Causing Delay in Telecommunication Projects in Algeria**		
	Youcef Zidane	Lead author, idea, literature study, data collection, complete analysis and main contribution to text.	Working paper
16	**Delay Factors in Road Construction Project – Case of an Algerian Highway Megaproject**		
	Youcef Zidane	Lead author, Sole author, idea, literature study, data collection, complete analysis and sole contribution to text.	Submitted to IJBM
17	**Project Speed vs Project Flexibility, Uncertainty and Complexity**		
	Youcef Zidane Nils O.E. Olsson Bassam A. Hussein	Lead author, idea, literature study, data collection, complete analysis and main contribution to text.	Working paper
18	**The Role of Project Life Cycle and Decision Gate Model in Managing Projects**		
	Youcef Zidane Max R. Wideman	Lead author, idea, literature study, data collection, complete analysis and main contribution to text.	Working paper
19	**Project Evaluation and Learning – Experiences from the Construction of a Highway Megaproject**		
	Youcef Zidane Bjørn Otto Elvenes Bassam A. Hussein	Lead author, idea, literature study, data collection, complete analysis and sole contribution to text.	Submitted to MJSS
20	**Yin and Yang, Time and Timing, and Efficiency and Effectiveness in Managing Projects**		
	Youcef Zidane	Lead author, sole author, idea, literature study, data collection, complete analysis and sole contribution to text.	Working paper

Summary

"... The saddest summary of a life contains three descriptions: could have, might have, and should have."
— Louis E. Boone

Time is a fact, and using the term "managing time in project management" does not make sense, at least to me. No one can manage time, time will keep running – we cannot stop it, buy it, store it, recover it or transfer it. We cannot improve it (improve the practices, so that we get better sequences), extend it (extend the deadline but not the time), rewind it, going back physically to a certain moment in the past (except for memories, or maybe the day we have time travelers). Time (chronos) will always keep running and the clocks ticking as they have always done.

Today, in many industries, time is the cutting edge. The time to market (kairos – i.e., the right moment, the timing) in many industrial projects is a key factor in the competition between companies, especially when it comes to innovative projects. The pace and speed of a project – i.e., the scope in delivering the progress to time rate – are manageable and we can talk about managing project speed and pace instead of talking about managing time (chronos – i.e., the clock time) in a project. Time (chronos), being one of the most critical resources and a vital determinant of a project's success, has huge importance in the modern industrialized world. Being first in the market, gaining a competitive advantage and reducing time-dependent costs can all be driving factors for companies trying to reduce delivery time.

The need to reduce project duration is driving firms to continuously search for tools, techniques, methods and philosophies to achieve that. There are many scheduling tools, techniques and methods available, which have been practiced for decades. However, many researches and studies show that a significant number of projects exceed their desired time to delivery. To some extent, it has been concluded that operational implementation of these tools, techniques and methods alone, in isolation, is not satisfactory for gaining the desired benefits; it should be well supported by complementary factors such as, for example, stakeholders' commitment, improvement of organizational culture and management practices, competent personnel, continuous improvement processes, supportive management, etc.

Time management is the act or process of planning and exercising conscious control over the amount of time spent on specific activities, especially with a view to increasing effectiveness and efficiency. Time is one of the most critical constraint in projects. It is also one of the vital success criteria for every kind of project. Time management in projects involves processes required to accomplish timely completion of projects. Business economic value creating the potential to speed up projects manifests itself as a reduction in time-related costs and increased income due to reduced waste and less rework.

One of the key aims of this Ph.D. dissertation is to develop a better understanding of the concept of time (chronos) and timing (kairos) in managing projects. The aim is to gain and present in-depth knowledge of the subject and contribution to new knowledge, thorough knowledge of different research methods and a good understanding of real-world application.

Five research questions have been formulated in order to fulfill the research objectives:

- ***RQ1.*** What is the current state of affairs and performance vis-à-vis the elapsed time, the time to delivery and other project aspects in a sample(s) of large-scale engineering projects?
- ***RQ2.*** What are the factors that cause delays in large-scale engineering projects?
- ***RQ3.*** What are the relationships between project speed and project flexibility, uncertainty and complexity?
- ***RQ4.*** Is faster project delivery always better? If so, why?
- ***RQ5.*** How can projects be delivered faster?

The fulfillment of the research objectives has been achieved through 20 individual publications. Some of these publications answer the research questions directly, such as publications 1, 6, 9, 11, 12, 13, 14, 15, 16, 17 and 20, which contribute directly to some extent to the research questions. The focus points in the publications listed above are:

- ***Publication 1.*** Discusses the barriers and challenges of employing concurrent engineering as a philosophy within Norwegian construction projects.
- ***Publication 6.*** Presents a comparison of the value of time between new product development and construction projects.
- ***Publication 9.*** Develops a project speedometer for road construction projects.
- ***Publication 11.*** Discusses the existing definitions of efficiency, efficacy and effectiveness in project management.
- ***Publication 12.*** Presents a case study that had a schedule compressed dramatically to reach the desired time to delivery, which met the market needs.
- ***Publications 13, 14, 15 and 16.*** Investigate the delay factors and causes in large-scale engineering projects.
- ***Publication 17.*** Investigates the relationship between project speed and project flexibility, uncertainty and complexity.
- ***Publication 20.*** Reflects the dualism of Yin and Yang in terms of project efficiency and effectiveness.

The paradigm followed in answering the research questions is *pragmatism*. *Pragmatism* allows multiple positions, but one position may be more appropriate than another for answering a particular research question, which confirms the pragmatist's view that it is perfectly possible to work with different philosophical positions. The author used methods that enable credible, well-founded, reliable and relevant data to be collected that advance the research. Two strategies were used: a case study strategy and a survey strategy. In addition, interviews as a sole technique are conducted to answer some of the research questions. Most of the methods used are qualitative, and both approaches were used (i.e., inductive and deductive). This resulted in developing some conceptual models based on the findings in the conducted studies during this Ph.D. research work.

The findings of this dissertation are oriented toward developing a better understanding of time as a constraint on the one hand (chronos), and as a competitive advantage on the other (kairos).

Moreover, this dissertation will look at the notion of "timing" and its relation to time with respect to project efficiency and effectiveness. Two other concepts will be introduced to this dissertation, "Yin" and "Yang", where they reflect project efficiency and effectiveness, respectively. These two concepts are a paradox and contradictory, and yet interrelated (dualities), as they exist simultaneously and persist over time. These elements seem logical when considered in isolation, but irrational and inconsistent when juxtaposed; they are competing, but each has its own advantages and disadvantages. The reflection of efficiency and effectiveness will be based on the concepts of Yin versus Yang, and time versus timing.

This dissertation also looks at time (chronos – i.e., clock time) from many angles, by describing a generic project life cycle and providing explicit definitions for many concepts (e.g., project duration, project speed, etc.). It also investigates the existing tools, techniques, methods and philosophies for shortening/reducing project life cycle/duration. It identifies major delay factors from an intensive literature review and from empirical data based on surveys and a case study. Other explicit terms introduced and discussed with regard to other concepts are "flexibility," "uncertainty" and "complexity." This multiple investigation of the topic gave the dissertation rich overall insights into the concept of time in managing projects.

Another developed model is the PESTOL model; this model is used for post-project evaluation and can help in accumulating lessons learned for future similar projects. The evaluation is linked to learning to give an overall model on how to integrate both for better project management, which will also lead to better use and improve project speed and pace. Another model related to measuring performance is a project speedometer for measuring project pace and productivity.

The findings of the dissertation give multiple insights into the concept of time and timing in managing large-scale engineering projects. The issues are analyzed from different angles and from philosophical and practical approaches. The results of these studies, which led to the writing of this dissertation, contribute to new knowledge with respect to both theory and practice.

The theoretical contribution to new knowledge is the development of the above-mentioned conceptual models mentioned above, which are expected to be improved by other researchers in the future. The first contribution has resulted from checking the correlation between time and cost, and time and scope within the different phases of the project (pre-project, project and post-project). I found that the total project cost at the end of the project did not always reflect the time window needed to complete it, and the same was found for the complete scope at the end of the project with respect to the time window. A second finding was that more that 90% of the total project cost was spent in the implementation phase. My third finding related to the gaps and delays in the pre-project phase, which in turn led me to consider the identification of such delays, which was addressed in the second research question (RQ2). Thus, the contribution to the theory is the identification of new delay factors not found in similar previous studies. I used both quantitative and qualitative methods, but the qualitative method had not been used in previous studies at the time I conducted my research. An fourth contribution to theory is the recognition of project speed (scope delivered per unit of time) as new way of managing the productivity in projects, as well as identification of the relationship between project speed and project flexibility, complexity, and uncertainty. While answering the why delivering project faster, a fifth contribution to theory is that TTM in NPD differs from TTD in engineering projects. The main differences are market demands and the needs: in the case of NPD, time is the main key success factors, whereas this is not always the case for the LSEP.

By contrast, the most important practical contributions of my research are in facilitating the potential understanding of the concepts and defining them explicitly to enable practitioners to make better use of them (e.g., chronos, kairos, how efficiency is related to effectiveness, and the use of evaluation and linking it to learning).

Explicit practical contributions are the clear analyses of the correlation between time versus cost, and time versus scope. This will help project managers to consider changing their perceptions regarding the iron triangle. Additionally, by showing that there are gaps in the pre-project phase, my research will help project managers to increase the efficiency of their teams in the study and planning phases, either by increasing resources or through resource allocation. A further practical contribution is the identification of the major delay factors in LSEPs in the Norwegian configuration, as this will help organizations to update their risk factors lists. I have given some suggestions for to how to deal with such delay factors. Yet another practical contribution is my recommendations for how to deal with flexibility to increase project speed, such as using modularity during execution phase. Complexity and uncertainty play negative roles and they hinder project speed, and therefore I recommend that project managers should be aware of these complexities and uncertainties.

In conclusion, the findings from the research on which my doctoral dissertation is based contribute to a better understanding of the concept of time in its two dimensions (i.e., chronos and kairos). Further research on testing and how to apply pragmatically the developed models (e.g., PESTOL, Speedometer and Yin-Yang) should enrich the topic and deepen the understanding of the relation between project speed and flexibility, uncertainty, and complexity. There is potential for improving the models and concepts, depending on the context of use.

CHAPTER 1

Introduction

"This is the very perfection of a man, to find out his own imperfections."
— Saint Augustine of Hippo

"The problem is not that there are problems.
The problem is expecting otherwise and thinking that having problems is a problem."
— Theodore Isaac Rubin

This research investigates and looks for a better understanding of the concept of time as a constraint on the one hand (chronos), and as a competitive advantage on the other (kairos). It is about developing a deeper understanding of how these two concepts are related to project efficiency and effectiveness. The aim of the study is to enable the emergence of new knowledge about time (chronos), along with time to delivery (kairos) frameworks and how they influence large-scale engineering projects. Project speed is currently not clearly defined and does not draw on an explicit specific line of research or published scientific papers; rather, it covers several other ways to interpret it. In this introduction, a map of this landscape is drawn by explaining some key contributions to relevant areas. The dissertation is then placed on this map by explaining its starting point and approach. This study goes beyond project management and puts itself within an emerging body of literature with a strategic perspective on the project in focus. The issues identified in this introduction will be addressed in the research chapters in this dissertation. This chapter further gives an overview of definitions used in this dissertation, defines the scope of the research, explains the research process and limitations and their expected consequences, and last but not least, outlines the content of all the chapters with a graphical presentation and brief description of the content of each chapter.

1.1 Background and Motivation

"Time" is the most precious asset available to humans; all of our activities use time, but time (i.e., chronos time) is limited as a resource – i.e., there are 1000 milliseconds in a second, 60 seconds in a minute, 60 minutes in an hour, 24 hours in a day, 7 days in a week etc. So the supply of chronos time is perfectly rigid, and because of this nature of time, it is imperative to optimize its use.

However, time is not actually a universal concept; in a way, we have to think about time in modern humans' life as a linear measurable commodity that is not the way people in all places and all cultures around the world understand time. The Pirahã people of the Amazonian rainforest have no concrete concept of time. They have no past tense, they tell no stories, everything exists for them in the present, and when it can no longer be perceived, and essentially it ceases to exist. On the other hand, the language of the Indians of Arizona has no verb tenses – i.e., no past, no present and no future – and consequently no way of talking about time (Witherspoon, 1977). In Mexico, they say being on time is a worse cultural "faux pas" than being late (Moran *et al.*, 2014). Moreover, whether or not it is true, time flies differently for different cultures, and it is certainly true in the three Abrahamic religions that they do not talk about time in the way we do.

In the three Abrahamic religions, there are actually two different kinds of time happening at once – two words for time, which describe two distinct concepts of time running simultaneously. There is chronos time, where "chronos" is the Greek word that gives us all of our time-related words like "chronology" and "chronological" (Lee and Liebenau, 1999; Momigliano, 1966). Chronos is sequential time, it is linear measurable time, it is the kind of time that marches on, that keeps on ticking and that waits for no man. Clocks and calendars are on chronos time. We live on chronos time.

However, the three Abrahamic religions also talked about something called "kairos" time. "Kairos" is a Greek word that refers to the right occasion, or the right season for something, the right now for something to happen. In addition, in the three Abrahamic religions, kairos times vary from chronos time (Smith, 1969). Chronos is about quantity; kairos is about quality (Momigliano, 1966; Smith, 1969). Chronos is about the present (efficiency) that was the future and is the past before we know it. Kairos is about the now, and especially when the "right now" is the "right time" for what is happening (effectiveness) right now – that is kairos. The artist at work is in kairos, the child at play is in kairos and I writing this summary am in kairos.

However, what really happens with large-scale engineering projects is much less satisfactory. Many projects end up as failed and abandoned and not meeting the anticipated outcomes measured in terms of effectiveness. This is true despite the tremendous investments that are made (Bar-Yam, 2002). Likewise, project failure to meet the desired efficiency translated in terms of cost overrun and time delays is a common practice (Thamhain and Wilemon, 1986; Morris and Hough, 1987; Flyvbjerg *et al.*, 2003). Many studies have demonstrated that most projects do not meet time and budget goals, or fail to satisfy customer and/or company expectations (Tishler *et al.*, 1996; Hammer and Champy, 2003; Zhang *et al.*, 2003; Guerrero *et* *al.*, 2014). Although the utilization of project management tools and techniques has improved significantly in recent years, quite a lot of projects still fail to meet their objectives.

Project success is a multidimensional concept that includes both short-term project management success, which is efficiency, and the longer-term achievement of desired results from the project, that is, effectiveness (Shenhar *et al.*, 1997; Songer and Molenaar, 1997; Judgev *et al.*, 2001; Joslin and Müller, 2015). To achieve a common understanding of what project success is, it should be measurable and therefore defined in terms of success criteria (Müller and Turner, 2007; Joslin and Müller, 2015). The understanding of project success criteria has evolved from the iron triangle (time, scope and cost) to something more than the iron triangle, which that encompasses many more success criteria (Atkinson, 1999; Judgev and Müller, 2005; Shenhar and Dvir, 2007; Joslin and Müller, 2015). In the last two decades, literature about large-scale engineering projects has increasingly argued the need to use time efficiently and effectively to meet the desired outcomes (Thamhain and Wilemon, 1986; Morris and Hough, 1987; Rämö 2002; Flyvbjerg *et al.*, 2003). Some authors argue that successful projects should be delivered before the project due dates and within budget (e.g., Flyvbjerg *et al.*, 2003). However, significant variance exists between the assumptions made regarding the intended results and actual outcomes (Samset, 2010).

Time, cost and scope, which form the famous "iron triangle," are project success criteria, and they are frequently mentioned by many practitioners and researchers (Ahsan and Gunawan, 2010; Guerrero *et al.*, 2014). In particular, predicting the required time to carry out the construction of a building has been of great interest for most professionals in many industries, since it has traditionally been identified as a key success criterion in a large-scale engineering project (Chan and Kumaraswamy, 1997; Guerrero *et al.*, 2014). However, despite the many improvements made in the discipline of project management, in general, large-scale engineering projects have performed poorly in terms of their planned duration (Ng *et al.*, 2001; Chan and Kumaraswamy, 2002; Guerrero *et al.*, 2014). Predicting the duration of this kind of project accurately in the early stages is of vital importance for a successful project (Dursun and Stoy, 2011). There is a strong relationship between a project's time to delivery and a project's total costs. For some types of costs, the relationship is in direct proportion; for other types, there is a direct trade-off. There is an optimum project duration for minimum total costs. By understanding the time-cost relationship, one is better able to predict the impact of a schedule change on the project cost (Kerzner, 2009). The purpose behind balancing time and cost is to avoid wasting resources. Time-cost trade-off relationships are made by searching for the lowest possible total costs (i.e., direct and indirect) that likewise satisfy the area of feasible budgets. These methods, like the critical path method (CPM), contain the concept of slack time and the maximum amount of time that a job may be delayed beyond its early start without delaying the project completion time. The optimum project duration is determined by the critical path, and this will determine the minimum total costs of the project (Kerzner, 2009). One of the most significant problems in projects is time-cost trade-offs. Crashing the project's schedule would lead to an increase in the project cost (De Marco, 2011).

The economist's valuation of the opportunity cost of time has become increasingly stressed, embracing almost every aspect of human life. Particularly in management, time has become not only a tool for organizational study, but also a means to gain competitive advantages in the marketplace (Rämö, 2002).

Time to market (TTM) in new product development projects (NPDs) is a key factor in the competition between firms. The time to market in new product development projects has gradually become the cutting edge. In fact, as a strategic weapon, time is the equivalent of money, productivity, quality, even innovation. In production, in new product development, and in sales and distribution, time represents the most powerful source of competitive advantage (Stalk and Hout, 1990, 2003) – particularly in markets where the first mover has a strong advantage (Stalk and Hout, 1990, 2003; Cordero, 1991; Brown and Eisenhardt, 1998; Ben Mahmoud-Jouini *et al.*, 2004). There are several companies in place that have employed time-based strategies, such as the mobile telephony industry, the automotive industry and many other types of industries where production starts by developing new products. Delivering faster new product development projects in these markets reduces costs, increases profits and creates values (Schmelzer, 1992; Ben Mahmoud-Jouini *et al.*, 2004).

The equivalent to time to market for large-scale engineering projects is the time to deliver (TTD), which should be one of the key success factors for these projects (Ben Mahmoud-Jouini *et al.*, 2004). Thus, there is a need to identify impetuses and there are good reasons to shorten the project duration and create a faster delivery for LSEP projects. The control of time has become the ultimate imperative, either in terms of cutting off yet another fraction of time in ventures undertaken, or in terms of finishing something according to a strict deadline (Rämö, 2002). In the last few decades, a great deal of attention has been paid to the notion of time and temporality (Rämö, 2002).

Nevertheless, some researchers have chosen to look at the concept of "time" from different aspects of the question in organizational settings (e.g., Zerubavel, 1979; Clark, 1985, 1990; Bluedorn and Denhart, 1988; Blyton *et al.*, 1989; Adam, 1990, 1995; Burrell, 1992; Whipp, 1994; Butler, 1995; Lee and Liebenau, 1999; Rämö, 2002). Several writers have also noted that qualitative analysis of organizational time has been consistently overlooked (e.g., Bluedorn and Denhart, 1988; Adam, 1990, 1995; Burrell, 1992; Butler, 1995). Almost without exception this attention to the limitations of treating organizational time as exclusively quantitative and clock time still relies upon an understanding of time as chronological time, depicted as linear, circular or spiral time. There is a difference between the notions of chronological and nonchronological time in organizational settings with a particular focus on managing projects (Rämö, 1999, 2000, 2002).

The purpose of this study is twofold: first, it seeks to establish an understanding regarding time (chronos) as a "constraint" in managing large-scale engineering projects (LSEPs); second, it aims to show how time can be used as a competitive advantage (kairos). Moreover, I strive to demonstrate how the performance of ongoing or upcoming projects can be improved through the use of tools, techniques, methods, and/or philosophies in cases where time is a competitive advantage, and I contribute new knowledge by introducing the concept of speed and its relationship to other aspects, such as flexibility, complexity, and uncertainty. The concept was developed by conducting a survey, case studies, and interviews, with the aim of investigating time from different perceptions and angle of attacks, namely time versus scope and time versus cost, time wasted during the project life cycle, and the importance of TTD. In addition to contributing to existing project management research by introducing a new concept (i.e., project speed) and investigating its relationships with project flexibility, complexity, and uncertainty, I have attempted to contribute to the development of approaches that are more effective, and to provide new insights into the concept of time in the management of LSEPs.

1.2 Research Objective

The main objective of this dissertation, as discussed in the previous section, is to develop a better understanding of the concept of time and timing in managing projects. The aim is to gain and present in-depth knowledge of the subject, thorough knowledge of different research methods and a good understanding of the practical application.

To reach these objectives, five research questions have been formulated in order to achieve the research objectives. They are listed briefly below (and described in more detail in Chapter 2, Subsection 2.3):

- ***RQ1.*** What is the current state of affairs and performance vis-à-vis the elapsed time, the time to delivery and other project aspects in a sample(s) of large-scale engineering projects?
- ***RQ2.*** What are the factors that cause delays in large-scale engineering projects?
- ***RQ3.*** What are the relationships between project speed and project flexibility, uncertainty and complexity?
- ***RQ4.*** Is faster project delivery always better? If so, why?
- ***RQ5.*** How can projects be delivered faster?

The accomplishment of the research objectives has been achieved through 20 individual publications. Some of these publications answer the research questions directly, such as publications 13, 14, 15 and 16, which are directly related to the second research, which is related to the delay factors. However, those publications also contribute partially to the fourth and fifth questions.

More description of the individual publications will be given in Chapter 2, Subsection 2.7.

1.3 Scope Definition

This research is associated with, and financed by, the SpeedUp research project. Hence, it was necessary for the choice of dissertation topics and research questions to fall within the project's field of interest.

While the SpeedUp project was progressing and getting more input from the different participants in this research project and other collaborators, the number of questions increased and the scope started to get wider with multiple goals and objectives. However, the author kept on his own scope regarding the Ph.D. research project.

The setting in which the Ph.D. research project was initiated was the investigation of: "why" shortening project duration is a matter? "what" the benefits are of faster project delivery? And the setting was extended to the how to achieve the first two.

The dissertation does not cover direct problems and questions connected to the SpeedUp research project. However, it is connected financially to it and there are some intersections in some common points when it comes to using some of the findings.

The "SpeedUp" research project describes its mandate in this way on the project's web page (prosjektnorge 2014):

"Major projects have a ripple effect beyond the parties involved in the actual planning and implementation. It is essential that one chooses the correct project and that the projects are conducted in a safe and proper manner. Large projects use long periods for creating and anchoring plans among the various stakeholders and use long periods to choose solutions that address security, climate change, energy, etc. During the implementation phase, a large number of contractors and project players interact so that the project deliveries are reached without compromising quality and safety. How is it possible to be more efficient in large projects when the complexity increases, and when there are more actors and regulations? What can be done to reduce the planning and implementation time? These are some of the core questions in SpeedUp."

There were limitations described in Chapter 10, and these were important in order to define a realistic scope for the Ph.D. work, and in defining the chosen perspective of the investigation and the research questions (see Chapter 2 for a more detailed methodology).

The research focus in this dissertation, and based on the wording in its title, *"Need for Speed" – Insights into the Concept of Time in Managing Large-Scale Engineering Projects*, implies a wide range of research areas but also some important limitations (discussed in Chapter 10).

The research scope of this dissertation includes three components. The first part includes an elaboration on time as a constraint and/or as a means in managing large-scale engineering (the "what").

The next investigates the need and the reasons behind the necessity to deliver projects faster and within a short time window; in other words, "why" the problem identified in the first should be solved or at least considered.

The last, but not least, is "how" to deliver faster than usual. In other words, the possible solutions find remedies for reducing, avoiding or eliminating delay factors, and identify more suitable tools, techniques, methods and/or philosophies aimed at shortening project duration and/or project life cycle (pre-project and during the project).

The industries involved in this research are construction (in general), building, infrastructure, telecommunications and road. Moreover, they are from both public and private sectors. LSEPs are from more than the covered industries; however, due to the limitations in getting data, the research scope covered only the available industries. The involvement of NPD projects in this research was only for a comparison and not as a main part of the scope. The source of data for the study is projects, with very few of them being included in the SpeedUp project. The majority of the data were collected from different sources and based on the available opportunities. They were collected from different countries to avoid a narrow data set from Norway only. The descriptions of the sources of data are more detailed in the methodology chapter in Subsection 2.4.6 and in each section discussing the findings in Chapters 5 to 9.

1.4 Definitions

It is necessary to define a number of terms that will be appearing in this dissertation. There will be a short discussion based on literature for each concept, and that will reflect how these terms are used within this dissertation.

The ancient Greeks had two words for time: “kronos/chronos” and “kairos.” While the former refers to chronological or sequential time, the latter signifies a period or season, a moment of indeterminate time in which an event of significance happens (Liddell and Scott 1896). Below, both are discussed in a bit more detail.

Time – Kronos/Chronos: Clock time, chronological, linear, circular or spiral time. In Physics IV.11, Aristotle defined chronos as the “number of motion with respect to the before and the after” (Corish, 1976), which is a classical expression of the concept of time as change, measure and serial order (Rämö, 2002). In this dissertation, kronos/chronos is used as an exact quantification of time: for example, the passing time expressed in successive readings of a clock. In terms of managerial performance in project organizations, this clock time of chronos is the dominant factor, particularly in time management, administration and the improvement of what already exists and is known (Rämö, 2002).

Timing – Kairos: Occurring at a suitable time, seasonable, opportune, well-timed (Merriam-Webster, 1984). In contrast to kronos/chronos, kairos is a nonchronological aspect of time; kairos tends to be associated with experiential time and timeliness (Stephenson, 2005). What is happening when referring to kairos depends on who is using the word. While chronos is quantitative, kairos has a qualitative meaning (Liddell and Scott, 1896). Kairos also means “weather” in Modern Greek. Etymological studies of the word “kairos” associate it with both archery and weaving. In archery, kairos denotes the moment in which an arrow may be fired with sufficient force to penetrate a target. In weaving, kairos denotes the moment in which the shuttle can be passed through threads on the loom (Stephenson, 2005). Among the English translations of kairos is right or opportune moments that carry ideas of wisdom and judgement in timely situations. All managers face timely situations characterized as “moments of truth,” which might imply intelligent actions beyond the mechanically learned and beyond timetables. The chronological time of chronos, whether it is described as clock time, linear, circular or spiral, remains inadequate in such timely situations. Instead, the chronological time of chronos must be complemented by such a nonchronological notion of time as Kairos (Rämö, 2002).

On-Time Delivery (OTD): On-time delivery (OTD) is more related to process and supply-chain efficiency, and measures the amount of finished goods or services delivered to customers on time and in full.

Time To Delivery (TTD): The LSEP project is a complex transaction involving a set of products, services and construction works designed specifically to complete a specific asset for a customer within a certain period of time, e.g., a building, a turnkey factory, a power plant, a weapons system, etc. (Cova and Hoskins, 1997; Ben Mahmoud-Jouini *et al.*, 2004). Time to delivery is the time needed to design and/or produce/fabricate/build/construct the desired product once the LSEP project reaches its end (building, a turnkey factory, a power plant, a weapons system, etc.), and is a function of the system complexity and requirements. In this dissertation, TTD is mostly used to express the final milestone date of completing the project.

Time To Market (TTM): Time to market (TTM) is the length of time it takes from a product being conceived until its being available for sale. TTM is important in industries where products become outdated quickly. It is an important driver for sustainable competitive advantage, and it is mostly used in NPD projects (e.g., Kessler and Chakrabarti, 1996; Datar *et al.*, 1997). Perhaps the most familiar motivation for slashing time to market is the "market clock." If a new product enters the market prematurely, it may die from lack of interest despite having a bright future (Mascitelli, 2007). A common assumption is that TTM matters most for first-of-a-kind products, but actually, the market leader often has the luxury of time, while the clock is clearly running for the followers.

1.5 Guidance for Readers – The Ten Chapters

This Ph.D. dissertation consists of two main parts: the report, which is a book of ten chapters (see Figures 1-5.1 and 1-5.2), and the written papers during the Ph.D. work (presented briefly in Chapter 2 and attached as Appendices). The dissertation comprises ten chapters. The first chapter is an introduction and the second chapter outlines the methodology. Chapters 3and 4 are both based mostly (not totally) on a literature review. Chapters 5 to 9 are related to the research questions. Last but not least, Chapter 10 contains the conclusions and recommendations for further research. Figure 1-5.1 is a diagram showing the structure of this Ph.D. dissertation.

Figure 1.5-2 tells the story behind the three years of this Ph.D. work; it is like water when it is filling a jar – having a cross-sectional view of the jar and looking from above as the level of the water rises while filling it. The circular surface at the base of the jar is quite small. The same can be said for Ph.D. work. Things start quite small, they get wider to a certain level, and then from that level they start to get narrower until they reach the neck of the jar where it is smaller than where the work started, at the base of the jar. The largest circular surface is when starting the accumulation of the findings from the different research questions, where it is necessary to narrow them by discussing them along with theory.

Chapter 1.

This is an introductory chapter to the dissertation and the Ph.D. research work. It explains the purpose and structure of the dissertation. An explanation of the background and motivation in relevant areas of research helps the reader to understand how this dissertation relates to many different research areas. In addition, this chapter presents the research objectives in doing this research. The scope is defined based on the context of this Ph.D. and on the involvement in the research project (SpeedUp). It also includes basic definitions of terms used throughout the work. This chapter sets the platform for the rest of the dissertation.

Chapter 2.

This chapter discusses methodology and explains the choices made in this Ph.D. research work. As this is partly a paper-based dissertation, each of the papers contains a methodology section. To avoid unnecessary overlapping, the chapter only contains an explanation of the broader perspectives on the chosen methodology. The detailed choices are explained in the respective chapters and papers. However, in this second chapter, there is a very structured explanation of the methodology starting from "why" this research is being done, and going through "what" this research is about, where research questions have been asked and discussed. Last but not least is "how" the research objectives are accomplished and the research questions answered.

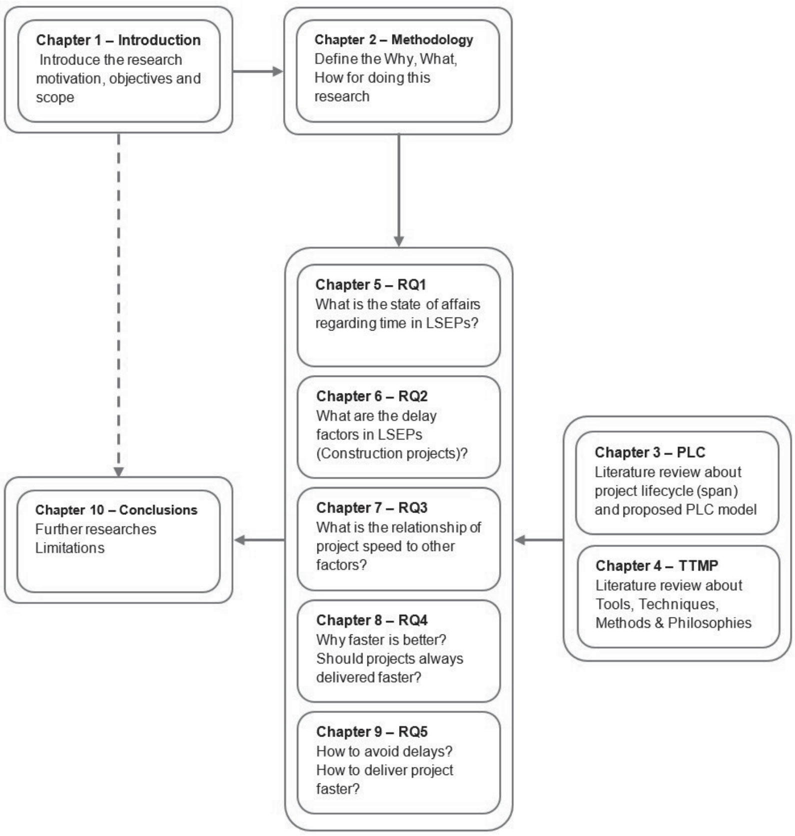

Figure 1.5-1: This Ph.D.'s dissertation structure.

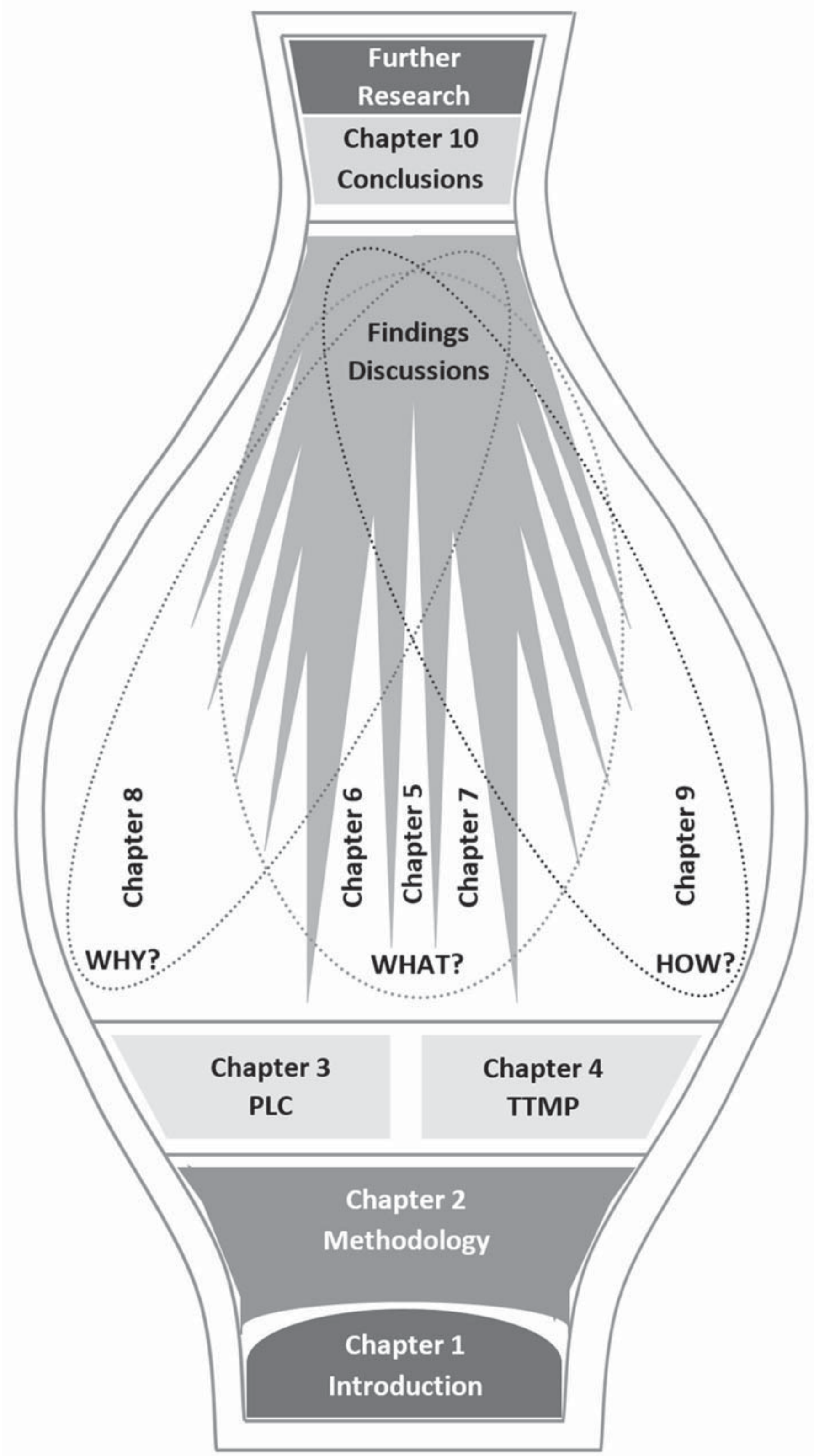

Figure 1.5-2: The Ph.D. dissertation in a jar.

Chapter 3.

This chapter and the next are a platform and set the context for the coming chapters. This chapter consists of two parts. First, it provides a literature review on the key theoretical perspectives that are relevant to this study. It presents very brief general theory about life cycle thinking and the material life cycle, product life cycle and asset life cycle, and in particular a theory on the project life cycle. The theory presented in this chapter explains how the project life cycle has been developed over time, including project duration. It discusses several important aspects of the role of the project life cycle and a decision model to manage projects. Second, this chapter ends by developing a generic PLC and explains the role that plays.

Chapter 4.

This chapter provides a literature review on some of the tools, techniques, methods and philosophies used to shorten the project life cycle and project duration. Different tools, techniques, methods and philosophies have been developed to manage projects in better ways. From the range of tools, techniques, methods and philosophies, one has to choose the TTMPs that best fit the organization. Against this background, this chapter will discuss very briefly some of these TTMPs and the basic principles behind them. The chapter is divided into two sections: the first section discusses literature about a few selected TTMPs; the second section is about management techniques for reducing project duration and speeding up project delivery.

Chapter 5.

This chapter presents an introduction for answering the other research questions. The first research question as formulated previously is: What is the current state of affairs and performance vis-à-vis the elapsed time, the time to delivery and other project aspects in samples of large-scale engineering projects? The samples used here to answer this question are sets of projects from medium- to large-scale projects from the construction industry in Norway. This chapter starts by explaining the context of the sample – i.e., presenting the whole project life cycle, the different stakeholders and their different project life cycles; this will allow a better understanding and seeing the whole elapsed time within the project instead of just considering one position or a mix between different standing points (e.g., client or contractor, etc.).

Chapter 6.

This chapter discusses the delay factors from literature and based on empirical studies. It consists of three sections. The first section is about the causes of delays in LSEPs and the construction industry in general from a theoretical perspective. A broad literature review had been conducted, and a long list of all possible delay factors is generated from the theory. The second section is about delay factors from empirical studies done in Norway based on a survey and two studies performed in Algeria, one based on a survey and another on a case study. The third and last, but not least, section is a summary of all delay factors from all previous studies and the three empirical studies in this chapter; the results are a list of the most common delay factors; or in other words, the universal delay factors.

Chapter 7.

In this chapter some concepts are introduced, discussed and defined, such as project speed, intensity and value. The second step is to investigate the relationship between project speed and project flexibility, uncertainty and complexity. This investigation was based on interviews with project managers from the telecommunication industry in Algeria.

Chapter 8.

This chapter is more concerned with investigating the most important impetus behind fast project delivery. The fundamental assumption in this chapter is that early project delivery is always better, and the related project's stakeholders should secure the fulfillment of that. The choice to limit the scope to only these two key criteria is decisive for this chapter. The assumption that faster is always better should be investigated from different angles – i.e., waste (delays); time-cost trade-offs and the economic benefits of fast project delivery; the impetus behind faster project delivery; and categorization of projects that deserve a fast delivery.

Chapter 9.

This chapter is divided into four sections. The first is a discussion about the cures and remedies for "how" to deal with delays based on a survey and on some conducted interviews. The second section of the chapter is a discussion about superfast projects, using the case study employed in Chapter 8. The schedule of the case was dramatically compressed, and a discussion of how that happened is contained within the section. Moreover, there is a discussion about the negative side of fast tracking based on telecommunications cases. Lastly and in the same section, the barriers to using CE in Norwegian construction based on a Norwegian case company are outlined. The third part of the chapter is about "how" to boost project speed in construction projects. A speedometer was developed using performance measurements and identifying KPIs to develop the framework for this speedometer. The use of a road construction project as a case based on interviews helped in identifying the KPIs. The second part of boosting project speed was based on the case study used in Chapters 6 and 8, which has also been used in many individual papers, in which the case has been evaluated, and from the evaluation it has been examined how lessons learned can help to avoid similar mistakes being made and how opportunities can deliver the project within or ahead of schedule. The last section is about how to reflect the Yin and Yang in time and timing, along with project efficiency and project effectiveness.

Chapter 10.

This chapter contains the conclusions and recommendations for further research. The conclusions are based on all of the chapters and papers collectively and summarize the main findings of this research, including the limitations of the study. There is also a summary and discussion about which areas need more research, as identified in this dissertation, which questions are answered and which are not. This chapter attempts to pull together all the ends and clarify the contribution of this research.

CHAPTER 2

Methodology

"Do what you can with what you have where you are."
— Theodore Roosevelt

"You have your way. I have my way.
As for the right way, the correct way, and the only way, it does not exist."
— Friedrich Nietzsche

"We are all different, you are different, I am different, and each individual is different.
Different is the only thing that all of us, humans, have in common."

This Ph.D. work went through a process, in which many questions have been asked within the context and the content to structure the work and obtain the outputs to reach the results presented in this dissertation. This chapter will summarize the research process from its beginning until the writing of this dissertation. The purpose of this chapter is to provide a methodological review and discussion in order to demonstrate why the research questions were formulated and how they have been answered through this dissertation. The process is divided into three parts. The first part is about the "why do this research?"; this was discussed in the previous chapter and it is extended here. The second part is about "what is this research about?" where research questions have been formulated to reflect that. The last, but not least, part is "how should I answer the research questions and achieve the results?"; a detailed step-by-step description and discussion of all the layers of the methodology is in this Chapter.

2.1 Research Process

Traditionally research has been conceived as the creation of true, objective knowledge, following a scientific method. From what appears or is presented as data, or facts, the unequivocal imprints of "reality," it is possible to acquire a reasonably adequate basis for empirically grounded conclusions, and as a next step for generalizations and theory building (Alvesson and Sköldberg, 2009). Research is a process of enquiry and investigation; it is systematic, methodical and ethical. Research can help solve practical problems (Neville, 2007). Research is about "systematically" acquiring and analyzing data in order to increase knowledge about a topic. It is something that people undertake in order to "find out" things in a systematic way, thereby increasing their knowledge (Saunders *et al.*, 2012), where "Systematic" means that research is based on logical relationships and not only beliefs (Ghauri and Grønhaug, 2010). Thus, research will involve an explanation of the methods used to collect the data; in the course of research, questions are to be answered or problems are to be addressed, and it will indicate why the results obtained are meaningful and it will explain any limitations that are associated with them (Saunders *et al.*, 2012). Moreover, "doing research" proposes that there is a multiplicity of possible purposes for it. It is therefore an activity that means it has to be finished at some time to be of use (Becker, 1998; Saunders *et al.*, 2012). This will undoubtedly be true for any research project, which will have a specific deadline, and purposes that may include describing, explaining, understanding, criticizing and analyzing (Ghauri and Grønhaug, 2010).

The choice of methodology for solving the research problem is one of the several major aspects that require significant consideration by researchers (Saunders *et al.*, 2012). Each research method has specific advantages and disadvantages (Yin, 2013). Holden and Lynch (2004) believe that choosing a research methodology that is, the "how" of research, involves something much deeper than practicalities. Indeed, it requires a philosophical solution to "why" we should research. The process for the Ph.D. work consists originally of development of the project plan, which includes the identification of the research's objectives, identification of the gaps in the research topic and development of the research questions, producing papers based on the available data. This Ph.D. dissertation is an output of this process. Figure 2.1-1 presents the process of the Ph.D. project and the steps of the research process.

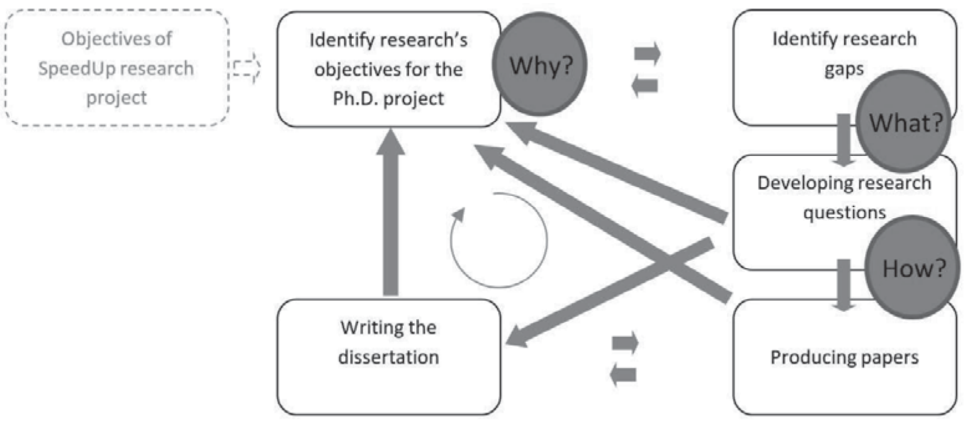

Figure 2.1-1: Research process.

The development of the project plan started with understanding the objectives of the SpeedUp research project. Since the Ph.D. project is financed from the SpeedUp project, it was necessary to take its objectives as a starting point for this Ph.D. research project. The SpeedUp project was well defined within its context, but less so when it came to its content, and thus it was necessary to identify clear research objectives for this Ph.D. research project. This is often referred to as "addressing the research objectives" or "meeting the research aim" (Saunders *et al.*, 2012). It is crucial to overcome the "why" questions related to research (see Figure 2.1-2). In other words, it is required to indicate the purpose of the research and to provide a clear rationale as to why this purpose is important and worth studying.

Once the objectives of the research are clarified and the research gaps identified, the "what" question is asked. This part is more related to research questions that the dissertation will answer. Identifying the research gaps from the research objectives helps to develop the research questions and update them gradually while progressing in the research. Thus, it provided the basis for development of the written papers. Moreover, while research objectives were modified gradually based on the research progress and the findings, the same would affect the identification of the research gaps and the research questions. As shown in Figure 2.1-1, there is continuous interplay between identification of the Ph.D. work research objectives and the identification of the research gaps. Also the inputs coming from the negative feedback while producing the papers. The written papers have been produced to some extent according to the research scope on the one hand, and from the available on-hand data on the other. Most of the papers were from the second case, where it was necessary to use available data on hand. This philosophy in the research (explained in Section 2.4 of this chapter) was dictated by circumstances rather than as an initial choice from the start, and in addition there were numerous barriers and limitations in getting the data based on the initial designed research directed at that choice of philosophy.

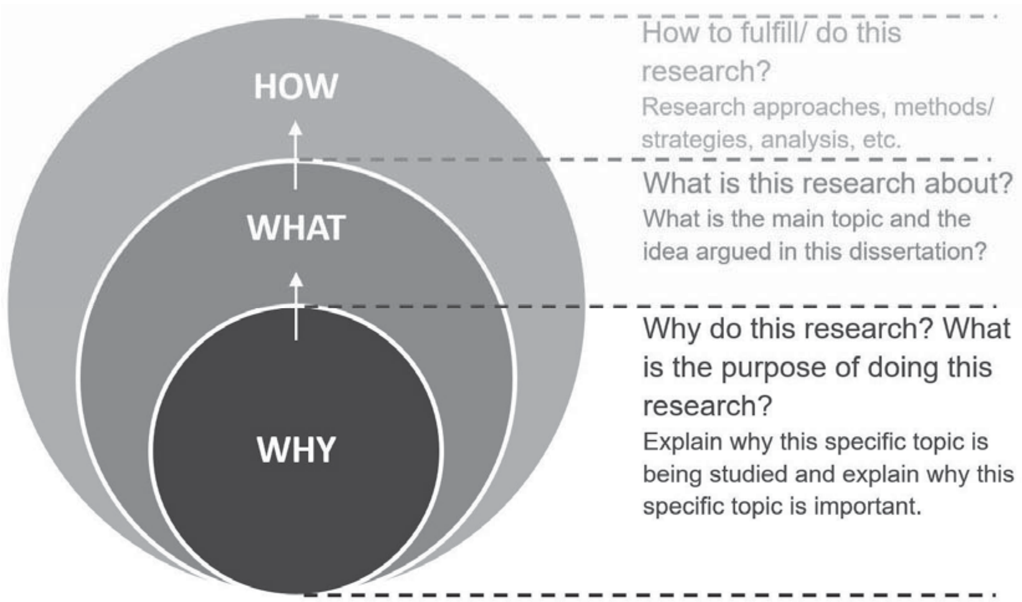

Figure 2.1-2: The why, what, how.

The writing of the dissertation involves taking a step back to reconsider the motivations and background, the goals and the objectives of the Ph.D. project, the rationale for formulating the research questions, the methodology applied for carrying out the research and how the papers have contributed to answering the research questions. It also involves discussing the main findings of most papers. However, this "perfect" process was not exactly the case for this specific dissertation, and that is due to the time constraint.

It is important to mention that the published journal articles have been subject to extensive peer review and have been revised based on the reviewers' feedbacks. The conference articles have also been under peer review in order to be accepted. However, the dissertation is more than the sum of the individual publications. Chapters 5, 6, 7, 8 and 9 provide a synthesis of the papers. In addition, they show how the research as a whole contributes to both theory and practice.

2.2 Research Purpose – (WHY?)

The purpose of doing this research has been discussed in the introductory chapter, in the first three sections. However, hopefully the additional details discussed in this section will add some light and clarity. As mentioned previously, this research is associated with, and financed by, the SpeedUp research project. Its mandate is described as follows:

"…. Large projects use long periods for creating and anchoring plans among the various stakeholders and also for choosing solutions that address security, climate change, energy, etc. During the implementation phase, a large number of contractors and project players interact so that the project objectives are achieved without compromising quality and safety."

This first statement is more related to the "unjustified" long duration in the pre-project phase for delivering the necessary plans to achieve efficiency in large projects. However, project efficiency is not explicitly described in this first statement.

"How is it possible to be more efficient in large projects when the complexity increases, when there are more actors and regulations? What can be done to reduce the planning and implementation time?"

This second statement is more related to the efficiency of doing tasks in large projects and shortening project duration (planning and execution phases). However, the extent to which the project should be efficient is not mentioned anywhere. Furthermore, it is not clear what is meant by "efficient" in the mandate or the rest of the SpeedUp project description. Nevertheless, the reader may interpret it as "fast project delivery" with respect to security, climate change, energy, quality of the deliverables and safety.

On the other hand, while saying "*to be more efficient*" and with respect to project success, that does not mean that a large-scale project will be successful just by being more efficient.

Based on the mandate discussed above, the Ph.D. research project is not limited only to project efficiency, but includes project effectiveness (both concepts are well defined explicitly in Chapter 9). Both concepts, efficiency and effectiveness, are used to reflect the degree to which the project is a success or failure. Thus, when dealing with time as a constraint or competitive advantage in managing large projects, someone should consider reflecting that in both concepts. In other words, there is no need to be efficient if at the end of the endeavor the deliverables do not bring any benefits or meet the planned goals.

This study was motivated not only by earlier research and a literature review, which revealed that quite a significant number of projects still fail to meet their efficiency and effectiveness, but also from investigating what is happening in the field about ongoing or completed LSEPs, where the time to delivery of these projects is not proportional with their types, budgets, sizes and scales as first observed.

The purpose of research, according to Yin (2013), can be exploratory, descriptive, explanatory or policy-oriented. Since any research develops over time, more than one of these purposes may be identified. Saunders *et al.* (2012) defined exploratory, descriptive and explanatory as follows:

Exploratory study is research that aims to seek a new insight into phenomena, to ask questions and to assess phenomena in a new light.

Explanatory study is research that focuses on studying a situation or a problem in order to explain the relationships between variables.

Descriptive study is research for which the purpose is to produce an accurate representation of persons, events or situations.

Finally, as described by Yin (2013), the policy-oriented approach aims to focus on approaches for solving or preventing a specific problem. In the study models, it is usual to distinguish between induction and deduction. An inductive approach proceeds from a number of single cases and assumes that a connection that has been observed in all these is also generally valid. A deductive approach, on the other hand, proceeds from a general rule and asserts that this rule explains a single case (Alvesson and Sköldberg, 2009). These two approaches are discussed further in Subsection 2.4.2.

To sum up, this Ph.D. work is about time and timing (chronos and kairos, respectively) in managing LSEPs and an investigation on possible approaches that can be applied to reduce project duration and improve meeting the time to delivery in cases where there is a need to finish faster. In other words, the study is twofold. Firstly, it seeks to establish an understanding regarding time as a “constraint” in managing LSEPs, which can be interpreted by the chronos time; moreover, it examines how to improve the performance of ongoing or upcoming projects through the use of TTMPs. Secondly, it seeks to establish how time could be used as a competitive advantage, which is in this case timing or kairos. In addition, this study endeavors to scrutinize possible barriers to the effective use of time within projects. In order to fulfill the research purpose, five research questions have been formulated and are discussed in the next section; the formulation of the research questions was based on the research purpose.

2.3 Research Questions – (WHAT?)

In accordance with the description in the introductory chapter 1, which is based on the existing gaps in the theory, and the preceding section, Section 2.2. Section 2.2 relates the purpose of this work, the ultimate objectives are to improve the understanding of the chosen research area and to provide practical suggestions as to how to solve the specific problems arising from the SPEEDUP research project.

The initial approach to formulating the final research question and designing the research project was to ask a wide range of questions. To narrow down the research approach, the context was defined as the speed of delivery of large-scale engineering projects and was limited to the project attributes versus time (where time may vary between the chronological and the kairos, as defined in Section 1.4 in Chapter 1)

The starting point of this doctoral research project originated in the "Why" question in Section 2.2, followed by the "What" question—the first question to be asked in the "WHAT" or "What is this research about?" circle (see Figure 2.1-2) and "What is the problem?" (see Figure 2.3-1).

Problems were identified in the SPEEDUP mandates and the gaps in the research, such as the "unjustified" long duration in the pre-project phase for delivering the necessary plans to achieve efficiency in LSEPS. The latter problem has been discussed by several scholars (Thamhain and Wilemon, 1986; Morris and Hough, 1987; Flyvbjerg *et al*., 2003), and I therefore identified the need to investigate the current state of affairs, and check whether projects really are delayed and deliver behind schedule. This was done based on a sample of projects. The first question relates to what is the state of affairs regarding time in LSEPs.

Since my research focused on the time (chronological, linear, and sequential) taken by projects, and the timing (kairos) of project delivery (with TTD and/or OTD as a final milestone), the question of "What is the problem?" is subdivided into three "What" questions because there is a need to understand the real problem instead of creating one. By contrast, when examining the first problem, two questions were asked, based on observations made from findings of RQ1 related both to the time wasted during the project lifecycle and to various project aspects, mainly flexibility and complexity.

Accordingly, the second "What" question is based on the first "What" question to some extent, and I investigate what caused time wasting, or, as termed in this dissertation, "delay factors." The last "What" question, but no less important, concerns how things are seen from one more angle and how problems are standardized, rather than checking only the delay factors, which may vary due to many related parameters for each project. This second "What" question has been investigated by many researchers, and I have identified more than 100 studies in the literature. However, little research has been done in Europe and none in Scandinavia to date.

The third and last "What" question is supplementary to the second one, and is about project speed and the aspects that may influence it, such as flexibility, uncertainty, and complexity.

The question is not based on a gap in theory, but rather my findings relating to it are an entirely new contribution. Studies conducted to date have mainly focused on the relationship between TTD and flexibility, complexity, and uncertainty. However, I aimed to check these aspects with respect to project speed and the extent to which they can hinder it.

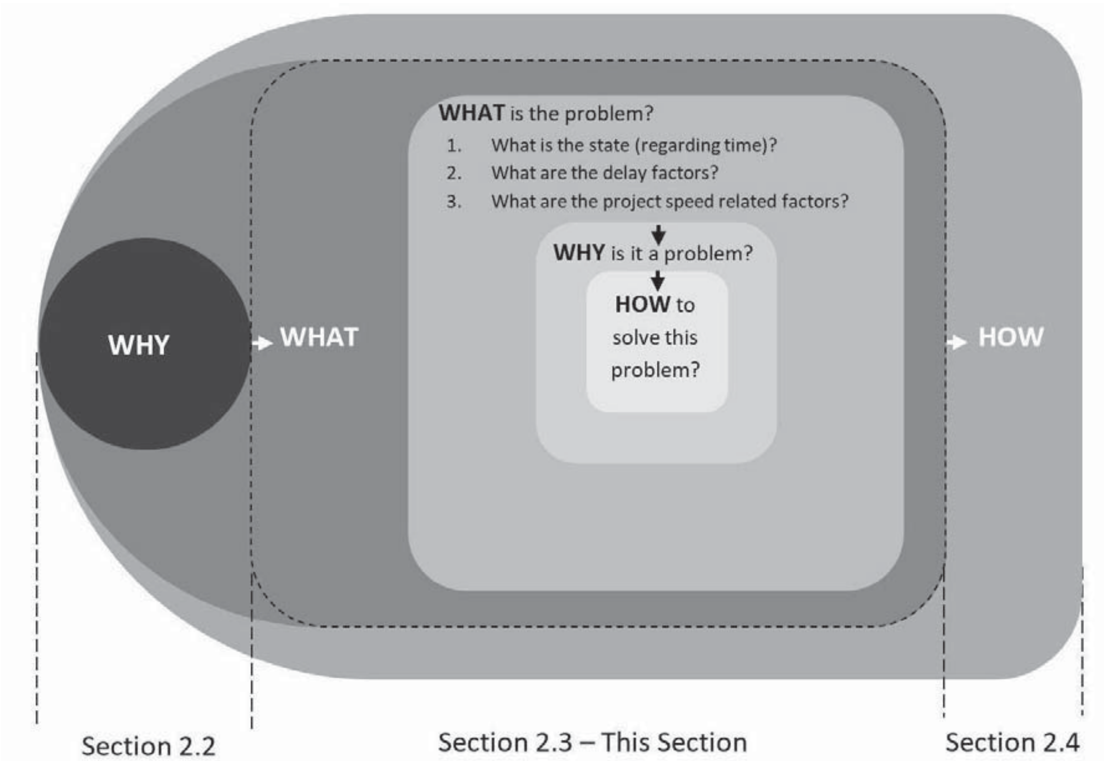

Figure 2.3-1: The “WHAT?” – The research questions.

With regard to the SPEEDUP project, one mandate was to address the following question:

How is it possible to be more efficient in large projects when the complexity increases, and when there are more actors and regulations?

Once the problem has been identified from different angles, it is very important to check whether the problem is really worth investigating, understanding, and solving, or whether instead it is preferable to identify a new problem. Thus, one of the most relevant questions to ask after the three “What” questions is the “Why” question: Why is “what have been identified” in the first three research questions a problem? In other words, is it worth shortening the project lifecycle (planning and execution), and why should we care? Moreover, why is it worth understanding issues and solving problems? Knowing the problem and understanding it signifies that one is halfway towards solving it.

With regard to the SPEEDUP project, a further mandate was to address the following question: *“What can be done to reduce the planning and implementation time?”*

The knowledge that a problem is worth solving will encourage the finding of a solution to it. Accordingly, the question that fitted the last, but not least important, part of the research was to ask the "How" question: How can I solve the identified problems in the first three research questions, and ensure that they are continuous to also stick to the answer to the fourth research question, which is about the "Why" of solving the problem.

There is a great need to examine in more detail the present state of affairs with respect to time and timing practices in large-scale engineering projects. This research area cannot be reduced to a few questions through any simple reductionist approach. Hence, my research questions were chosen according to the explanation given above, relating to the SPEEDUP project research objectives and the gaps identified in the theory. The research questions are:

Part I: What is the problem?

Research Question 1: **What is the current state of affairs and performance vis-à-vis the elapsed time, the time to delivery and other project aspects in a sample(s) of large-scale engineering projects?**

This first research question will open the door for the next two questions and enable a better understanding of them once answered. Moreover, the answers will assist in solving the last two questions (4 and 5). What is the current state of affairs and performance vis-à-vis the elapsed time (chronological, linear and sequential)? This part is more related to the time elapsed during the project (from the implementation to the delivery of the project). What is the current state of affairs and performance vis-à-vis the time to delivery (TTD) of large-scale engineering projects? This part is more related to the timing and effectiveness of the project; and this part will help more in the last research question, number 5. Answering this question will provide a foundation for better understanding the relationships between time and other constraints and project attributes and thus help build a foundation for further investigations.

Research Question 2: **What are the factors that cause delays in large-scale engineering projects?**

The purpose of this research question is to identify the major factors causing delays from the theoretical perspective initially. The identification will continue through empirical studies. The answers to this research question are very important in understanding the reasons for why this is a problem, and how to solve it.

Or in other words, the outputs from this research question are inputs for upcoming research questions.

Research Question 3: **What are the relationships between project speed and project flexibility, uncertainty and complexity?**

The definition of project speed as given in Section 7.1 of Chapter 7 will be the starting point for answering this research question. Flexibility, uncertainty and complexity will also be defined within Chapter 7, where the answers to this question are discussed. The aim of this research question is to understand how the aspects of flexibility, uncertainty and complexity affect project speed positively or negatively and vice versa.

Part II: Why is it a problem?

Research Question 4: **Is faster project delivery always better? If so, why?**

Having clear answers to the three first research questions will open the door to answering to some extent this research question systematically. This research question, asked in another way, would be "Why is delivering slowly and/or behind schedule a problem, and should we always go faster?" Of course, without discarding to explain the negative effects of the delay factors identified in Research Question 2.

In other words, "Why should delay factors be dealt with?" When answering this question, the perception of the stakeholders should be considered. There is a high probability that fast project delivery or ahead-of-schedule delivery is not wanted by all stakeholders, thus it ought to be established which types of projects need to be delivered faster and/or whether there is a need for projects to be categorized.

Part III: How can this problem be solved?

Research Question 5: **How can projects be delivered faster?**

The answers to this research question will be based mostly on the first three questions; however, there is an overlap with the previous research question, number 4.

The answers are related to fast project delivery, shortening project duration and improvements on how to achieve that. Is it possible to shorten each project phase separately (on what conditions)? If so, how? Do project phases overlap enough (the degree of concurrency)? If not, how can they overlap more?

2.4 Research Design – (HOW?)

Research design is the general plan of how to answer the research questions. It will specify the sources from which it is intended to collect the data, and how to collect and analyze those (Saunders *et al.*, 2012). Figure 2.4-1 shows the different layers that a researcher should define explicitly and follow before fulfilling the aims and objectives of the research.

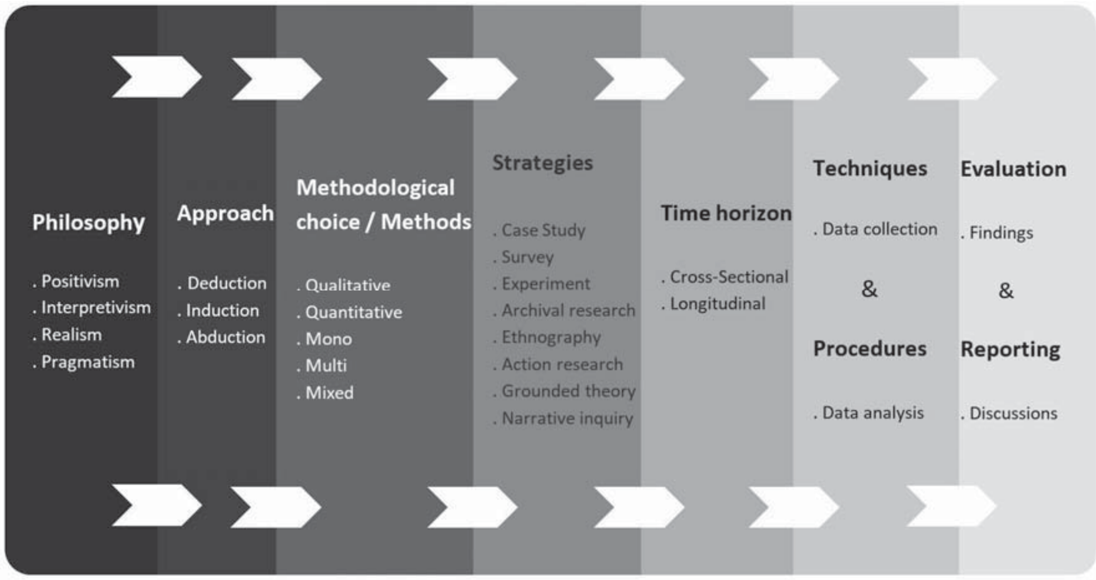

Figure 2.4-1: Research's layers.
(Adopted from: Saunders *et al.*, 2012)

Ongoing through different Ph.D. dissertations, it was noticed that there is distorted use of various terms in many of the methodology chapters of those dissertations. There was mixed use of the terms "research approach," "research method," "research strategy," "data collection techniques" and "data analysis procedures." The terms were used interchangeably and there were ambiguities. In this dissertation, hopefully the terms will be used explicitly and clearly.

Biedenbach (2015) emphasizes the importance of utilizing paradigms and articulating the research philosophy to effectively direct a new research endeavor. He stresses that the use of paradigms should be explicit for these reasons:

- to allow a fundamental categorization of the research field;
- to incorporate challenging viewpoints (paradigmatic pluralism);
- to offer new conceptual perspectives when taking a different ontological perspective; and to gain legitimacy outside the research field.

Easterby-Smith *et al.* (2012) suggest three reasons as to why the choice of approach is important. First, it enables the researcher to make a better-informed decision about his/her research design. Second, it helps the researcher to think about the associated research strategies that will and will not work for him/her. Third, knowledge of the different research traditions enables him/her to adapt his/her research design to cater for constraints, such as limited access to data or a lack of prior knowledge of the subject.

Choosing the research paradigm and research approach will facilitate the choice of the methods to be used in the research between a mono qualitative method, a mono quantitative method, multiple methods or mixed methods. Of course, depending on the previous choices made, the strategies are selected based on those previous choices. Research strategies are plans for how to answer the research questions, thus it is very important to determine the choices based on a very clear research scope. This section is divided into seven subsections. The next subsection is about the chosen research paradigm (Philosophy in Figure 2.4-1).

The following subsections are about the approach, literature review, research methods, research nature, research strategies, and techniques and procedures for data collection and analysis.

2.4.1 Research Paradigm – Philosophy

At every stage of a research, assumptions are made. Assumptions about human knowledge and about the nature of realities the researcher encounters in his/her research inevitably shape how he/she understands his/her research questions, the methods used and the interpreted findings (Crotty, 1998; Watson, 2011; Saunders *et al.*, 2012). The adopted research philosophy can be thought of as the way in which the researcher views the world. These assumptions will underpin the research strategy and the methods chosen as part of that strategy (Saunders *et al.*, 2012). The philosopher Kuhn (1962) in his seminal work "The Structure of Scientific Revolution" initially proposed the term "paradigm." One of the definitions of "paradigm" is "[a] way of examining social phenomena from which particular understandings of these phenomena can be gained and explanations attempted" (Saunders *et al.*, 2012). Alternatively, Merriam-Webster (1984) defines it as "a philosophical and theoretical framework of a scientific school or discipline within which theories, laws, and generalizations and the experiments performed in support of them are formulated".

Masterman (1970) classified three different paradigm categories: (1) A metaphysical paradigm or metaparadigm that relates to wider beliefs such as worldwide; (2) A sociological paradigm that concerns a set of scientific habits; and (3) A construct paradigm that can be seen as a concrete artifact or research vehicle for puzzle solving. Other definitions in the research literature include: a world view, a general perspective, a way of breaking down the complexity of the real world (Patton, 2002); shared understandings of reality (Rossman and Rallis, 2003); a definition of how the world works, how knowledge is extracted from this world and how one is to think and talk about this knowledge (Dills and Romiszowski, 1997); and a basic belief system or worldview that guides the investigation (Guba and Lincoln, 1994). A research paradigm is the belief system that guides how research should be conducted, based on people's philosophies and their assumptions about the world and the nature of knowledge (Collis and Hussey, 2009). According to Guba (1990), paradigms can be seen as basic beliefs directing researchers' actions in a net of epistemological, ontological and methodological premises –

ontology is “what is real?”, epistemology is “what is the relationship between the inquirer and the known?”, and methodology is “methods for exploring this knowledge” (Creswell 2013). The paradigm thus frames the philosophical stance of the researcher and determines the choices regarding how research will be conducted (Biedenbach, 2015). In this regard, Johnson *et al.* (2007) use the term “paradigm” on a methodological level referring to quantitative, qualitative and mixed methods as possible research paradigms.

Different paradigms have been developed in the past century due to significant growth in social science research. Ontology is concerned with the nature of reality (Saunders *et al.*, 2012). It concerns the question of whether social entities have a reality independent of social actors or whether they are social constructions of social actions and perceptions (Biedenbach, 2015; Bryman and Bell, 2015). Ontology is divided into two categories: (1) Objectivism represents the position that social entities exist in reality externally to, and independently of, social actors (Collis and Hussey, 2009; Saunders *et al.*, 2012); (2) Subjectivism views reality as socially constructed and where actors that engage in social interactions and social phenomena are in a constant state of change (Saunders *et al.*, 2012; Biedenbach, 2015). Table 2.4-1 summarizes and compares the existing philosophies.

Table 2.4-1: Comparison of four main philosophies
(Adopted from: Saunders *et al.*, 2012, p.140)

	Pragmatism	Positivism	Realism	Interpretivism
Ontology – Researcher’s view on nature of reality	External, multiple, most appropriate view chosen for answering the research question.	External, objective and independent of social actors.	Objective, exists independently of human thought or knowledge about their existence (realism) but is interpreted through social conditions (critical realism)	Subjective, socially constructed, may alter, multiple.
Epistemology – Researcher’s view on acceptable knowledge	Depending on research question, either or both, observable phenomena and subjective meanings can provide acceptable knowledge.	Only observable phenomena enable the production of facts and credible data. Focuses on causality and law-like generalizations.	Observable phenomena provide credible data and facts. Insufficient data means inaccuracies in sensations (realism) or phenomena create sensations that are open to misinterpretations (critical realism). Focuses on explanations within a context.	Subjective meanings and social phenomena. Focus on details of situation and its reality, subjective meanings motivating actions.
Axiology – Researcher’s view on role of values in research	Large role of values in interpreting results. A researcher takes both an objective and subjective view.	Value-free research with the researcher being objective and independent of the data.	Value-laden research, because the researcher is biased concerning worldview, cultural experiences and background, which affect the research.	Value-bound and subjective. The researcher is part of what is researched and cannot be separated.

Epistemology concerns what constitutes acceptable knowledge in a field of study (Saunders *et al.*, 2012). Four stances can be distinguished in epistemology: positivism, realism, interpretivism and pragmatism.

Positivism relates to natural science traditions in which interrelationships between objects are studied and are unaffected by the research activities (Collis and Hussey, 2009; Biedenbach, 2015). Positivism emphasizes an objectivist approach to studying social phenomena, and attaches significance to research methods focusing on quantitative analysis such as surveys and questionnaires (Dash, 2005).

Interpretivism sees the world as too complex to develop precise law-like generalizations as in the natural sciences. However, it indicates that it is necessary for the researcher to understand differences between humans in our role as social actors (Saunders *et al.*, 2012).

Realism assumes that objects exist independently of the human mind and sees natural science as the development of knowledge (Saunders *et al.*, 2012). According to Saunders *et al.* (2012), there are two types of realism. The first type is direct realism, which means that what you see is what you get; and it implies that with our senses we are capable of experiencing the world accurately. The second type of realism is critical realism, which denotes that instead of experiencing the world directly, we only experience images of the world. According to Easton (2010), critical realism is a coherent, rigorous and novel philosophical position that not only substantiates case research as a research method but also provides helpful implications for both theoretical development and the research process.

Pragmatism emphasizes that concepts are only relevant where they support action (Kelemen and Rumens, 2008). It recognizes that there are many ways to conduct research and interpret the world, thereby accepting different philosophical positions and multiple methods, from which comes pluralism (Saunders *et al.*, 2012).

In the field of project management, researchers rarely state explicitly their philosophical foundations (Biedenbach, 2015). Generally, research in the field of project management is mostly dominated by positivist epistemology (Cooke-Davies *et al.*, 2007; Smyth and Morris, 2007; Biedenbach, 2015). Before revealing the position chosen in this Ph.D. work, it is important to mention that a researcher should be attentive about the choice of position apropos the relationship between theory and practice, research and knowledge, and epistemology and ontology. Here added that the choices include the research approach (deductive, inductive and adductive approaches, as discussed in the next subsection), objectivist versus constructivist orientation in ontology, and positivist versus relativist or realist orientation in epistemology (Klakegg, 2015).

Hess (1997) pointed out that sciences become more interdisciplinary, and thus our thinking about sciences needs an interdisciplinary perspective. Sørensen (2006, p.16) defines an interdisciplinary approach as “an approach that is about producing holistic, integrated knowledge”. However, researchers come with a background from one or a few disciplines, which contradicts the notion of a single researcher delivering interdisciplinary research (Klakegg, 2015).

A solid position is one that can address multiple questions within a multidisciplinary area. This will allow the researcher to choose between any of the three research approaches (deductive, inductive and adductive), and pluralism in the choice of the research methods (quantitative, qualitative, multimethod, mixed methods). Epistemological paradigms include pragmatism (Howe, 1988) and critical realism, where qualitative and quantitative methods can coexist (Mingers, 2006). On the other hand, recent researches in the field of project management have increased mutual acceptance of positivism and interpretivism, due to the complexity of project management (Williams, 1999; Cooke-Davies *et al.*, 2007); thus there is a need for pragmatic pluralism (Pellegrinelli, 2011). A way to overcome dualism has been found in the paradigms of pragmatism (more tolerant) and critical realism (comprises influences from two opposing paradigms) (Biedenbach, 2015).

First, critical realism has some common features with positivism and interpretivism paradigms but recognizes that multiple causes usually influence events and situations in open systems (Klakegg, 2015). Critical realism is philosophically a more complex position that incorporates the need for critical evaluation of objects to gain an understanding of social phenomena (Sayer, 1992). This position encourages interdisciplinary research and it has some features in common with natural science (Easton, 2010). In project management research, Biedenbach (2015) argues that the critical realism position can allow the application of mixed methods while conducting the research, where mixed methods can be designed to be sequential or concurrent, as well as quantitative, qualitative or both (Johnson and Onwuegbuzie, 2004). Critical realism is also the most heuristically suggestive position, and therefore encourages interdisciplinary research (Bhaskar and Danermark, 2006).

Second, pragmatism means that the exact position on a positivism and interpretivism continuum is determined by the research question, which directs the methodological choices in order to gain the best knowledge from the research (Kelemen and Rumens, 2008; Saunders *et al.*, 2012).

Pragmatism allows multiple positions; in other words, it means that the most important determinant of the researcher's position on each of the continua is the research question. One position may be more appropriate than another for answering a particular research question; this confirms the pragmatist's view that it is perfectly possible to work with different philosophical positions (Saunders *et al.*, 2012).

The position embraced in this Ph.D work in order to fulfill the research objectives and based on all that is argued above is pragmatism. The research questions in this dissertation cover a wide multiplicity of aspects, which requires paradigmatic pluralism, which allows the use of different approaches (inductive, deductive and/or adductive). This enables the use of pluralism in the choice of methods, and thus pragmatism is found to be a suitable paradigm as a platform for the research strategy.

The most important thing for pragmatists in the meaning of an idea (research finding) is the practical consequences (Saunders *et al.*, 2012). Pragmatists recognize that there are many different ways of interpreting the world and undertaking research, that no single point of view can ever give the entire picture and that maybe there are multiple realities. This does not mean that in the pragmatism position, the researcher always uses multiple methods; rather he/she uses the method(s) that enables credible, well-founded, reliable and relevant data to be collected that advance the research (Kelemen and Rumens, 2008).

In general, data collection is done through applying a quantitative or qualitative approach or a combination of both methods (Saunders *et al.*, 2012; Creswell, 2013). Although a combination of qualitative and quantitative methods has been employed in this dissertation in order to obtain the essential data, the author tends to subjectively analyze the data, because human factors are the most influential aspect in managing projects.

According to the previous discussion and supported by Table 2.4-1. The choice of pragmatism as a philosophy on ontology (researcher's view on nature of reality), epistemology (researcher's view on acceptable knowledge) and axiology (researcher's view on role of values in research) is the best to answer freely the selected research questions and it is considered the best choice by the author. As can be seen, pragmatism allows a high level of flexibility in answering the research questions and selecting the appropriate methods for that.

2.4.2 Research Approach

In most of the literature about research approaches, it is always mentioned that research approaches are deductive and inductive. However, in Figure 2.4-1 there is a third one: abduction. A deductive approach tests the validity of the assumptions in hand, whereas an inductive approach contributes to the emergence of new theories and generalizations. The relations between theory and research can be described as deductive (theory guides research) or inductive (theory follows from research). Abduction is a combination of deduction and induction. Table 2.4-2 is a guide for choosing between the different approaches; below the three approaches are discussed.

A deductive approach involves the development of a theory that is then subjected to a rigorous test through a series of propositions; this approach is more dominant in natural sciences (Sanders *et al.*, 2012). Deduction means deriving logically valid conclusions from given premises – deriving knowledge about individual phenomena from universal laws (Næss, 2004). Deduction is often associated with scientific research and positivism, and its principal goal is to test a hypothesis through falsification (Tong and Thomson, 2015). The hypothesis can then be confirmed or falsified from subsequent findings, which leads to modification of the theory if that is necessary (Robson, 2011).

Blaikie (2010) suggests six steps through which deduction will progress: (1) Present a tentative idea or set of hypotheses to form a theory; (2) Use existing theory to deduce a testable proposition(s); (3) Examine the premises and the logic of the argument that produces them, comparing this argument with existing theories; (4) Test the premises by collecting appropriate data to measure the concepts or variables and analyzing them; (5) In cases where the results of the analysis are not consistent with the premises, then the theory is false and must be either rejected or modified and the process restarted; (6) If the results of the analysis are consistent with the premises then the theory is corroborated. Deduction allows findings to be generalized through inferences on the wider population (Tong and Thomson, 2015). The approach is illustrated in Figure 2.4-2 with the two other approaches.

The inductive approach emerged from the development of the social sciences during the twentieth century as a direct critique of the dominant deductive approach associated with the natural sciences. Researchers using an inductive approach are likely to be concerned with the context in which events take place (Tong and Thomson, 2015). Thus, studying samples of subjects might be more appropriate than studying a large number as with a deductive approach (Saunders *et al.*, 2012).

Induction means drawing universally valid conclusions about a whole population from a number of observations (Tong and Thomson, 2015). An inductive approach involves collecting data at the outset to establish what is happening and to enable a better understanding of the nature of the problem by asking questions about the phenomenon of interest. Once data are collected, they need to be categorized into meaningful categories from which a theory may be developed (Saunders *et al.*, 2012). This approach creates a more flexible structure that allows alternative explanations of the phenomenon to be considered. The approach is illustrated in Figure 2.4-2.

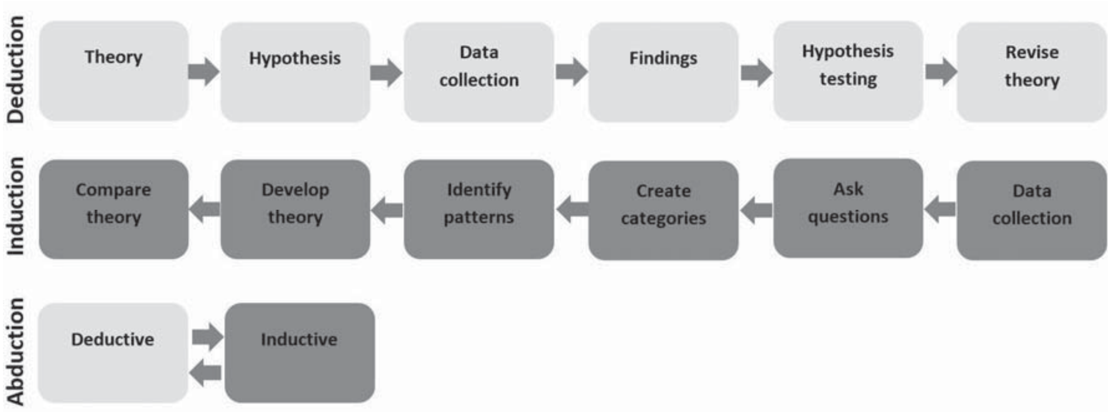

Figure 2.4-2: Deduction, induction and abduction.
(Adopted from: Saunders *et al.*, 2012; Tong and Thomson, 2015)

Abduction is a combination of deduction and induction; in theoretical terms, instead of moving from theory to data (deduction) or data to theory (induction), an abductive approach moves back and forth (Suddaby, 2006). Abduction begins with observation of a "surprising fact," then works out a plausible theory as to how this could have occurred (Saunders *et al.*, 2012). Abduction can also be understood as when a particular phenomenon is interpreted from a general set of ideas or concepts, and retroduction as a reconstruction of the basic conditions for anything to be what it is. This means that one seeks to identify qualities beyond what is immediately given (Næss, 2004). The approach is illustrated in Figure 2.4-2.

Table 2.4-2: Choice for the research approach
(Adopted from: Leedy and Ormrod, 2005)

Use this approach if:	Deductive – Quantitative	Inductive – Qualitative
1. You believe that	- There is an objective reality that can be measured	- There are multiple possible realities constructed by different individuals
2. The audience is	- Familiar with quantitative studies	- Familiar with/supports qualitative studies
3. The research question is	- Confirmatory, predictive	- Exploratory, interpretive
4. The available literature is	- Relatively large	- Limited
5. The research focus	- Covers a lot of breadth	- Involves in-depth study
6. The time available is	- Relatively short	- Relatively long
7. The ability/desire to work with people is	- Medium to low	- High
8. The desire to structure is	- High	- Low
9. You have skills in the area(s) of	- Deductive reasoning statistics	- Inductive reasoning and attention to detail
10. Your writing skills are strong in the area(s) of	- Technical, scientific writing	- Literary, narrative writing

The selected position as discussed in the previous subsection is pragmatism. The choice was based on the need for paradigmatic pluralism, which allows the use of different approaches to answering the research questions. Thus, there is a lot of flexibility in the choice of the approach for each research question.

The choice of the approaches incorporated in this Ph.D. work in order to fulfill the research objectives and based on all that is discussed above is *inductive* and *deductive* approaches (see Table 2.4-3).

Table 2.4-3: Research questions and the approaches used

Research questions	Approaches
Research Question 1: What is the current state of affairs and performance vis-à-vis the elapsed time, the time to delivery and other project aspects in a sample(s) of large-scale engineering projects?	Inductive/deductive
Research Question 2: What are the factors that cause delays in large-scale engineering projects?	Deductive/inductive
Research Question 3: What are the relationships between project speed and project flexibility, uncertainty and complexity?	Inductive
Research Question 4: Is faster project delivery better? If so, why?	Inductive
Research Question 5: How can projects be delivered faster?	Inductive

The research questions in this dissertation cover a wide multiplicity of aspects, which requires pluralism in the choice. One approach may be more appropriate than another for answering a particular research question; this confirms the pragmatist's view that it is perfectly possible to work with different approaches. However, in the chosen position (pragmatism), it is permissible to use both approaches within the same research question; this will allow the use of both methods (qualitative and quantitative) or a mixture of the two. This also justifies the use of the pragmatism position and inductive/deductive approaches. In Section 2.6, Table 2.6-1 summarizes all the approaches used within each chapter, paper and research question. Table 2.4-3 is about the research questions and the approaches used for each one.

2.4.3 Critical Literature Review

Research in the field of project management makes use of a wide range of literature. Research with a deductive approach will use literature to identify theories that will be tested with the findings. On the other hand, research with an inductive approach will aim to develop theories from data/findings that are subsequently related to the literature. Therefore, in both cases, there should be a literature review to complete the research work. Robinson and Reed (1998, p.58) define a literature review as "a systematic search of published work to find out what is already known about the intended research topic." It also allows researchers to acquire an understanding of the research topics and the key issues (Hart, 1998).

A literature review allows the researcher to find out what has been done in terms of the problem being investigated, thereby ensuring that duplication does not occur (Aitchison, 1998). However, the research in this dissertation is based on a critical literature review. According to Petticrew (2001), systematic reviews are not just big literature reviews, but address specific issues. Being systematic reduces bias in the selection and inclusion of studies. It is a scientific, replicable and evidence-based methodology, which minimizes bias (Cook *et al.*, 1997; Tranfield *et al.*, 2003).

Tong and Thomson (2015) explain that for a researcher, being critical is about adopting a skeptical stance and being willing to question what he/she is reading. They added that it requires the researcher to have gained topic-based background knowledge, understanding and the ability to reflect upon and analyze the literature, and based on this, to make reasoned judgements that are argued effectively.

They proposed a process for performing a literature review, which consists of these steps: (1) defining the parameters of the research aim and objectives; (2) generating keywords and conducting a preliminary search; (3) refining the parameters to undertake further searches, but still focusing on the research aim and objectives; and (4) further refining the research aim and objectives in light of the review. The literature review process is presented in Figure 2.4-3.

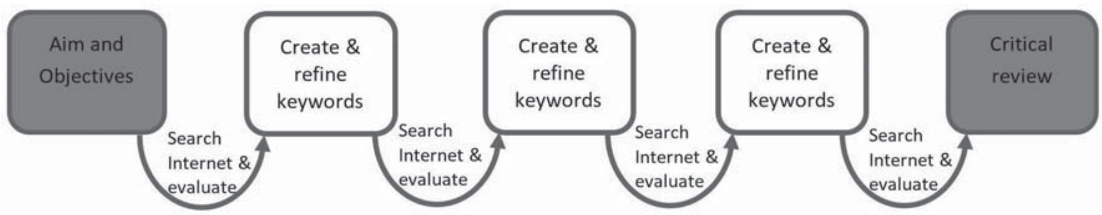

Figure 2.4-3: Literature review process.
(Adopted from: Tong and Thomson, 2015)

A preliminary literature review is essential for aiding the generation of ideas, developing an understanding of where the research sits in relation to the body of knowledge and establishing research questions that are relevant and add value (Saunders *et al.*, 2012). There are diverse techniques for searching literature, however using Internet searches increasingly facilitates both basic and specialized searches. The main techniques used in this dissertation are: (1) keyword search, by using keywords to structure the search by themes, subthemes, phrases, etc.; in this dissertation the themes, subthemes and keywords depend on each research question separately, since the paradigm used in this research is pragmatism; (2) backward search, using references or authors from previous searches; and (3) forward search, by looking at those who have cited particular articles.

In the case of this Ph.D. work, the literature study was guided by searches on the Internet, where important knots of knowledge were found. The difficult part was trying to sort out the most relevant literature from a long list of titles. This was sometimes very time-consuming and inefficient; however, it is unavoidable at the start of such a journey. Then the backward search technique was used afterward to refine the aim and objectives of the research. An intensive literature review was conducted based on different sources.

A wide variety of books and journal articles were considered. Most of the journal articles were found through resources given by university databases such as SCOPUS (Elsevier) and Web of Science (ISI). Searches were extended to the reference lists provided in the search results (reference lists of the relevant articles). Searches were prolonged by using Google Scholar. All countries worldwide and authors were considered in these searches, without any exception or exclusion. Table 2.4-4 represents the literature search by keywords and the associated research question.

A search for sources that have proposed different relevant literature and frameworks was conducted through relevant library and science databases covering all journals of management and project management that were considered relevant, e.g., *International Journal of Project Management*, *Journal of Project Management*, *Project Appraisal Journal*, *Administration in Social Work Journal* and many other academic journals related to evaluation. The list is too long to mention all of them here.

Table 2.4-4: Research questions, the associated keywords and the literature search

Research questions	Keywords	Sources
Research Question 1: What is the current state of affairs and performance vis-à-vis the elapsed time, the time to delivery and other project aspects in a sample(s) of large-scale engineering projects?	Iron triangle, project speed, project pace, time overrun, project behind schedule	For all the searches: Use of university database for searching journal articles, conference papers, e-books, unpublished papers. Use of Google Scholar Use of printed books from library. Purchase of books not found in library.
Research Question 2: What are the factors that cause delays in large-scale engineering projects?	Project delays, delay causes, delay factors, delay effects	
Research Question 3: What are the relationships between project speed and project flexibility, uncertainty and complexity?	Project speed, project pace, project flexibility, project complexity, project uncertainty	
Research Question 4: Is faster project delivery better? If so, why?	Delay effects, methods, tools, techniques, philosophies, performance, barriers, fast tracking, concurrent engineering, cost-time trade-offs, project categorization	
Research Question 5: How can projects be delivered faster?	Delay remedies, delay cures, dealing with delays, Yin and Yang, project efficiency, project effectiveness, time, timing, chronos, kairos, project evaluation	

The search was extended to other journals related to social sciences, behavioral sciences, psychology, public heath practice and health care, since these were the first to publish articles about different aspects of management and project management. Other databases and search engines were utilized to uncover books published since the 1950s. The results of the literature search demonstrate that although there are many literature sources that directly refer to the concept of “time” in project management, there are many more that discuss concepts that are closely associated with the fact that is “time” and have been extensively applied to answer the research questions.

Over 2000 literature sources, including journal articles, conference articles, books, public documents, etc., were studied in the course of this research. Once the most relevant sources had been selected (mostly journal articles, where their number exceeded 1000 articles), the second step was how to compare those theories with the findings of this Ph.D. work and answer the research questions.

It is important to mention that other types of documents were used, but they are not considered to be literature (e.g., technical reports, newspapers, etc.). However, they are considered to be secondary data and more details about these types of data are discussed in Subsection 2.4.7.

2.4.4 Research Methods – Methodological Choice

The difference between quantitative and qualitative research is repeatedly seen as quite fundamental. The quantitative view is labeled as being *realist* or sometimes *positivist*, while the worldview underlying qualitative research is viewed as being *subjectivist* (Muijs, 2011).

Saunders *et al.* (2012) suggested that one way to tell between qualitative research and quantitative research is to distinguish between numeric data (numbers) and nonnumeric data (e.g., words, images, video clips, etc.). They added that quantitative research is often used as a synonym for any data collection technique or data analysis procedure that generates or uses numerical data. In contrast, qualitative research is often used as a synonym for any data collection technique or data analysis procedure that generates or uses nonnumeric data. However, they emphasized that this is a problematic narrow distinction.

Table 2.4-5 summarizes the main differences between qualitative research and quantitative research.

Table 2.4-5: Quantitative research versus qualitative research
(Adopted from: Bryman, 2008)

Qualitative research	Quantitative research
Words	Numbers
Point of view of participants	Point of view of researcher
Researcher close	Researcher distant
Theory emergent	Theory testing
Process	Static
Unstructured	Structured
Contextual understanding	Generalization
Rich, deep data	Hard, reliable data
Micro	Macro
Meaning	Behavior
Natural setting	Artificial setting

Bryman (1989) mentions that a very important distinguishing feature of qualitative methods is that they start from the perspective and actions of the subjects studied, whereas quantitative studies usually proceed from the researcher's ideas about the dimensions and categories that should constitute the central focus.

a. Qualitative Research

Qualitative research has an emphasis on words rather than quantification in the collection and analysis of data (Bryman, 2008). Creswell (2012) describes quantitative research by its six characteristics, which are:

1. Exploring a problem and developing a detailed understanding of a central phenomenon.
2. Having the literature review play a minor role but justifying the problem.
3. Stating the purpose and research questions in a general and broad way so as to reflect the participants' experiences.
4. Collecting data based on words from a small number of individuals so that the participants' views are obtained.
5. Analyzing the data for description and themes using text analysis and interpreting the broader meaning of the findings.
6. Writing the research report using flexible, emerging structures and evaluative criteria, and including the researcher's subjective reflexivity and bias.

Creswell (2012) states that qualitative study is best suited to addressing a research problem where you do not know the variables and need to explore. Denzin and Lincoln (2011, p.3) strongly accentuate the researcher's presence and interpretive work in this type of research method: *"Qualitative research is a situated activity that locates the observer in the world. It consists of a set of interpretive, material practices that make the world visible. These practices transform the world. They turn the world into a series of representations, including field notes, interviews, conversations, photographs, recordings, and memos to the self. At this level, qualitative research involves an interpretive, naturalistic approach to the world. This means that qualitative researchers study things in their natural settings, attending to make sense of, or interpret, phenomena in terms of the meanings people bring to them."*

Alvesson and Sköldberg (2009) state that this characterization of qualitative studies is valid for the majority of such research (based on the latter statement). According to Watkins (2012), the following techniques are the most common means associated with qualitative research: (1) group interviews/focus groups: group of people discussing a particular phenomenon; (2) individual interviews: meeting with individuals to discuss a particular phenomenon (open-ended, unstructured, semi-structured or structured); (3) participation observation: observing individuals in a particular setting to study a specific phenomenon; and (4) document review: systematic document analysis, which provides insight into contextual history/information regarding the study group.

b. Quantitative Research

Quantitative research is generally associated with positivism, especially when used with predetermined and highly structured data collection techniques. However, a distinction should be made between data related to attributes of people, organizations or things and data related to opinions (qualitative numbers), where the latter may be seen to fit interpretivism philosophy (Saunders *et al.*, 2012). Quantitative research, according to Aliaga and Gunderson (2000), explains phenomena by collecting numerical data, which are analyzed through mathematically based methods, in particular statistics. Creswell (2012) describes quantitative research by its six characteristics, which are:

1. Describing a research problem through a description of trends or a need for an explanation of the relationship among variables.
2. Providing a major role for the literature through suggestions of the research questions to be asked and justifying the research problem and creating a need for direction for the study.
3. Creating purpose statements, research questions and hypotheses that are specific, narrow, measurable and observable.
4. Collecting numeric data from a large number of people using instruments with preset questions and responses.
5. Analyzing trends, comparing groups or relating variables using statistical analysis, and interpreting results by comparing them with prior predictions and past research.
6. Writing the research report using standards, fixed structures and evaluation criteria, and taking an objective unbiased approach.

Creswell (2012) added that in quantitative research, the researcher identifies a research problem based on trends in the field or on the need to explain why something occurs. Describing a trend means that the research problem can be answered best by a study in which the researcher seeks to establish the overall tendency of responses from individuals and notes how this tendency varies among people. The most common techniques associated with quantitative research, according to Bryman (2008), include: (1) survey/questionnaires; (2) observation schedules; arranging schedules for recording observations; and (3) coding frames, a transcript of respondents' replies that identifies the types of answers associated with each question and the respective codes.

c. Methodological Choice

Figure 2.4-4 shows the possible methodological choice (Saunders *et al.*, 2012, p.165). The basic choice is between using single data collection techniques and corresponding analytical procedures, which is known as ***mono method research*** (a choice has to be made between qualitative study and quantitative study).

Bryman (2006) states that ***multiple methods research*** is increasingly advocated within management research. Saunders *et al.* (2012) describe it as using more than one data collection technique and analysis procedure to answer the research question. Multiple methods research, in turn, is divided into two types:

Multimethod research, where more than one data collection technique is used with associated analysis procedures; however, this is restricted to either qualitative research design (multimethod qualitative study) or quantitative research design (multimethod quantitative study) (Tashakkori and Teddlie, 2010; Saunders *et al.*, 2012).

Mixed methods research, where both quantitative and qualitative research are joined in the research design, and these may vary from simple to complex fully integrated forms (Saunders *el al.*, 2012). The use of both a qualitative method and a quantitative method during data collection and analysis and at every stage, including during the interpretation and presentation of the research, reflects ***fully integrated mixed methods research***, while if one of the methods is used separately within a stage this indicates ***partial integrated mixed methods research*** (Leech and Onwuegbuzie, 2009; Teddlie and Tashakkori, 2009; Nastasi *et al.*, 2010; Saunders *el al.*, 2012).

Mixed methods research may be conducted sequentially or concurrently (Creswell and Clark, 2007; Saunders *et al.*, 2012).

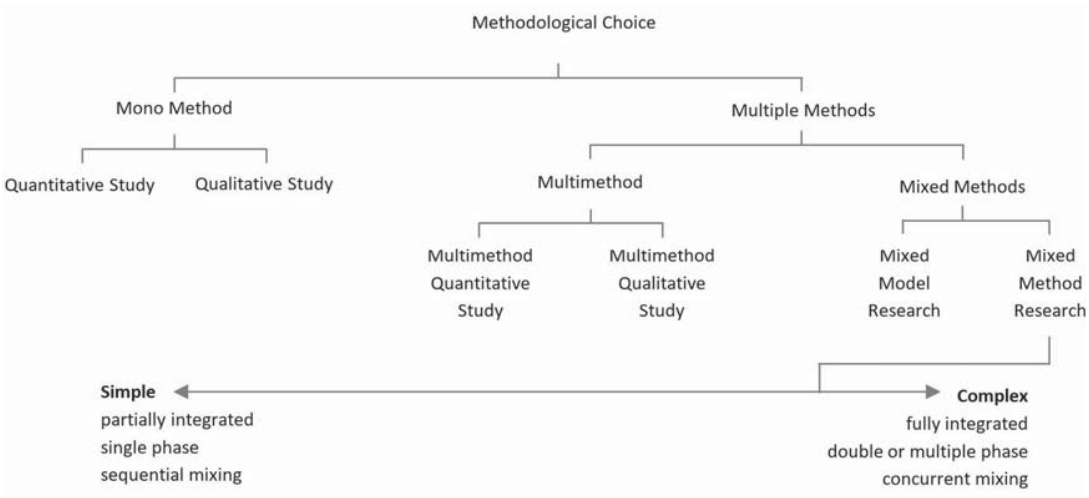

Figure 2.4-4: Methodological choice.
(Adopted from: Saunders *et al.*, 2012, p.165)

Sequential mixed methods research involves more than one phase of data collection and analysis, where the research will follow the use of one method with another in order to expand or elaborate on the initial set of findings (Saunders *et al.*, 2012).

Concurrent mixed methods research involves the use of both quantitative and qualitative methods within a single phase of data collection and analysis, which allows both sets of results to be interpreted together to provide a richer and more comprehensive response to the research questions (Saunders *et al.*, 2012). The selected position as discussed in the previous subsection is pragmatism. The choice was based on the need for paradigmatic pluralism, which allows the use of different approaches to answer the research questions. Thus, there is a lot of flexibility in the choice of the approach for each research question and the associated methods (methodological choice).

The choice of the research methods incorporated in this Ph.D. work in order to fulfill the research objectives and based on all that has been discussed above is *mono qualitative*, *mono quantitative* and *multimethod* (qualitative and quantitative). Table 2.4-6 is about the research questions and the methodological choices used for each one.

Table 2.4-6: Research questions and the methodological choices

Research questions	Methodological choices
Research Question 1: What is the current state of affairs and performance vis-à-vis the elapsed time, the time to delivery and other project aspects in a sample(s) of large-scale engineering projects?	Multimethod: Qualitative/quantitative
Research Question 2: What are the factors that cause delays in large-scale engineering projects?	Multimethod: Quantitative/qualitative
Research Question 3: What are the relationships between project speed and project flexibility, uncertainty and complexity?	Qualitative
Research Question 4: Is faster project delivery better? If so, why?	Qualitative
Research Question 5: How can projects be delivered faster?	Qualitative

The research questions in this dissertation cover a wide multiplicity of aspects, which requires pluralism in the choice, as mentioned several times in previous subsections. One research method may be more appropriate than another for answering a particular research question; this confirms the pragmatist's view that it is perfectly possible to work with different research methods. However, in the chosen position (pragmatism), it is permissible to use both research methods (qualitative and quantitative) separately, in parallel or mixing them within the same research question. This also justifies the use of the pragmatism position and inductive/deductive approaches.

2.4.5 Research Nature

The way in which a research question is asked will involve exploratory, descriptive or explanatory research leading to an answer that is either descriptive, descriptive and explanatory, or explanatory (Saunders *et al.*, 2012).

Exploratory study is a valuable way to ask open questions to discover what is happening and gain insights into a topic of interest; it may begin with a broad focus but it will become narrower as the research progresses (Saunders *et al.*, 2012), with the various ways of conducting exploratory research including literature study, interviewing experts, conducting in-depth individual interviews and focus group interviews. Saunders *et al.* (2012) argue that exploratory research has the advantage of being flexible and adaptable to change, so that the researcher, if he/she is conducting exploratory research, may be willing to change his/her direction as a result of new data that appear and new insights that occur to him/her.

Descriptive research is aimed at gaining an accurate profile of events, persons or situations. In addition, it is necessary to have a clear picture of the phenomenon about which the researcher wishes to collect data prior to the data collection (Saunders *et al.*, 2012). Descriptive research incorporates a detailed description of people and places to carry the narrative (Creswell, 2012).

Explanatory research is studies that establish causal relations between variables, where the emphasis is on studying a situation or problem in order to explain the relationships between variables (Saunders *et al.*, 2012). Many authors refer to relational research as an explanatory correlation research (Cohen and Manion, 1994), or explanatory research (Fraenkel and Wallen, 2000). Creswell (2012) defined explanatory research as a correlational design in which the researcher is interested in the extent to which two variables (or more) covary, that is where changes in one variable are reflected in changes in the other. He added that explanatory designs consist of a simple association between two or more variables.

Table 2.4-7 is about the research questions and the nature of research associated with each one.

Table 2.4-7: Research questions and the associated research nature

Research questions	Research nature
Research Question 1: What is the current state of affairs and performance vis-à-vis the elapsed time, the time to delivery and other project aspects in a sample(s) of large-scale engineering projects?	Exploratory, Explanatory
Research Question 2: What are the factors that cause delays in large-scale engineering projects?	Exploratory, Explanatory
Research Question 3: What are the relationships between project speed and project flexibility, uncertainty and complexity?	Exploratory, Explanatory
Research Question 4: Is faster project delivery better? If so, why?	Exploratory, Explanatory
Research Question 5: How can projects be delivered faster?	Explanatory

It is very important to recognize the nature of the research design that emerges from the research by the researcher. The nature of the research has something to do directly with the research questions. In this Ph.D. work, as there are five research questions, it is very possible to touch on the three-research nature (exploratory, descriptive and explanatory). The research nature in this Ph.D. work, in order to fulfill the research objectives and based on all that has been discussed above, covers the three-research nature (exploratory, descriptive and explanatory). The research nature (exploratory, descriptive, explanatory or combination) is the consequence of the way research questions are asked. However, the answers will also have a nature that is exploratory, descriptive, explanatory or a combination of all three.

2.4.6 Research Strategies

A ***research strategy*** is a plan of action to achieve a goal. For that reason, it may be defined as a plan of how a researcher will go about answering his/her research question (Saunders *et al.*, 2012). Moreover, it is a working bridge to fill the gap between the research paradigm and the choice of methods for collecting and analyzing data (Denzin and Lincoln, 2011).

In this dissertation, from among the eight research strategies listed below, only those relevant to this Ph.D. work will be discussed. However, that does not mean that not all of these research strategies are relevant for answering the research questions.

- Case Study;
- Survey;
- Experiment;
- Archival Research;
- Ethnography;
- Action Research;
- Grounded Theory;
- Narrative Inquiry.

These strategies can be used separately or in combination with each other. Quantitative research in general is associated with experiments and surveys. Qualitative research is linked to many strategies, including action research, case study, ethnography, grounded theory and narrative research. However, some of these strategies can also be used in quantitative research, for instance case study, or even mixed methods.

In terms of different combinations of mixed methods, Saunders *et al.* (2012) dispute that this will lead to various research strategies. They add that the principal mixed methods research strategies are concurrent triangulation design, concurrent embedded design, sequential explanatory design, sequential exploratory design and sequential multiphase design.

Creswell (2012, p.20) used the term "research design" instead of research strategy; and he defined research designs by saying, "they are the specific procedures involved in the research process: data collection, data analysis, and report writing." Figure 2.4-5 represents the choice of methods and the corresponding strategies; however, these strategies are agreed by educational researchers. The rest of this subsection comprises detailed descriptions about the case study strategy and the survey strategy since they are used within the Ph.D. work and the reasons for the strategy choices and other strategies (experiment, archival research, ethnography, action research, grounded theory and narrative inquiry) are not presented.

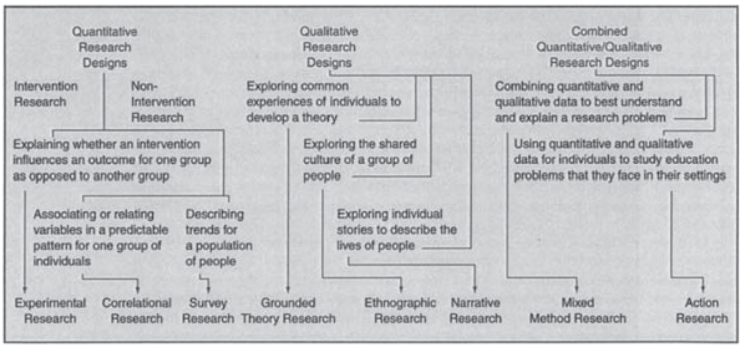

Figure 2.4-5: Methodological choices and the corresponding research strategies.
(Adopted from: Creswell, 2012, p.20)

The research strategies chosen were case study and survey. Table 2.4-8 shows the research questions and the associated strategy choices.

Table 2.4-8: Research questions and the associated research strategy

Research questions	Research strategies
Research Question 1: What is the current state of affairs and performance vis-à-vis the elapsed time, the time to delivery and other project aspects in a sample(s) of large-scale engineering projects?	Case study
Research Question 2: What are the factors that cause delays in large-scale engineering projects?	Case study/Survey
Research Question 3: What are the relationships between project speed and project flexibility, uncertainty and complexity?	Case study
Research Question 4: Is faster project delivery better? If so, why?	Case study/Survey
Research Question 5: How can projects be delivered faster?	Case study/Survey

Figure 2.4-6 summarizes the choices made about the research paradigm, research approaches, research methods, research nature, research strategies, and the timeframe for the research work.

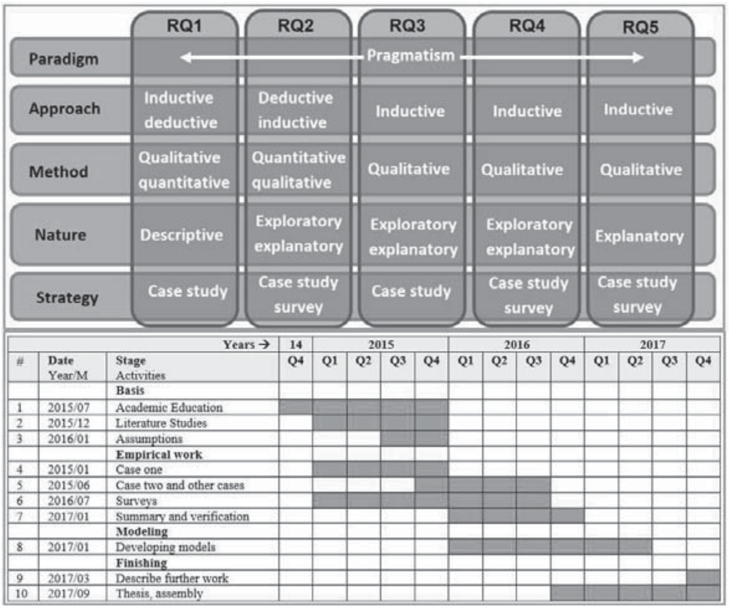

Figure 2.4-6: Research questions, research design choices and the timeframe.

Next, there is a discussion about the case study as a strategy and justification of the chosen case studies in this research, as well as a discussion about the survey strategy and a description of the survey process.

a. Case study

A case study explores a research topic or phenomenon within its context, or within a number of real-life contexts (Saunders *el al.*, 2012). The boundaries between the phenomenon being studied and the context in which it is being studied are not always apparent (Yin, 2013).

Yin (2013) defines the case study research method as an empirical inquiry that investigates a contemporary phenomenon within its real-life context, when the boundaries between a phenomenon and its context are not evident, and in which multiple sources of evidence are used. The aim of case study research is not only to describe a situation but also to understand the conditions under which events occur. In addition, this approach is particularly well suited to new research areas or research areas for which existing theory seems inadequate (Eisenhardt, 1989). This approach allows more in-depth development and testing of one specific approach, typically combined with action research where the researcher takes an active role in developing and implementing the changes to be validated (Greenwood and Levin, 2007).

Yin (2013) distinguishes between four case study strategies based on two discrete dimensions: (1) Single case versus multiple cases; (2) Holistic case versus embedded case.

A single case is used where it represents a critical case or an extreme unique case. Contrariwise, a single case may be selected because it is typical or because it provides the researcher with an opportunity to observe and analyze a phenomenon that few have considered before (Saunders *et al.*, 2012).

Multiple cases as a case study strategy are used when findings can be replicated across cases, where the cases are chosen on the basis that similar results will be produced, and this is called "literal replication" (Yin, 2013). "Theoretical replication" is another term used for the use of multiple cases by Yin (2013); this is when cases are chosen based on different contextual factors. Reich (2015) explains that in the use of theoretical replication, all the cases share some key characteristics (e.g., on time, on budget, etc.), but the researcher is not sure about what factors have contributed to these outcomes, or how they have contributed. Alternatively, literal replication is used if the researcher does not know what outcomes to expect, but he/she is interested in looking at one or more specific factor. A case study may use qualitative or qualitative research methods; however, most case studies mix both of these methods to collect and analyze data (Yin, 2013). Mostly the techniques used to collect data in case study strategies include interviews, observation, documentary analysis and questionnaires (Saunders *et al.*, 2012). Thus, there will be a need to triangulate the multiple sources of data. Triangulation is discussed more in upcoming sections.

A case study strategy is more relevant for gaining a rich understanding of the context of the research and the processes being enacted (Eisenhardt and Graebner, 2007). In social science, most researchers consider case studies to be exploratory and therefore should only be used at the beginning of the research into a phenomenon (Reich, 2015). However, they have often been viewed as a useful tool for the preliminary, exploratory stage of a research project, as a basis for the development of the "more structured" tools that are necessary in surveys and experiments (Rowley, 2002). A case study has considerable merits in answering the questions "Why," "How" and "What," and for this reason a case study strategy is most often considered for research of an explanatory or exploratory nature (Yin, 2013). Moreover, this explains the choices of the research nature made as listed in Table 2.4-7.

This dissertation uses case studies as one of the strategies in order to answer the research questions. For this type of research, the case study strategy, which allows better understanding of the concept through thorough examination of specific approaches in practice, is a suitable solution. In order to select a case, there are several criteria one can apply: variety in the types of project and context, suitability for testing the chosen approach, access to data, etc. Reich (2015) lists three conditions for using a case study as a research strategy: (1) a reason why this particular case is worth studying; (2) access to many people in the case, including people who may not be with the organization; and (3) access to many documents at the case site, including internal and external, private and public documents. He stresses that the first condition is the most important. These three conditions were the platform for the choice of the cases in this study. However, a dominant criterion is the convenience sample, which is the sample where the researcher is allowed a suitable measure.

The process of choosing the cases within this study consists of three steps besides the three listed conditions above: 1) choice of industry; 2) choice of a specific case project within industries; 3) choice of the size of the project. The choice of industry included in this study is related to engineering projects (construction in general, building, roads, infrastructure, etc.).

The first case is from road construction projects, and it is a megaproject; the choice of this first case was due to the availability of data to the researcher (interviews, case documents, organizations' documents, etc.). The second main case is from the telecommunication industry and it is considered a large-scale project based on its budget, but a megaproject based on its short- and medium-term objects. Again, the choice was based on the availability of the data and the number of participants in the interviews. Both cases were completed while conducting this research, and both cases are from the same country (Algeria). Last but not least, another reason for choosing these cases is because they had shown irregularity regarding the "time" aspect (urgency, delay, time overrun, and timing). In the course of this study, two main cases from two different industries (telecommunication and transportation) were studied in order to observe how time played a role in the project success or failure (e.g., competitive advantage, constraint). Other secondary cases (company cases) were used to investigate other aspects related to time.

The two main case studies used in this dissertation are presented next in more detail. Other case studies (projects, companies) are further discussed within the associated chapters or papers. There is more discussions in the related chapters about the specific methodology used within each chapter for more clarity of the process.

Case 1: Algerian East-West Highway Megaproject

The first of the three biggest megaprojects in terms of the road construction projects in Algeria is "The East-West Highway" (red line in Figure 2.4-7), which crosses Algeria from the Tunisian border to the Moroccan border, and this is our case to evaluate in this report. The second megaproject is the "The Road of the African Union," which starts from the Algerian capital Algiers and goes through the Algerian Sahara as far as the border with Niger. The third megaproject, which is a completely new megaproject, is "The High Plateaus Bypass," which is a parallel highway to the East-West Highway.

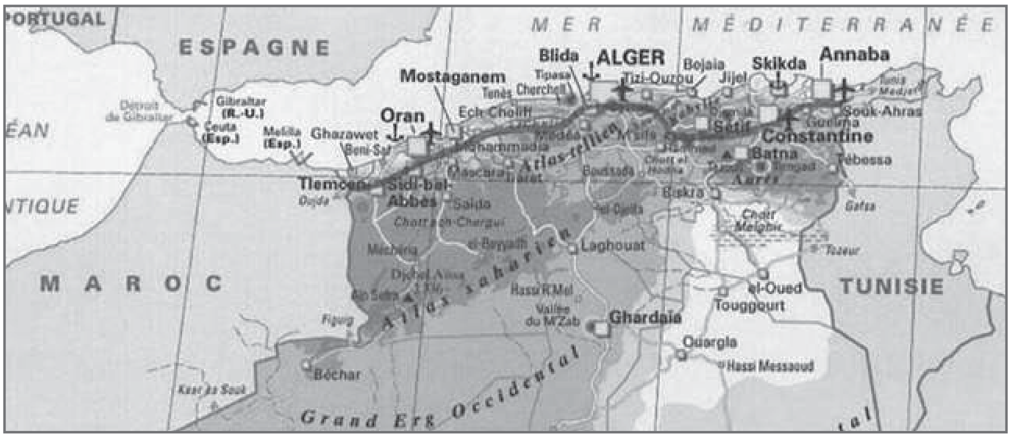

Figure 2.4-7: Algerian East-West Highway on the map.
(Source: MTP, 2013)

The cost of the Algeria East-West Highway megaproject was $US 11.2 billion. It is considered Algeria's most important road project and the largest public works project in the world. It was scheduled for completion in the fourth quarter of 2009, but it was delivered five years behind schedule. The 150 km stretch of highway between Constantine and Skikda was the only pending section as of June 2014. The megaproject has generated over 100,000 jobs. The project will cut travel times and provide better and safer access to the north of the country, stimulating economic development.

Table 2.4-9 summarizes the cost, schedule, scope and quality of the deliverables as planned and as built. It should be mentioned that the scope of the project increased due to the reworking of some parts because of the quality (MTP, 2013).

Table 2.4-9: Case 1 summary

Attributes	Description	
Budget/Cost	Estimated project cost:	< US$ 7 billion
	Final project cost:	> US$ 11.2 billion
	Project overrun cost:	> US$ 4.2 billion
Schedule	Starting:	Late 2006
	Planned finish date:	Late 2009
	Actual finish date:	Late 2014
	Project delivery behind schedule:	> 5 years
Scope	The total length of the highway is1,216 km including: 12 tunnels 70 viaducts 60 interchanges Truck stops, service stations and maintenance facilities	
Quality of deliverables	The quality of the highway is high on average, but in some parts, the quality of the road was very bad and the work needed redoing.	

The megaproject is a six-lane toll highway. It is being developed along Algeria's borders with Morocco and Tunisia. It will connect Algiers, Constantine, Oran, Annaba, Tlemcen and Setif. The development will have 12 tunnels, 70 viaducts and 60 interchanges. It also includes a provision for building truck stops, service stations and maintenance facilities. The project is part of the 7,000 km-long "AutoRoute Transmaghrébine Megaproject" (i.e., North Africa Road Transportations Highways Megaproject), which is being developed in two stages. The first phase, the East-West Highway, involves the construction of a 1,216 km section linking Annaba in the east to Tlemcen in the west, passing through 24 Algerian provinces (among the 48 Algerian provinces).

Case 2: 3G/4G Network Upgrade – Phase 1 of the Megaproject

The case project was conducted within the Algerian telecommunications industry. The Algerian telecommunications industry relies on three operators (MPTIC, 2016): Operators A, B and C.

Operator A is state-owned with some stock owned by Algerian citizens, and it was the first telecommunications operator in Algeria, created in 1962 after the independence of Algeria. Operator A provides all telecommunications services, from 2G/3G/4G networks to Internet via fiber (FTTH), landline phones through wire or wireless (CDMA, WiMAX) and many other services. Operator B started investing in the Algerian market in 2001, with the network starting operations in early 2002. This operator is 51 percent state-owned, and the remaining 49 percent of the stocks are owned by a multinational telecommunications corporation.

Operator B provides only a 2G service. This operator was 100 percent nationalized in mid-2013 and the government decided to upgrade the network to 3G/4G technologies before reselling the 49 percent share.

Operator C came to the Algerian market in late 2003 and started operating its network in late 2004. It is 20 percent owned by the state and 80 percent owned by another multinational telecom corporation. Operator C provided a 2G service at its opening, and has provided 3G/4G services since 2015 (ARPT, 2015).

Once Operator B had decided to upgrade the network to 3G/4G services, a main supplier was chosen for the project after a compressed bidding process. During the bidding competition, all other potential contractors involved in the bidding declined to accept the three-month project time: Most asked for at least a year and a half to deliver the planned scope. However, the chosen contractor accepted the fixed time to delivery.

The choice of contractor was made in late 2013 and the main contractor was given the task of delivering the scope – i.e., upgrading the network to 3G/4G services before the end of the first quarter of 2014. The main contractor had already delivered a similar project scope for Operator A within a time schedule of two years and three months.

This second case project is used for comparison purposes and some details of both case projects are presented in Table 2.4-10. Figure 2.4-8 represents a simplified network architecture after upgrading the network from 2G to 3G/4G services; the figure does not show the counting of the elements in the network, but the unit existing one in the network.

Table 2.4-10: Two project cases (same main contractor/different clients)

Item	Contract with Operator B	Contract with Operator A
Total contract monetary value	Approx. 100 million USD	Approx. 109 million USD
Scope	Network design, core network with seven MSC[1], two ngHLR/VLR[2] (1+1), six SR[3] (1+1), one SMSC[4] and one billing system upgrade. In addition, radio access network with seven RNC[5] and 1320 Node-B[6], network optimization and end-to-end delivery.	Network design, core network with nine MSC, three ngHLR/VLR, nine SR (1+1), one SMSC and one backup, and two billing systems (1+1). In addition, radio access network with 12 RNC and 1850 Node-B, network optimization and end-to-end delivery.
Delivery time	3 months	27 months
Penalty for late delivery	Yes	No

[1] MSC: mobile switching center.

[2] ngHLR/VLR: new generation home location register/visitor location register.

[3] SR: switch register.

[4] SMSC: short message service center.

[5] RNC: radio network controller.

[6] Node-B: used instead of BTS (base transceiver station); for data service the term Node-B is used.

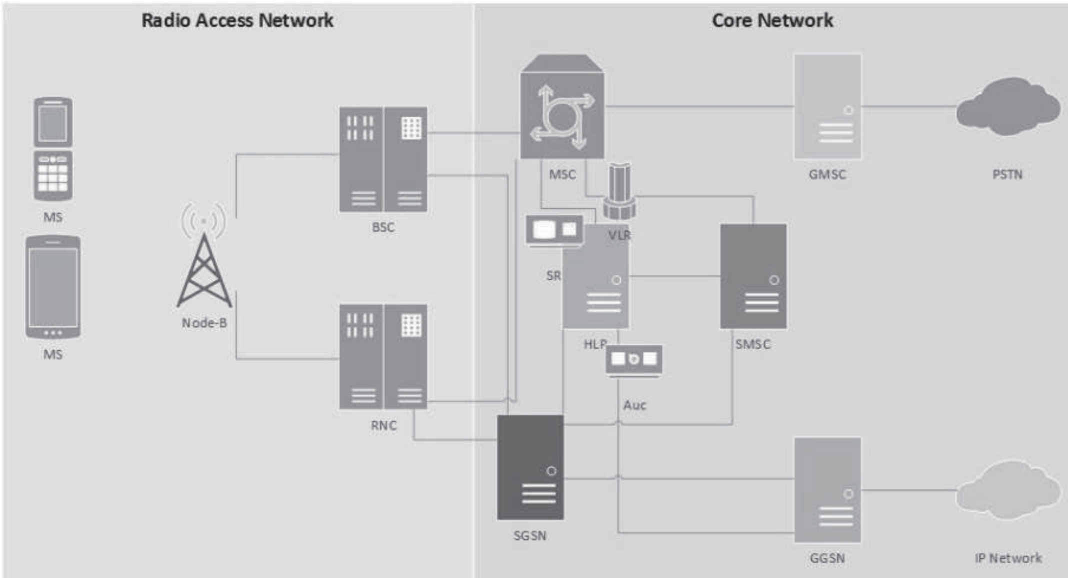

Figure 2.4-8: Simplified network architecture.

b. Survey

A survey strategy is usually associated with a deductive research approach, and it is mostly used to answer "What," "Who," "Where," "When," "How much" and "How many" questions. Moreover, it tends to be used for exploratory and descriptive research (Saunders *et al.*, 2012). A survey strategy is quantitative research, where the survey designs are procedures in which the researcher administers a survey or questionnaire to a small group of people (sample) to identify trends in the attitudes, opinions, behaviors and/or characteristics of a large group of people (population) (Creswell, 2012).

A survey research strategy is adopted in this Ph.D. work, with an inductive approach for the first survey and a deductive approach for the second one. In addition, the nature of the research is combination of exploratory, descriptive research for the first survey and explanatory research for the second. The reason for using the survey strategy as well as the case study strategy discussed previously is to fulfill the research objectives, as a survey with an exploratory nature is used in the early stages of the investigation and research on a phenomenon is used when the researcher's aim is to obtain preliminary insight into a subject. Then descriptive to reflect some facts obtained from the survey. A survey with an explanatory nature is performed when knowledge of a phenomenon has been articulated in a theoretical form using well-defined concepts, models and propositions (Filippini, 1997; Forza, 2009). And both of these research natures have been used within this strategy – an exploratory survey with an open questionnaire, then descriptive survey based on the quantities obtained from the exploration. Another survey is performed based on theory to reflect some facts quantitatively but within the same topic as the first survey.

According to Pinsonneault and Kraemer (1993), survey research is a quantitative method that requires standardized information about the topics being studied and the subjects studied might be individuals, groups or organizations, and they might also be projects, applications or systems. Correspondingly, researchers often differentiate between exploratory, explanatory and descriptive survey research (Filippini, 1997; Malhotra and Grover, 1998; Forza, 2009).

Some literature on survey research strategies describes the major components of surveys and of survey error instead of giving a definition (e.g., Groves, 1989; Fowler *et al.*, 2002). Others provide definitions, ranging from concise definitions (Groves *et al.*, 2004; Czaja and Blair, 2005) to elaborate descriptions of criteria (Biemer and Lyberg, 2003). According to Scheuren (2004), the word "survey" is used most often to describe a way of gathering information from a sample of people. Besides "sample" and "gathering information," other recurring terms in definitions and descriptions are "systematic or organized" and "quantitative." Consequently, a survey can be seen as a research strategy in which quantitative information is systematically collected from a relatively large sample taken from a population (De Leeuw and Dillman, 2008). In common with other types of field study, applying surveys as a research method can contribute to the advancement of scientific knowledge in different ways (Forza, 2009).

Criteria for survey quality have been widely discussed. One very general definition of quality is fitness for use. This definition was coined by Juran and Gryna (1980), and has been widely quoted since. How this general definition is further specified depends on the product that is being evaluated and the user. Deming (1944) gave a warning of the complexity of the task facing the survey designer when he listed no less than 13 factors that affect the ultimate usefulness of a survey. Among those are the relatively well-understood effects of sampling variability, but also more difficult to measure effects. Deming incorporates the effects of the interviewer, the method of data collection, nonresponse, questionnaire imperfections, processing errors and errors of interpretation (De Leeuw and Dillman, 2008).

Other authors (e.g., Groves, 1989) basically classify threats to survey quality in two main categories: differentiating between errors of no observation (e.g., nonresponse) and observation (e.g., in data collection and processing) (De Leeuw and Dillman, 2008). Biemer and Lyberg (2003) group errors into sampling error and nonsampling error. Sampling errors are due to selecting a sample instead of studying the whole population. Nonsampling errors are due to mistakes and/or system deficiencies, and include all errors that can be made during data collection and data processing, such as coverage, nonresponse, measurement and coding error (De Leeuw and Dillman, 2008). Social scientists use the term "construct validity": the extent to which a measurement method accurately represents the intended construct. This first step is conceptual rather than statistical; the concepts of concern must be defined and specified. On this foundation we place the four cornerstones of survey research: coverage, sampling, response and measurement (Groves, 1989; Groves and Couper, 1998; Salant and Dillman, 1994).

The two surveys used in this study are discussed next. The first survey was conducted in Norway based on a combination of different industries and organizations, and it used an inductive approach. The second survey was conducted in Algeria and was based on the telecommunications industry, with only a contractor and a client.

Survey 1: Identification of Delay Factors and their Remedies in Major Norwegian Projects

The identification of delay factors in Norwegian projects was based on an open questionnaire. Surveys involved selecting a representative and unbiased sample of subjects drawn from the group the researcher wished to study. The main methods were asking questions face-to-face or by telephone, or sending a questionnaire by e-mail/web. The researcher typically used some kind of multiple-choice, semi-structured questionnaires, or more questions that were open-ended where the respondent could state their own opinion (Marshall and Rossman, 1995; Kvale *et al.*, 2009).

There are two main types of survey: the descriptive survey and the analytical survey (Marshall and Rossman, 1995; Kvale *et al.*, 2009). Descriptive surveys are concerned with identifying and counting the frequency of a particular response among the survey group, as in our case. Analytical surveys are concerned with analyzing the relationship between different elements (variables) in a sample group.

An open questionnaire survey was designed to draw on the work experiences of practitioners in the construction industry in Norway. Three hundred practitioners from companies involved in an ongoing research project were selected, based on their having had active involvement in the planning and follow-up of construction projects. This survey was developed to assess the perceptions of clients, consultants and contractors on the relative delay factors in the industry. The data collected through the questionnaire surveys were analyzed and ranked based on their frequency. This survey presents 44 delay factors, clustered into 11 major groups of delay factors.

The open questionnaire survey was designed to consist of these main parts:

1. Background data about the respondents and their company (name of company, public or private sector, years of project experience and role in projects).
2. Delay factors, asking the respondents to name the most important delay factors in their projects.
3. Suggestion of remedies to deal with these delay factors.

A total of 202 respondents completed the questionnaires out of 300 participants. This gives a return rate of approximately 67%. Most of the respondents (50%) had more than 10 years of construction industry experience; a further 22% had 5 to 10 years of experience. Most of the respondents were project managers (54%) and team members (40%). Some 60% of the respondents were from public organizations, and 40% from private companies.

It is important to mention that the participants comprised clients, owners, sponsors, contractors, subcontractors and suppliers. The years of working experience of the participants and their role in the projects played an important part in answering the survey; by drawing on respondents in all the layers of the construction project, it is obtained more complete picture of all the different perspectives of delay factors.

Survey 2: Identification of Delay Factors and their Remedies in Algerian Telecommunications Projects

The identification of major delay factors in the Algerian telecommunication industry went through three major steps.

1. The first step was collecting the most common delay factors from literature; this led to the identification of 224 delay factors/causes.
2. The next step was discussing those factors with some experts in the Algerian telecommunications industry. Two experts were from the telecom operators (owner/client) and three were from the same main contractor; this second step allowed us to come up with new delay factors (e.g., users' delay factors-related group) and reduce the list almost by half.
3. The last step was to get those selected factors sent to and ranked by the participants, and then calculate their ranking index based on that. The final number was 123 delays.

It should be mentioned that the study sample was very small, with only 33 respondents, and half of them did not select all the delay factors (maybe another reason was because those delay factors were of no importance in their perception). The respondents from the contractors' side belonged to only one main contractor (the only available resources on hand for this study). The other thing noted from the results was that all stakeholders tried to undervalue the factors related to them.

2.4.7 Techniques & Procedures for Data Collection & Analysis

In this subsection, the discussion will be about the techniques used for the data collection and the procedures for the data analysis. Data can be qualitative or quantitative (see Table 2.4-11); they can also be primary or secondary.

Table 2.4-11: Distinctions between qualitative and quantitative data
(Adopted from: Dey, 1993; Healey and Rawlinson, 1994; Saunders *et al.*, 2012, p.547)

Qualitative data	Quantitative data
. Based on meanings expressed through words. . Collection results in non-standardized data requiring classification into categories. . Analysis conducted with conceptualization.	. Based on meaning derived from numbers. . Collection results in numerical standardized data. . Analysis conducted with diagrams and statistics.

a. Techniques for data collection

Secondary data are data that have already been collected to serve another purpose. Secondary data include qualitative (nonnumeric) and/or quantitative (numeric) data, and are used principally in both descriptive and exploratory research (Saunders *et al.*, 2012). Many researchers (e.g., Bryman,1989; Saunders *et al.*, 2012) have generated a variety of classifications of secondary data. The subgroups of secondary data are: (1) documentary (text, nontext); (2) survey (censuses, continuous and regular surveys, ad hoc surveys); and (3) multiple source (snapshot, longitudinal).

Documentary data are in text format (e.g., organization's database; communication in the form of emails, letters, memos; website; reports; magazines; newspapers; etc.) or in nontext format (e.g., television and radio; voice recordings; video recordings; images and photographs; etc.). Survey-based secondary data are data collected using a survey strategy to serve a purpose other than the researcher's own purpose (Bryman, 1989). There are three types of survey-based secondary data: (1) Census surveys (e.g., government censuses; population; employment; etc.) are generally of good quality when it comes to their coverage since they are organized by authorities and governments where participation is obligatory; (2) Continuous and regular surveys (e.g., labor market trends; employee attitude surveys; etc.) are surveys that do not include a census, and are repeated over time; (3) Ad hoc surveys (e.g., government surveys; organization surveys; academics' surveys; etc.) are usually one-off surveys and are far more specific in their subject matter (Saunders *et al.*, 2012).

Multiple-source secondary data (snapshots, which are data compiled from government publications; books; journals; etc. Alternatively, longitudinal data, which are data compiled from industrial statistics reports; newspaper reports; etc.) can be compiled from documentary evidence or surveys, or an amalgam of the two (Saunders *et al.*, 2012). Secondary data from the three different main sources above can be combined, if they have the same geographical basis, to form area-based data sets. In this dissertation and accompanying papers, a combination of secondary data from the three main types has been used to complete the work.

Primary data are newly collected data; these data are collected by the researcher for one purpose, which is to achieve the research objectives and answer his/her research questions. The techniques and procedures used for data collection and analysis in this dissertation and the accompanying papers are explained next. The collection of primary data as described in Saunders *et al.* (2012) can be done through: (1) observation (either participant or structured observation); (2) interviews (e.g., semi-structured interviews; in-depth interviews; group interviews; etc.); or (3) questionnaires (two groups: a. self-completed: web-based, postal mail, delivery and collection; b. interviewer-completed: telephone questionnaire, structured interview).

This dissertation and the accompanying papers have only used interviews and questionnaires to collect primary data, and thus the observation technique is excluded from the discussion.

1) Interviews

Interviews can take many forms (see Figure 2.4-9). They are categorized as: (1) structured interviews; (2) semi-structured interviews; or (3) unstructured or in-depth interviews. Another typology is: (1) standardized interviews; or (2) nonstandardized interviews (Saunders *et al.*, 2012). According to Robson (2011), another typology is: (1) focused interviews; or (2) nondirective interviews.

Structured interviews, as defined by Fontana and Frey (2005), are when the interviewer asks all respondents the same series of pre-established questions with a limited set of response categories. According to these authors, there is very little flexibility in the way in which questions are asked or answered in structured interviews. And the instructions often include: never get involved in long explanations of the study; never deviate from the study introduction; never let another person interrupt the interview; never suggest an answer or agree or disagree with an answer; never interpret the meaning of a question; never improvise, such as by adding answer categories or making wording changes.

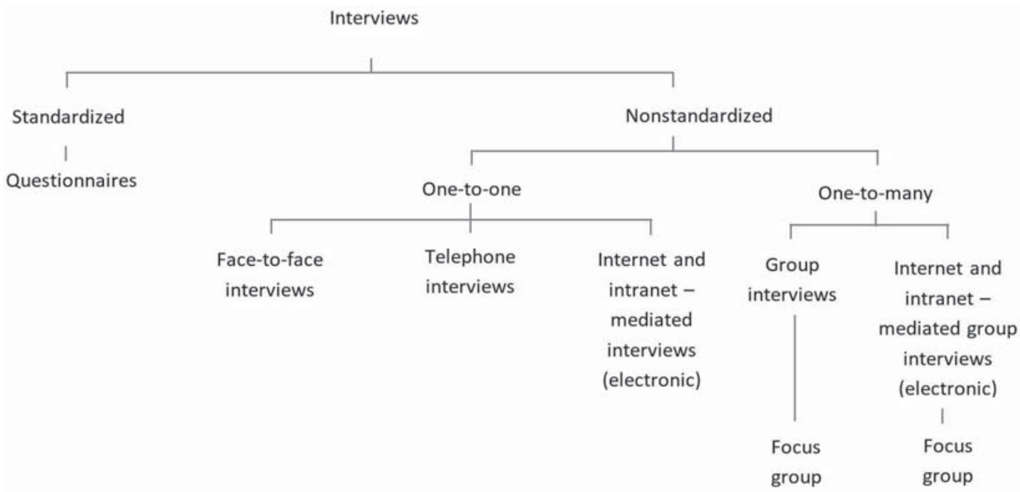

Figure 2.4-9: Forms of interview.
(Adopted from: Saunders *et al.*, 2012, p.375)

In ***semi-structured interview***s, the researcher will have a list of themes and possibly some key questions to be covered, although their use may vary from one interview to another (Saunders *et al.*, 2012). In contrast to structured interviews, semi-structured interviews are "nonstandardized", and they are always referred to as "qualitative research interviews" (King, 2004).

Unstructured interviews are informal and they are used to explore in depth a general area in which the researcher is interested (Fontana and Frey, 2005). The two go hand in hand, and much of the data gathered in participant observation comes from informal interviewing in the field (Lofland, 1971; Crocker and Algina, 1986). In an unstructured interview, the interviewee is given the opportunity to talk freely about the topic, where the interaction is nondirective, and this is labeled an informant interview. On the other hand, the other type of unstructured interview is the focused interview, where the interviewer exercises direction and guides the interview (Ghauri and Grønhaug, 2010; Robson, 2011).

When it comes to the nature of the research, in-depth interviews and semi-structured interviews fit better qualitative research with an exploratory nature and inductive approach. For a descriptive study with a deductive approach it may be better to use a structured interview for identifying general patterns. An explanatory study may use either a structured or semi-structured interview with an inductive or deductive approach to discover why relationships occur (Saunders *et al.*, 2012). Interviews may be one to one, interviewer to interviewee. They may also be one to many, or as they are called, a "group interview." The use of the group interview has ordinarily been associated with marketing research under the label of "focus group," where the purpose is to gather consumer opinions (Fontana and Frey, 2005).

This Ph.D. work featured a combination of all the discussed forms of interviewing – from semi- and unstructured interviewing to one-to-one or group interviewing, and face-to-face or electronic interviewing. There were lots of sets of interviews; however, due to the separate contexts it would be too long to list them all here with all their details. All the details regarding the number and selection of interviewees, positions, etc. will be presented in detail in a related paper or chapter.

2) Questionnaires

Questionnaires are a method of data collection in which each individual is asked to respond to the same set of questions in a predetermined order (DeVaus, 2002). Questionnaires are one of the most widely used collecting data techniques within the survey strategy (Dillman, 2009). Because each participant is asked to respond to the same set of questions, they provide an efficient way of collecting responses from a large sample prior to quantitative analysis (Saunders *et al.*, 2012). However, some scholars argue that it is very hard to produce a good-quality questionnaire (e.g., Oppenheim, 2000; Bell, 2010).

According to Saunders *et al.* (2012), to maximize the validity of the collected data, the design of the questionnaire should also be maximized by the following:

- Careful design of individual questions;
- Clear and pleasing layout of the questionnaire;
- Lucid explanation of the purpose of the questionnaire;
- Pilot testing;
- Carefully planned and executed delivery and return of the completed questionnaire.

There are different types of questionnaire (see Figure 2.4-10). Self-completed questionnaires are completed by the respondents, and sent by email or postal mail, or are delivered and then collected. The other types are questionnaires completed by the interviewer using a telephone to contact the respondents (individually), or structured questionnaires when the interviewer meets face to face with respondents and completes the questionnaire in their presence (individually).

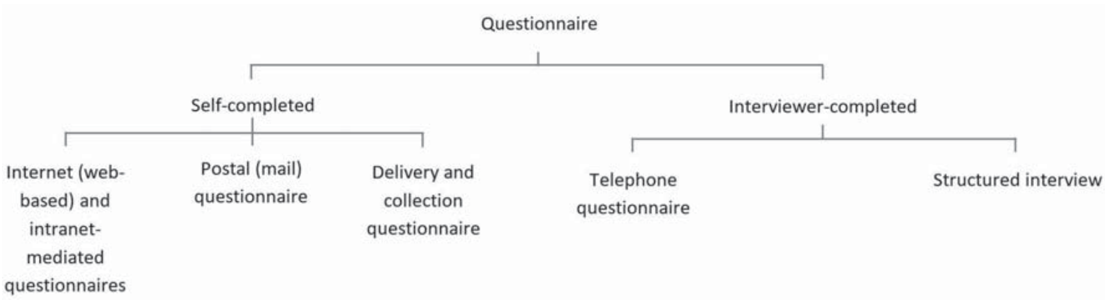

Figure 2.4-10: Types of questionnaire.
(Adopted from: Saunders *et al.*, 2012, p.420)

The choice of questionnaire will be based on: characteristics of the respondents from whom the researcher wishes to collect data; the importance of reaching particular persons as respondents; the importance of respondents' answers not being contaminated or distorted; the size of the sample required for analysis; the types of questions needed to be asked in order to collect the data; the number of questions required to be asked in order to collect the necessary data (Oppenheim, 2000; DeVaus, 2002; Dillman, 2009; Bell, 2010).

Ghauri and Grønhaug (2010) emphasize the importance of reviewing the literature carefully before starting to design any questionnaire related to the topic about which the researcher is going to pose his/her research questions. They added that the questionnaire should be discussed with other researchers and interested parties. Finally, the questionnaire should be tested and improved continuously before approving it and starting to distribute it to respondents. Once the questionnaire has been sent, it will be very hard or almost impossible to make any changes. The data collected from the survey are discussed within the related chapters in this dissertation.

To summarize, and as discussed in the last subsection, there were two questionnaires designed for two different surveys. However, the two surveys were designed primarily to answer part of the second research question, and then the fourth and fifth questions. The first designed questionnaire comprised open questions, which led to an inductive approach. The second survey was designed with a list of phenomena that have to be ranked, and that is a deductive approach.

b. Procedures for data analysis

Procedures for data analysis are divided into two types: (1) procedures for quantitative data analysis; and (2) procedures for qualitative data analysis. Table 2.4-5 shows the differences between the two types of methods related to collecting quantitative or qualitative data.

It is very important to clarify that there are no generic procedures for data analysis that fit all of them and all the collected data sets. The process is always tailored to some extent, or to a great extent, to a specific data set, even where many different procedures may be used for the same data set (depending on the researcher(s), the research's aim, the approach, etc.). However, some generic procedures and fundamental concepts are discussed in this part of the subsection to give a general idea about the procedures for data analysis, and further details are given within the associated chapter and/or paper.

1) Procedures for Quantitative Data Analysis

Saunders *et al.* (2012) define quantitative data as all primary and secondary data, as discussed above at the beginning of this subsection, which can be the product of all research strategies used, as well as secondary data. These data can range from simple counts (e.g., frequencies, occurrences, etc.) to complex data (e.g., scores, prices, etc.). These data must be analyzed and interpreted to make use of them; the analysis techniques help in doing that, and these vary from creating tables, diagrams and statistical relationships to complex statistical models. The analysis is done with the support of software (e.g., Excel, Minitab, Statview, RStudio, etc.). Robson

(2011) describes and summarizes all this as "a field where it is not at all difficult to carry out an analysis which is simply wrong, or inappropriate for your data or purposes. And the negative side of readily available specialist statistical software is that it becomes that much easier to generate elegantly presented rubbish". In this Ph.D. work, Excel spreadsheets have mainly been used for the data analysis. An exception was the data analysis for *RQ1*, discussed more in Chapter 5, for which Excel and RStudio software were used. The reason for using RStudio as well as Excel is its ability to provide more illustrative diagrams and its being open source.

Quantitative data can be categorized into two groups:

(1) Categorical data refer to data whose values cannot be measured numerically but can be either classified into sets according to the characteristics that identify or describe the variable or placed in rank order (Berman Brown and Saunders, 2008). This group of data can be divided into two subgroups: (1.1) Descriptive data cannot be defined numerically or ranked, thus these data simply count the number of occurrences in each category of variables.

Although these data are purely descriptive, they can be counted to establish which category has the most and whether cases are spread evenly between categories (Morris, 2012). Descriptive data can be dichotomous data (e.g., gender: male and female) or nominal data (1.2). Ranked/ordinal data are a more precise form of categorical data. Rating or scale questions, such as asking respondents to rank a statement and give it a score, will lead to ranked (ordinal) data being collected. However, some researchers, such as Blumberg *et al.* (2008), argue about the possibility of considering these data as numerical data.

(2) Numerical data are those whose values are measured or counted numerically as quantities (Berman Brown and Saunders, 2008). These data can also be divided into two subgroups: (2.1) interval data can show the difference between any two data values for particular variables, but the relative difference cannot be shown. This means that values can be added or subtracted, but not multiplied or divided (e.g., temperature (Celsius or Fahrenheit), air pressure, etc.); (2.2) ratio data are where the ratio difference or ratio between any two data of variables can be calculated (e.g., profit (can be doubled/multiplied by two), renting for one year (multiplied monthly as unit price by 12 months), etc.).

Numerical data can also be viewed as (2.a) continuous data, which are those values that can theoretically take any value provided that you can measure them accurately enough (Dancey and Reidy, 2008). (2.b) Discrete data can be measured precisely and each case takes one of a finite number of values from a scale that measures changes in discrete units. According to Saunders *et al.* (2012), and Berman Brown and Saunders (2008), it is very important to understand the differences between the types of data for two major reasons: (1) It is easy with analysis software to generate statistics from data that are inappropriate for the data type and are consequently of little value; (2) The more precise the scale of measurement, the greater the range of analytical techniques available.

Based on Saunders *et al.* (2012), all data types should be recorded using numerical codes to reduce the errors. On the other hand, some data need to be recoded to create new variables.

Numbers are often used for coding numerical data. Once the data are entered as a matrix (i.e., table format), the use of software will help to group and/or combine data to form additional variables. This process is called "recoding". Coding categorical data is applying codes with little thought. Coding at data collection ii necessary when there is a limited range of well-established categories into which the data can be placed. Coding after the data collection is necessary when the likely responses are not clear or there are a large number of possible responses in the coding scheme. This kind of coding was used in Survey 1, where the data were nominally descriptive. Then after the recoding they became ranked/ordinal data. This was not the case for Survey 2, where the obtained numerical data were ranked/ordinal data from the beginning and after recoding were discrete data. All possible types of numerical data are represented in Figure 2.4-11, in the next page.

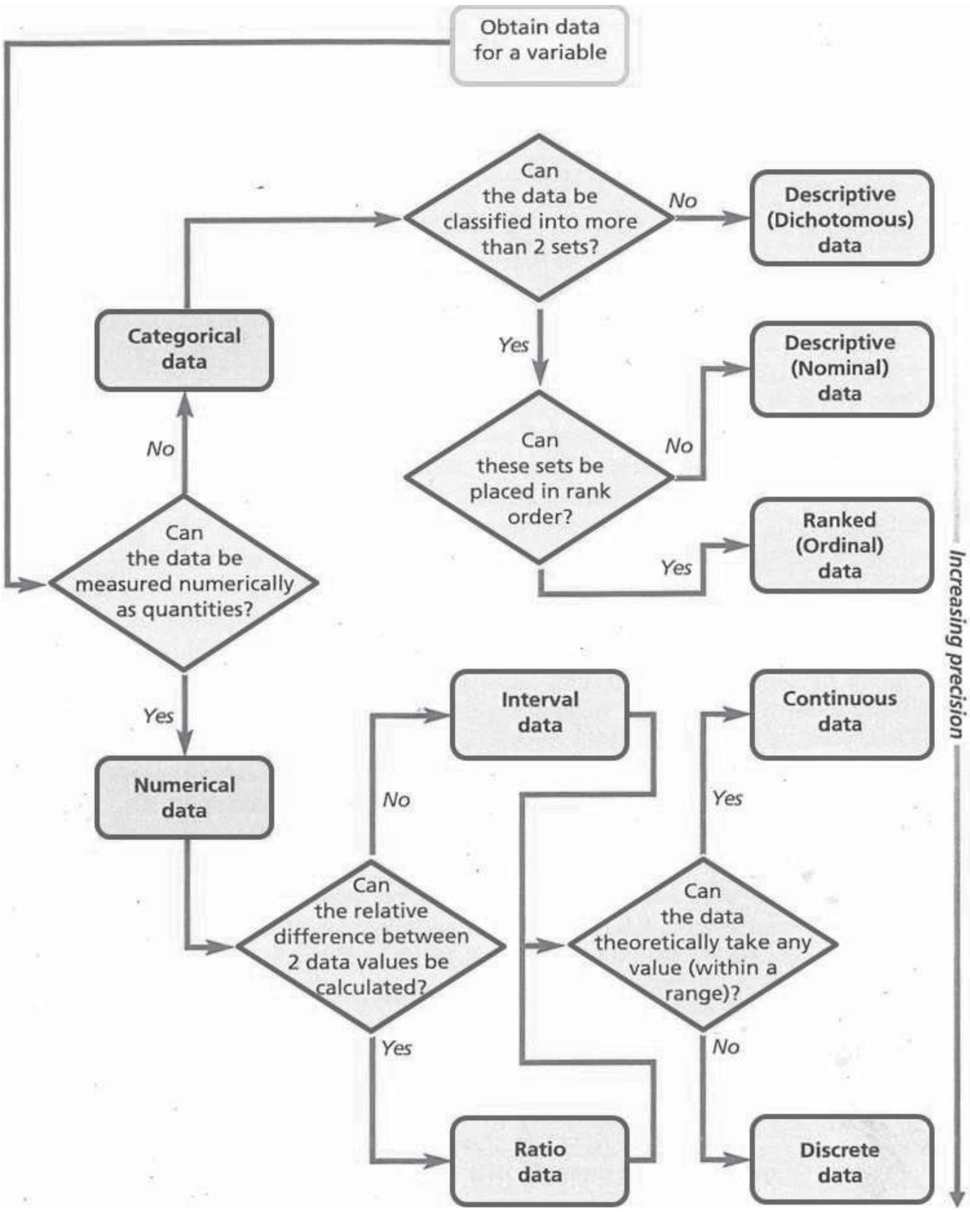

Figure 2.4-11: Quantitative data types.
(Adopted from: Saunders *et al.*, 2012, p.477)

In this Ph.D. work, the type of numerical data used are discrete data for *RQ1*, and the analysis was by diagrams and simple statistical relationships. *RQ2* involves two surveys: the first used coding descriptive data at first iteration, and then ordinal data after the recoding. The data of the second survey were ordinal at the collection and discrete after recoding. The two surveys were used to answer partially *RQ4* and *RQ5* and that was done using the same procedures as described previously. More detailed descriptions of the numerical data analysis procedures are included within the related chapters.

2) Procedures for Qualitative Data Analysis

Qualitative data can be approached based on the inductive or deductive perspective. It is very important to understand the meaning of qualitative data to be able to analyze them in a meaningful way. As discussed in the sections related to the paradigm and research methods, qualitative research is associated with interpretivism, because the researcher(s) needs to make sense of subjective and socially constructed meanings expressed by those who are taking part in the research about the phenomenon being studied (Dey, 1993; Saunders *et al.*, 2012).

In a deductive approach to data analysis, according to Yin (2013), to devise a theoretical or descriptive framework, it is necessary to identify the main variables, components, themes and issues in your research project and the predicted presumed relationships among them. A descriptive framework will rely more on the researcher's prior experience and 'what is expected from the analysis.

In an inductive approach, as previously discussed, the idea is to start to collect data and then explore them to see which themes or issues to follow up and concentrate on. According to Yin (2013), this inductive approach is more difficult and may not lead to success for beginner researchers with less experience in using it.

Data, as discussed previously and based on the sources, can be secondary (e.g., organizational documents, reports, emails, newspapers, videos, etc.) or primary (e.g., open questionnaires, interviews, etc.). Various ways to record qualitative data have been suggested (Kvale *et al.*, 2009), including interim or progress summaries, transcript summaries, document summaries, self-memos, research notebooks and reflective diaries or journals.

There are some procedures for analyzing qualitative data that are specific (e.g., grounded theory, template analysis, analytic induction, narrative analysis and discourse analysis) or generic. Procedures can be highly structured or unstructured (see Figure 2.4-12).

Mostly in this Ph.D. work, the procedures for qualitative data analysis were generic. According to Saunders *et al.* (2012), Robson (2011) and Dey (1993), the generic approach for analyzing qualitative data follows these five steps: (1) identifying categories or codes that allow the data to be understood. Strauss and Corbin (1998) suggest that there are three main sources from which to derive codes: the terms that emerge as the data are analyzed; the actual terms used by the participants; the terms used in existing theory and the literature; (2) attaching data from disparate sources appropriate categories or codes to integrate these data; (3) developing analytic categories further to identify relationships and patterns. When generating categories for the data according to them, means there is engagement in starting analyzing them (Dey, 1993; Yin, 2013). The analysis continues by searching for key themes and patterns or relationships; (4) developing testable propositions; as patterns revealed within the data and relationships are recognized between categories, it will be possible to develop testable propositions; (5) drawing and verifying conclusions.

Figure 2.4-12: Dimensions of qualitative analysis.
(Adopted from: Sanders *et al.*, 2012, p.556)

The qualitative study in this Ph.D. work was more predominant than the quantitative study. Thus, an inductive approach was always used within the process to answer all the research questions. It is important to mention that each research question was answered from different angles, in a different context and with different collected data. This will increase the validity and reliability of the findings, and will give us the maneuverability to apply triangulation. Reliability, validity and triangulation are discussed further in Section 2.5. The detailed procedures for each qualitative data set analysis are discussed within the related chapter. Limitations and their implications are discussed further in the last chapter of this dissertation.

2.5 Reliability, Validity and Generalization

Any scientific work in general, and particularly Ph.D. dissertations, should describe the methodology and sources of the data used, as is done in this chapter, as well as providing a clear description of the limits of the methodology and the data used. This will give access to the *validity* and *reliability* of the data and the methods/strategies/techniques/procedures used for achieving research objectives; this is why good research design is important. *Validity* and *reliability* are two factors that any researcher should be concerned about when designing a study, analyzing results and evaluating the quality of the study (Patton, 2002). Rogers (1961; cited in Raimond, 1993; Saunders *et al.*, 2012) summarizes this in the statement: "[S]cientific methodology needs to be seen for what it truly is, a way of preventing me from deceiving myself in regard to my creatively formed subjective hunches which have developed out of the relationship between me and my material." On the other hand, Patton (2002) states that validity and reliability are two factors that any researcher should be concerned about when designing a study, analyzing results and judging the quality of the study. This corresponds to the question: "How can an inquirer persuade his or her audiences that the research findings of an inquiry are worth paying attention to?" (Lincoln and Guba, 1985).

The purpose of discovering the truth through measures of reliability and validity is to establish confidence in the research findings (Golafshani, 2003). Although reliability and validity are treated separately in quantitative research, these terms are not viewed separately in qualitative research (Golafshani, 2003). According to Guba and Lincoln (1994), validity does not exist without reliability, so a demonstration of validity is adequate to establish the reliability. Bryman (2008) also indicates that although reliability and validity are analytically distinguishable, if a measure is not reliable, it cannot possibly be valid either.

Figure 2.5-1 represents a graphical version of reliability and validity with shooting targets, as interpreted by Cooper and Schindler (2003, p.235).

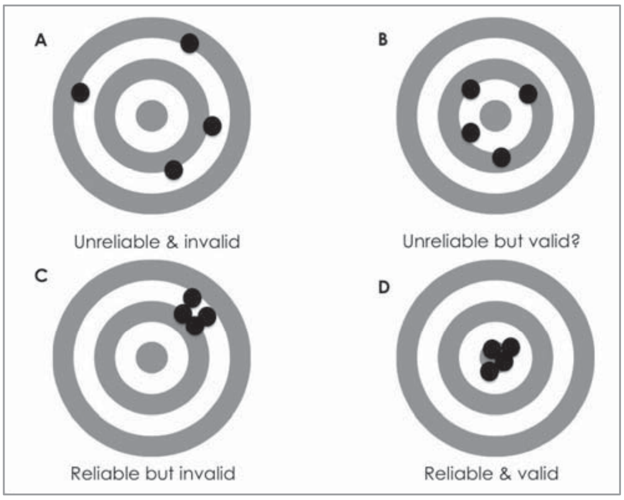

Figure 2.5-1: Reliability and validity.
(Adopted from: Cooper and Schindler, 2003, p.235)

Healy and Perry (2000) assert that the quality of a study in each paradigm should be judged on its own paradigm's terms. For example, while the terms *reliability* and *validity* are essential criteria for quality in quantitative paradigms, in qualitative paradigms the terms *credibility*, *neutrality* or *confirmability*, *consistency* or *dependability* and *applicability* or *transferability* are the essential criteria for quality (Lincoln and Guba, 1985). Table 2.5-1 shows a comparison of criteria for judging the quality of quantitative versus qualitative research.

Table 2.5-1: Criteria for judging the quality of quantitative versus qualitative research
(Adopted from: Hoepfl, 1997)

Conventional terms	Naturalistic terms
Internal validity	Credibility
External validity	Transferability
Reliability	Dependability
Objectivity	Confirmability

To be more specific regarding the term "reliability" in qualitative research, Lincoln and Guba (1985) use "dependability" in qualitative research, which closely corresponds to the notion of "reliability" in quantitative research. To eliminate any confusion in using terms, in this dissertation the only terms used to reflect the quality of the study are *reliability* and *validity* (conventional terms). In what follows, the terms are more clearly defined and discussed.

Reliability refers to whether the data collection techniques and analytic procedures would produce consistent findings if they were repeated on another occasion or if a different researcher replicated them (Saunders *et al.*, 2012).

In quantitative research, Joppe (2000) defines reliability as "The extent to which results are consistent over time and an accurate representation of the total population under study is referred to as reliability and if the results of a study can be reproduced under a similar methodology, then the research instrument is considered to be reliable." Kirk and Miller (1986) identify three types of reliability referred to in quantitative research, which relate to: (1) the degree to which a measurement, given repeatedly, remains the same; (2) the stability of a measurement over time; and (3) the similarity of measurements within a given time period. A high degree of stability indicates a high degree of reliability, which means the results are repeatable (Charles, 1995; Golafshani, 2003).

In qualitative research, a good qualitative study can help us "understand a situation that would otherwise be enigmatic or confusing" (Eisner, 1991). This relates to the concept of a good-quality research where reliability is a concept to evaluate quality in a quantitative study with the "purpose of explaining," while the concept of quality in a qualitative study has the purpose of "generating understanding" (Stenbacka, 2001). The reliability of a study can be ensured by demonstrating that the operations of a study, such as the data collection produced, can be repeated with the same results. This is achieved through documentation of procedures and appropriate record keeping (Rowley, 2002). However, ensuring reliability is not easy. Saunders *et al.* (2012) summarize the threats to reliability as shown in Table 2.5-2.

Table 2.5-2: Threats to reliability
(Adopted from: Saunders *et al.*, 2012, p.192)

Threat	Explanation
Participant error	Any factor that adversely alters the way in which a participant performs.
Participant bias	Any factor that induces a false response.
Researcher error	Any factor that alters the researcher's interpretation.
Research bias	Any factor that induces bias in the researcher's recording of responses.

The concerns about *reliability* in this Ph.D. study are more about the secondary data (e.g., organizations' reports and any other related documents) and primary data (interviews, questionnaires). The reason is that all the findings presented in this present dissertation are based on the quality of collecting techniques and the quality of the data.

The reliability of secondary data is a function of the tools by which the data were collected and the source from where these data were collected. Dochartaigh (2012) refers to this as assessing the authority or reputation of the source. Secondary data are data that have already been collected to serve another purpose in different forms, and those used in this study are: organizations' databases; communication in the form of emails, letters, memos; websites; reports; magazines; newspapers; television and radio archives; video recordings; images and photographs; data compiled in government publications; books; journals; data compiled in industrial statistics reports; newspaper reports. These multiple data sources will permit high triangulation and that will increase the reliability.

The interviews used in this study are semi-structured and in-depth interviews. The lack of standardization in these types of interview may increase concerns about the reliability. The other reasons are the threats listed in Table 2.5-2, and in terms of precision the interviewer and interviewee biases.

The value of using this technique to collect data is its flexibility in exploring the complexity of a topic (Marshall and Rossman, 2006). Therefore, it is very important to be clear on the point that ensuring that the quality of nonstandardized research can be replicated by other researchers would not be realistic or feasible without undermining the strength of this type of research (Marshall and Rossman, 2006). The concerns, then, were more about the collected data, and the findings from them. In this study, increasing the number of interviewees, giving them the choice of time for the interviews, flexibility regarding the means used in the interviews, etc. helped in dealing with the errors and biases to some extent. Nevertheless, in the end, triangulation will help to increase the reliability, at least for the findings in this study.

As regards the reliability of the questionnaires used, Mitchell (1996) outlines three approaches to assessing reliability: (1) test retest; this is done by correlating data collected with those from the same questionnaire collected under as near to equivalent conditions as possible; (2) internal consistency; involves correlating the responses to questions in the questionnaire with each other; (3) alternative form; this is to compare responses to alternative forms of the same question or groups of questions.

In this study, there were two questionnaires. The first was an open questionnaire, where the finding were compared to case studies conducted within the same organizations of the respondents. The second questionnaire was conducted with experts in the field and with a test retest approach. At the end, a triangulation of the data to increase the reliability was applied (case studies and the surveys).

Validity refers to whether a research is really measuring what it claims to be measuring and reliability refers to the consistency of a measure of a concept, meaning whether similar results would be obtained if another group containing different respondents or a different set of data points were used. Several forms of validity were identified to ensure the quality of the research (Saunders *et al.*, 2012).

Within the positivist terminology, validity resided amongst, and was the result and culmination of, other empirical conceptions: universal laws, evidence, objectivity, truth, actuality, deduction, reason, fact and mathematical data, to name but a few (Winter, 2000). Joppe (2000) provides the following explanation of what validity is in quantitative research: Validity determines whether the research truly measures that which it was intended to measure or how truthful the research results are. Wainer and Braun (1988) describe the validity in quantitative research as ***construct validity***, which is concerned with the extent to which the research measures actually measure what the researcher intends to assess (Saunders *et al.*, 2012).

The concept of validity is described by a wide range of terms in qualitative studies. Creswell and Miller (2000) suggest that validity is affected by the researcher's perception of validity in the study and his/her choice of paradigm assumption. As a result, many researchers have developed their own concepts of validity and have often generated or adopted what they consider to be more appropriate terms, such as "quality," "rigor" and "trustworthiness" (Stenbacka, 2001; Davies and Dodd, 2002; Golafshani, 2003).

Internal validity is established when the research demonstrates a causal relationship between two variables. Again, this concept is associated with both positivist and quantitative research; it can be applied to causal or explanatory studies, but not to exploratory or purely descriptive studies (Saunders *et al.*, 2012).

This type of validity can be ensured for explanatory or causal studies only, and not for descriptive or exploratory studies (Rowley, 2002). Some potential threats to internal validity are listed in Table 2.5-3 (Cook and Campbell, 1979; Saunders *et al.*, 2012). Most of the study in this work was explanatory, and its results should be tested for internal validity. Yin (2013) suggests pattern matching, explanation building and time series analysis in order to ensure internal validity within case studies.

Table 2.5-3: Threats to internal validity
(Adopted from: Cook and Campbell, 1979; Saunders *et al.*, 2012, p.193)

Threat	Explanation
Past or recent events	An event that changes participants' perceptions.
Testing	The impact of testing on participants' views or actions.
Instrumentation	The impact of change in a research instrument between different stages of a research project affecting the comparability of results.
Mortality	The impact of participants withdrawing from studies.
Maturation	The impact of change in participants outside of the influence of the study that affects their attitudes or behaviors, etc.
Ambiguity about causal direction	Lack of clarity

The key issue in internal validity is the extent to which causal conclusions can be drawn from the study (Gray, 2004). Secondary data should also be considered for a measurement of validity. Secondary data that fail to provide an answer to the research questions or meet the research objective will result in invalid answers (Easterby-Smith *et al.*, 2012). Thus, multiplying the sources of these types of data may help meet the desired validity (Denscombe, 2007).

There are no clear solutions to problems of measurements of invalidity. All that it was possible to do regarding the secondary data was to try to evaluate the data's validity and make decisions. Again, the same can be said for internal validity for this type of data as is said about reliability using multiple sources to collect, and multiplying the sources will increase and permit better evaluation of the data's validity, which will also allow those that are invalid to be excluded

External validity is concerned with the question: Can a study's research findings be generalized to other relevant settings or groups? (Saunders *et al.*, 2012). If the validity or trustworthiness can be maximized or tested, then a more "credible and defensible result" (Johnson, 1997) may lead to generalizability, which is one of the concepts suggested by Stenbacka (2001) as the structure for both doing and documenting high-quality qualitative research.

External validity, according to Yin (2013), is the extent to which the findings from a case study can be analytically generalized to other situations that were not part of the original study. In general, a researcher cannot often work with the entire population of interest, but instead must study a smaller sample of that population in order to draw conclusions about the larger group from which the sample is drawn.

External validity is concerned with the extent to which the conclusions can be generalized to the broader population. A study is considered to be externally valid if the researcher's conclusions can in fact be accurately generalized to the population at large (Pelhalm and Blanton, 2006).

The quality of a research is related to the generalizability of the result and thereby to testing and increasing the validity or trustworthiness of the research. In contrast, Maxwell (1992) notes that the degree to which an account is believed to be generalizable is a factor that clearly distinguishes quantitative and qualitative research approaches. Although the ability to generalize findings to wider groups and circumstances is one of the most common tests of validity for quantitative research, Patton (2002) states that generalizability is one of the criteria for quality in case studies depending on the case selected and studied. Validity in quantitative research is very specific to the test to which it is applied, while triangulation methods are used in qualitative research.

Triangulation is typically a strategy for improving the validity and reliability of research or the evaluation of findings. Triangulation refers to the use of multiple data collection techniques within the same study in order to ensure that the data are reliable (Saunders *et al.*, 2012). Triangulation is defined by Bryman (2008, p.717) as "The use of more than one method or source of data in the study of a social phenomenon so that findings may be cross-checked". Triangulation is a distinctive technique for improving the reliability of research findings (Golafshani, 2003).

According to Mathison (1988), triangulation has become an important methodological issue in naturalistic and qualitative approaches to evaluation in order to control bias and establish valid propositions because traditional scientific techniques are incompatible with this alternate epistemology.

Barbour (1998) argues that while mixing paradigms is possible, mixing methods within one paradigm, such as qualitative research, is problematic since each method within the qualitative paradigm has its own assumption in "terms of theoretical frameworks we bring to bear on our research". This argument does not align with the argument provided in this dissertation, where pragmatism is chosen as the position, moreover, the chosen paradigm tolerate using different positions to answer each research question.

Barbour (1998) does not disregard the notion of triangulation in a qualitative paradigm and she states the need to define triangulation from a qualitative research's perspective in each paradigm. Healy and Perry (2000) explicate the judging validity and reliability within the realism paradigm, which relies on multiple perceptions of a single reality. They argue for the involvement of triangulation of several data sources and their interpretations with those multiple perceptions in the realism paradigm.

Using multiple techniques, such as observation, interviews and recordings, will lead to a more valid, reliable and diverse construction of realities. To improve the analysis and understanding of the construction of others, triangulation is a step taken by researchers to involve several investigators' or peer researchers' interpretation of the data at different times or locations.

In a related way, according to Johnson (1997), a qualitative researcher can "use investigator triangulation and consider the ideas and explanations generated by additional researchers studying the research participants." Triangulation may include multiple methods of data collection and data analysis, but does not suggest a fixed method for all researches. The methods chosen in triangulation to test the validity and reliability of a study depend on the criterion of the research.

Patton (2002) is one of the supporters of the use of triangulation, and states, "Triangulation strengthens a study by combining methods. This can mean using several kinds of methods or data, including using both quantitative and qualitative approaches." Miles and Huberman (1994) distinguished five kinds of triangulation in qualitative research:

- Triangulation by data source (in this Ph.D. study: interviews, questionnaires, etc.);
- Triangulation by method (in this Ph.D. study: qualitative method and quantitative method);
- Triangulation by researcher (analysis from other researchers; compare it to this Ph.D. study analysis);
- Triangulation by theory (in this Ph.D. study: critical literature review for all the subtopics);
- Triangulation by data type (in this Ph.D. study: secondary data, primary data).

This study is more dominated by qualitative study using a case study strategy. Therefore, the results cannot be easily generalized to all types of projects and organizations in different contexts. However, due to the universal common characteristics of projects, society and human interactions, the results can be partially used as a basis for further research on projects within different contexts. It should be mentioned that in this study, external validity has not been the main objective.

According to Johnson (1997), if the validity and thus reliability of the results of a study can be maximized or tested, the result will be more credible and justifiable results, which may lead to generalizability. Generalization, according to Bryman (2008), is usually concerned with the ability to generalize research results beyond the constraints of the particular context under which the research has been conducted.

On the other hand, some of the results are tailored to a specific problem within a specific time; however, the process of doing the research and obtaining the results can be applied for similar problems but in different contexts. It is important to consider not only the results but also the process for generalization. Of course, more descriptions are included in each chapter related to research questions on the research process used.

2.6 Methodology Choice Summary

The paradigm in this Ph.D. work is *pragmatism* as discussed and supported previously in Subsection 2.4.1. *Pragmatism* is where social utility – social control as a result of research – constitutes the criterion of truth. *Pragmatism* has been disrobed as an anti-theoretical philosophy, which implies sticking as closely as possible to practical, empirical reality (Alvesson and Sköldberg, 2009).

In addition, since *pragmatism* means that the exact position on a positivism and interpretivism continuum is determined by the research question, which directs the methodological choices in order to gain the best knowledge from the research, this makes it the best choice for this Ph.D. work.

The dominant approach in this Ph.D. study is the *inductive* approach. The main reason behind the choice of the approach is the types of methods used mostly to answer the research questions.

All of them include qualitative methods, thus it is necessary to use inductive reasoning except in the two first research questions, and where both *inductive* and *deductive* reasoning were used since a quantitative method was used as well as a qualitative one.

A *qualitative method* was dominant in this Ph.D. study. All the answers had a case study (company or project case) to come up with findings. The choice of method was based on the available data at hand.

Most of the data sets presented in this study came from opportunities rather than planned sources; thus, this leads to choosing the method that is most suited to the types of data sets.

Table 2.6-1 summarizes how to achieve the research objectives, from the paradigm, to the reasoning used to answer each research question, to the methods (qualitative or quantitative), to the strategies used, to the types of data that determine the sources, to the data collection techniques and ending in the last column with data analysis procedures.

Table 2.6-1: The research approach, method, strategy, techniques and procedures

RQs	Chapters/ Papers	Approaches	Methods	Strategies	Data type	Techniques	Procedures
RQ1	Chapter 5	Inductive	Qualitative/ Quantitative	Archival research	Secondary data, primary data	Search Internet, interviews included all forms and types	Generic analysis, Statistical relationships
RQ2	Chapter 6 Papers 3, 4, 5, 13, 14, 15, 16.	Inductive/deductive	Qualitative/ Quantitative	Case study (project)/survey	Secondary data, primary data	Search Internet, interviews included all forms and types, questionnaires (open questions, multiple choices)	Generic analysis, coding/recoding to ranked, discrete data. Statistical relationships
RQ3	Chapter 7 Paper 17	Deductive	Qualitative	Case study (project)	Secondary data, primary data	Search Internet, interviews included all forms and types	Inductive generic analysis
RQ4	Chapter 8 Papers 4, 5, 6, 11, 12, 16.	Inductive/deductive	Qualitative	Case study (project)/survey	Secondary data, primary data	Search Internet, interviews included all forms and types, questionnaires (open questions)	Generic analysis, coding/re-coding to be ranked, discrete data.
RQ5	Chapter 9 Papers 1, 3, 4, 6, 9, 10, 11, 12, 14, 18, 19, 20.	Inductive/deductive	Qualitative	Case study (company, project)/survey	Secondary data, primary data	Search Internet, interviews included all forms and types, questionnaires (open questions)	Generic analysis, coding/recoding to be ranked, discrete data.

The strategies used in this Ph.D. study were case studies (project and company cases) and surveys (including an open questionnaire and a multiple-choice questionnaire). The choice of these strategies was based on the previous description of the choice of methods. The choices were dictated by the available resources and time to collect the data and not vice versa.

The choice of inductive reasoning as the dominating approach helped with the flexibility of the choice of methods and the strategies that followed. The types of data collected were secondary and primary data. The survey strategy used only primary data; however, the case study strategy made use of all types of data, both primary and secondary.

The techniques for collecting primary data were interviews of all types, and questionnaires for the survey. Moreover, the secondary data were acquired by asking the participants (interviewees, respondents) in the case studies and through an intensive search on the Internet.

The procedures for the data analyses were generic analysis for the qualitative data sets, and coding and recoding for the quantitative ones. More is discussed in the related chapters.

Next section is brief descriptions of the individual publications.

2.7 The Papers in Brief

A total of 20 papers were produced during the three years of Ph.D. work. Some of them are directly used in the dissertation. Below is very brief description of each individual publication.

Paper 1 investigates the barriers and challenges in employing concurrent engineering philosophy within the Norwegian construction industry. This paper is based on the case of a company, which is a contractor.

Paper 2 presents findings from a survey conducted in seven public and private organizations in autumn 2014 in Norway. The purpose of the study was to establish the most common factors extending a project life cycle or making a project go slower than planned.

Paper 3 is about developing a holistic framework for project evaluation; it is applied to a case study of an Algerian highway megaproject. This paper is about developing an *ex post* evaluation framework model.

Paper 4 is related to Paper 3 as described previously. Once the Algerian highway megaproject has been assessed – its extent and success – the paper lists all possible external and internal stakeholders of this megaproject and subsequently identifies the relationship between each stakeholder and the five success/failure measures.

Paper 5 establishes the relation between the problems associated with defining the project success criteria at the project initiation phase and the potential challenges when it comes to the project execution and closeout.

Paper 6 is concerned with studying the time factor in the case of NPD projects based on a time-cost trade-off curve. Is time to delivery of high importance in construction projects?

Paper *7* characterizes the Black Swan concept in projects, describe its nature and identifies organizational mechanisms that can be useful in dealing with Black Swan surprises in projects.

Paper 8 lists a set of possible shared values – values that affect project performance positively or negatively. In this regard, this paper looks at the characteristics of, and the interplay between, the shared values.

Paper 9 develops a framework for measuring project speed within a certain time of a project execution phase and compares it with the optimal average project speed based on difficulties and stimuli in that time, which should be defined based on other project parameters.

Paper 10 focuses on the development of the *ex post* conceptual holistic framework for the Project Evaluation on Strategic, Tactical and Operational Levels (PESTOL) model by reviewing different definitions of project success and/or failure and combining the findings with the logic framework. The model reflects the project life cycle by considering all project phases, such as identification and conception. This paper is an extension of the previously described Paper 3.

Paper 11 studies how the concepts of efficiency, effectiveness and efficacy are used in project management literature. The concepts relate to the degree of success or failure of projects and the degree to which the results are achieved.

Paper 12 investigates the aim of furthering the understanding of project speed and how to increase it, along with the management challenges involved in delivering a telecommunications infrastructure project in a much shorter period than originally planned. I wanted to understand the reasons behind the urgency and how the project management team succeeds in delivering in such a tight time window. Finally, it assesses the consequences (negative and positive, during and after the project delivery), knowing that the project was considered a success at its delivery from the client.

Paper 13 identifies the universal delay factors from an intensive literature review, supplemented by delay factors in major Norwegian construction projects based on empirical data. The study on which this paper is based includes a literature review and survey. This paper addresses the frequency and types of delay factors in construction projects worldwide.

Paper 14 identifies the delay factors in major Norwegian construction projects based on empirical data. The study on which this paper is based includes a literature review, survey and interviews. This paper addresses the frequency and types of delay factors in construction projects in Norway, and includes the remedies and solutions for how to deal with these delay factors from the same survey and from the conducted interviews.

Paper 15 identifies the delay factors in the Algerian telecommunications industry based on a quantitative method using a survey as the research strategy. The participants in the survey are experts in managing medium- to large-scale telecommunications infrastructure projects.

Paper 16 identifies the delay factors in Algerian construction projects. This identification is based on a case study strategy, and the case study used in this paper is similar to the one used in other papers. The case is the highway construction megaproject.

Paper 17 investigates the relationship between project speed and project flexibility, complexity and uncertainty. This is done by conducting case studies within similar organizations, and the cases chosen are telecommunications infrastructure projects.

Paper18 explains the role of the project life cycle and decision-making model in managing projects. This paper is a more practical paper and suggests conceptual models linking project life cycles to decision gate models.

Paper 19 reflects the benefits of evaluating learning. The case used in this paper is the same as in Papers 3, 4, 10 and 16. The types of evaluations discussed in this paper are all the existing evaluation types from *ex ante* to *ex post* evaluations.

Paper 20 is a reflection of the concept of “yin and yang” on time and timing, on chronos and kairos, and on efficiency and effectiveness. This reflection of the concept of “yin and yang” on efficiency and effectiveness is more from a philosophical approach.

CHAPTER 3

Project Life Cycle (Span)

"The life cycle is the only thing that uniquely distinguishes projects from non-projects."
— *Patel & Morris*

"Watch the product life cycle; but more important, watch the market life cycle."
— *Philip Kotler*

"We forget that the water cycle and the life cycle are one."
— *Jacques Cousteau*

This chapter and the next, Chapter 4, provide a platform and context for the chapters that follow. This chapter is based mostly on, but not limited to, a literature review and definitions about life cycle thinking, product life cycle, asset life cycle, material life cycle, project life cycle and project duration. The most important concepts are the last two. The reason to include the other concepts briefly is to ensure readers know about them and to present the view that project management is just a small picture of other broader horizons. Since this Ph.D. work is about the concept of "time" (chronos and kairos), it is very important to give a very clear picture about the project life cycle and project duration. This clear picture will facilitate the autopsy of this phenomenon called "project." The last section of this chapter ends with a real project life cycle example, involving different stakeholders. This PLC is based on a telecommunication operator in Algeria; in addition, the main contractors and subcontractors are reflected, again based on their own PLC. This PLC is just an illustration of a single case, and can never be generalized.

3.1 Life Cycle Thinking – Material Life Cycle

Filimonau (2015) defines ***Life cycle thinking*** (LCT) as follows: "[I]t is a qualitative approach to appraising the impacts associated with all stages of a product or service's life cycle. In contrast to ***Life Cycle Assessment*** (LCA), which strives to diligently quantify the magnitude of these impacts by assigning a numerical value to each impact, life cycle thinking is primarily concerned with the identification and acknowledgment of these impacts." LCT is about going beyond the traditional focus on a production site and manufacturing processes to include environmental, social and economic impacts of a product over its entire life cycle (Figure 3.1-1). The main goals of LCT are to reduce a product's resource use and emissions into the environment as well as to improve its socioeconomic performance throughout its life cycle. This may facilitate links between the economic, social and environmental dimensions within an organization and through its entire value chain (UNEP, 2007).

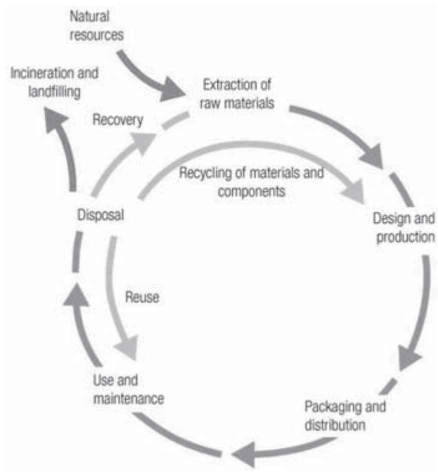

Figure 3.1-1: Life cycle thinking.
(Adopted from: UNEP 2007)

Life cycle thinking (LCT) helps people understand the various impacts associated with material consumption and waste emissions as part of the sequence of activities related to products and services (UNEP/SETAC, 2011), and thus LCT can be a useful technique in generating such information. Life cycle assessment (LCA) is considered to be a relatively recent method for appraising environmental impacts from products and services (Klöpffer and Grahl, 2014). The first attempts to adopt life cycle thinking when describing product and service systems date back to the sixties (Hunt and Franklin, 1996; Filimonau,2015). In the seventies, a number of studies were carried out in the USA on the basis of Resource and Environmental Profile Analysis, which can be considered the first evidence of practical LCA application in the sense of how its concept is understood nowadays (Klöpffer, 2006; Filimonau, 2015). Life cycle assessment (LCA) is defined by Sonnemann and Margni (2015): "[It] is a science-based technique to assess resource consumption and potential environmental impacts associated with a product or service throughout its whole life cycle, from extraction via manufacturing and use to end-of-life by compiling an inventory of relevant energy, material, water and land inputs, and releases to the environment."

Filimonau (2015) defines ***Life cycle management*** (LCM) as "a managerial paradigm of addressing environmental impacts, which is concerned with the management of products and services in a way that aims to rigorously and consistently review the totality of life cycle impacts. Moreover, not a single impact, attributed to a specific stage of a product or service's life cycle, thus enhancing sustainability of corporate operations." Sonnemann and Margni (2015) define Life Cycle Management "as a management concept applied in industrial and service sectors to improve products and services while enhancing the overall sustainability performance of business and its value chains. In this regard, Life cycle management is an opportunity to differentiate through sustainability performance on the market place, working with all departments of a company such as research and development, procurement, and marketing, and enhance the collaboration with stakeholders along a company's value chain. LCM is used beyond short-term business success and aims at long-term achievements minimizing environmental and socioeconomic burden while maximizing economic and social value." It is very clear that these concepts are very broad and contain products, materials, assets and projects as elements.

3.1 Product Life Cycle, Asset Life Cycle

As defined by the PMI (2013, p.18) in the PMBOK Guide, "the ***product life cycle*** consists of generally sequential, non-overlapping product phases determined by the manufacturing and control need of the organization. The last product life cycle phase for a product is generally the product's retirement. Project Life cycles occur in one or more phases of a product life cycle. Care should be taken to distinguish the project life cycle from the product life cycle. All projects have a purpose or objective, but in those cases where the objective is a service or result, there may be a life cycle for the service or result, not a product life cycle." Figure 3.2-1 shows a typical product life cycle; during this life cycle many projects may occur within it.

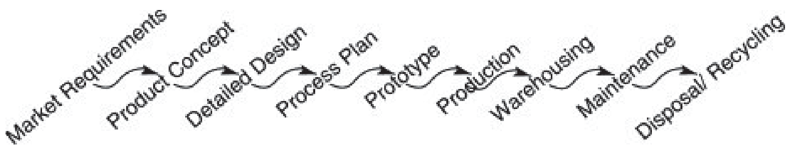

Figure 3.1-1: Product life cycle.
(Adopted from: Thimm *et al.*, 2006)

In modern product development, as the complexity and variety of products increase to satisfy increasingly sophisticated customers, so does the need for knowledge and expertise for developing products. Co-located and monolithic design teams can no longer efficiently manage the product development effort in its entirety. In order to avoid lengthy product development cycles, higher development costs and quality problems, collaboration across distributed and multidisciplinary design teams has become a necessity (Ameri and Dutta, 2005). This is the essence of ***Product life cycle management*** (PLM). Product life cycle management (PLM) appeared later in the nineties with the aim of moving beyond mere engineering aspects of an enterprise (Lee *et al.*, 2008). PLM seeks to manage information throughout all the stages of a product's life cycle including design, manufacturing, marketing, sales and after-sales service (Ameri and Dutta, 2005). These applications focus on specific processes during a product's life cycle and depend on product and process information. PLM extends product data management beyond engineering and manufacturing into more strategic areas like marketing, finance and after-sales service throughout the life cycle of the product (Ameri and Dutta, 2004; Lee *et al.*, 2008).

Product Life cycle Management (PLM) is the business activity of managing, in the most effective way, a company's products throughout their life cycles, from the very first idea for a product all the way through until it's retired and disposed of. PLM manages both individual products and the product portfolio, the collection of all of a company's products. PLM manages products from the beginning of their life, including development, through growth and maturity, to the end of life. The objective of PLM is to increase product revenues, reduce product-related costs, maximize the value of the product portfolio, and maximize the value of current and future products for both customers and shareholders. The scope of PLM is wide (Stark, 2015).

The ***Asset lifecycle management*** perspective is key and its importance is illustrated in numerous definitions of asset management. The Asset Management Council of Australia has developed the following definition of asset management (cited in: Hastings, 2010): "The life cycle management of physical assets to achieve the stated outputs of the enterprise." He added another definition: "systematic and coordinated activities and practices through which an organization optimally and sustainably manages its assets and asset systems, their associated performance, risks and expenditures over their life cycles for the purpose of achieving its organizational strategic plan." These definitions show that asset management is seen as a life cycle approach that covers the activities the organization undertakes to achieve its goals. This is in contrast to the assets being something an organization owns and must maintain. From the life cycle perspective, the management of the asset life cycle is central to the operational success of the organization (Van der Lei *et al.*, 2012).

Hastings (2010) uses the following stages: 1) Identification of business opportunities or needs; 2) Asset capability gap analysis and requirements analysis; 3) Pre-feasibility analysis, physical and financial – options selection; 4) Feasibility planning, physical and financial – for selected option; 5) Acquisition, development and implementation; 6) Operation, logistic support and maintenance; 7) Monitoring and review; 8) Disposal. The asset life cycle's phases (stages) resemble quite a lot those of the product life cycle discussed above.

3.2 Project Life Cycle/Span & Project Duration

All projects consist of a number of different phases that form the ***project life cycle/span***. Stuckenbruck (1981) states that the project life cycle of a project consists of sequential phases: "Conceptual"; "Definition"; "Production" or "Acquisition"; "Operation"; and then "Divestment." Cavendish and Martin (1982) described the relationship between contracting and the project life span; in other words, the life span from a general contractor's perspective. Youker (1989) defines six sequential steps: identification, preparation, appraisal, implementation (supervision), operations and *ex post* evaluation.

De la Garza *et al.* (1994) divide architecture/engineering/construction projects into five categories: residential, commercial, industrial, highway and heavy, and marine. The project life cycle, meanwhile, consists of the following phases: "Conception, "Design," "Construction," "Operation," "Maintenance," "Rehabilitation," "Renewal" and "Decommissioning." However, this definition can be confused with the product life cycle. Belanger (1997) also confuses product with project life cycle when he describes the life cycle phases of a construction project as "General Concept"; "Definition"; "Detailed Planning"; "Development and Construction"; "Implementation" and "Operation"; and "Closeout or Retirement." The two definitions go further than the handover of the product to operations and include the after product life.

Patel and Morris (1999) outline the life cycle as the only thing that uniquely distinguishes projects from nonprojects. They defined the project life cycle as "the sequence of phases through which the project will evolve. It is fundamental to the management of projects. It will significantly affect how the project is structured. The basic life cycle follows a common generic sequence: 'Opportunity,' 'Design' and 'Development,' 'Production,' 'Handover' and 'Post-Project Evaluation.' The exact wording varies between industries and organizations. There should be evaluation and approval points between phases often termed gates."

Morris (1998) came up with the concept of front-end analysis before the start of the project, and this was shared by Frame (1998). Cleland and Ireland (1999) in their generic project life cycle identify important points between the various phases, which are decision points, at which an explicit decision is made concerning whether the next phase should be undertaken. This idea represents an important development for two reasons: (1) It introduces the idea of strategic high-level decision gates, at which a decision is taken on whether or not to continue; and (2) It is distinguished from those earlier texts that emphasize that such phases may, and frequently do, overlap.

Forsberg and Cotterman (2000) suggest that the project life span has three aspects: "Business," "Budget" and "Technical." Archibald (2003) simplifies his previous generic project life cycle to generic project phases: "Concept," "Definition," "Execution" and "Closeout." He mentions that the project life cycle has an identifiable start and end, which can be associated with a timescale. Wideman (2004), in a generic project life cycle model reflecting construction projects, shows a generic model, which has four phases: "Concept" and "Economics"; "Functional design"; "Working drawing" and "Specifications," "Tender and award" then "Construction"; "Commission" then "Operate." Kerzner (2009) draws a clear distinction between the project life span and the product life span. A project passes through several distinct phases as it matures; the project life cycle includes all phases from the point of inception to the final termination of the project. The phases overlap and are seldom separated, and are respectively: "Start"; "Concept"; "Definition"; "Design"; "Manufacture"; "Installation" then "Project termination." The APM (2012) has its own project life cycle model, with four basic phases: "Concept"; "Definition"; "Implementation"; and "Handover" and "Closeout."

The project life cycle is defined by the PMI (2013) in the PMBOK as "the series of phases that a project passes through from its initiation to its closure. The phases generally are sequential, and their names and numbers are determined by the management and control needs of the organization or organizations involved in the project, the nature of the project itself, and its area of application." The project is divided into four generic phases: "Starting the project"; "Organizing and preparing"; "Carrying out the work"; "Closing the project". Recently, the acceleration of technological development has led to the need to administer and manage multiple projects to sustain competitive advantage. Whether this is a consequence of, or driver for, even greater focus at the front end of project life spans is difficult to say. Nonetheless, the focus of project management has moved "upstream" into program management and project portfolio management. Nowadays, most companies, institutions and large organizations of all types have their own tailored project life cycle model to meet their strategic plans (Zidane *et al.*, 2016c).

Project duration is a target (a success criterion), and a target specification. It starts from the kickoff meeting with the decision to start implementing the project; it ends when all the specifications are delivered, or success criteria met. This definition clashes with the PMBOK's definition of project life cycle (PMI, 2013), which here is the project duration. The perception in this dissertation does not agree with the PMBOK's definition, which is similar to that of project life cycle. However, in this dissertation project duration is part of project life cycle. Figure 3.2-1 shows the reasons why a distinction should be made.

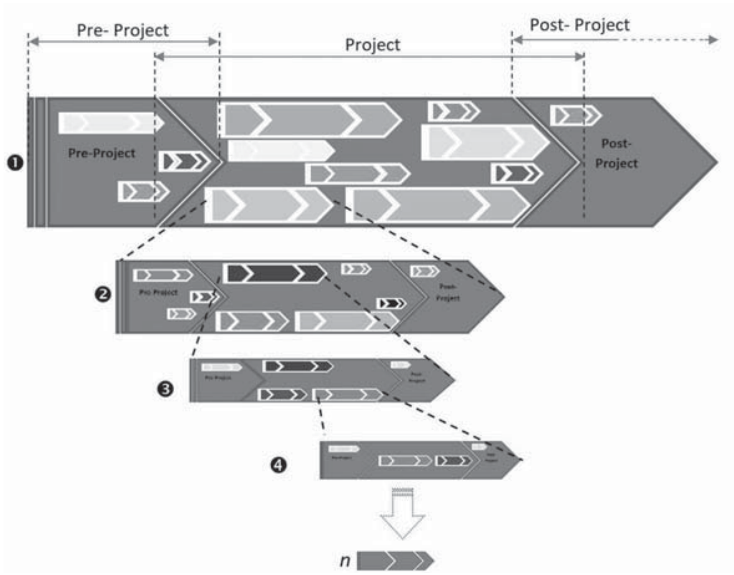

Figure 3.2-1: Project life cycles.

Numbers 1, 2, 3, 4 to *n* in Figure 3.2-1 represent the stakeholders. For example, in a project to build a hospital initiated by the municipality with its own budget, before bidding to select a contractor to build the hospital, they first selected a consulting company to carry out a pre-study and give all the estimations regarding budget and time with the related scope and deliverables. Number 1 is the owner/sponsor/client (municipality) and before starting the project (kickoff meeting with selected contractor, until starting operating the product – e.g., hospital) there will be some subprojects. Those subprojects, which are in the pre-project phase, also have pre-project and post-project phases.

Number 2 may be one of the subcontractors of the contractors. However, if I want to put everything in order, Number 2 should be for the contractor and the pre-project, project and post-project will be the "Project" on the first line in Figure 3.2-1. Again, within the project, which is the pre-project, project and post-project for the contractor, there will be many projects for subcontractors, consulting companies, suppliers, etc. and each of these stakeholders will consider the contract they signed with the contractor as the "Project." In their turn, their projects have pre-project, project and post-project phases.

Subcontractors, suppliers, etc. will also have to contract some of their wok to other organizations, and those organizations have to consider their projects with those three main phases (i.e., pre-project, project and post-project phases). All this keeps going until the work is not contracted anymore. The confusion in the PMBOK Guide's definition comes from considering only a few types of industries in building the definition (e.g., new product development). To sum up, in this dissertation the project life cycle includes the pre-project, project and post-project phases; on the other hand, the project duration is the only "project" phase that starts from the kickoff meeting and ends by closing the project.

3.3 Developing Generic PLC

The review of a number of models by the author, which built on the original logic model, led to the development of the logic model shown in Figure 3.3-1.

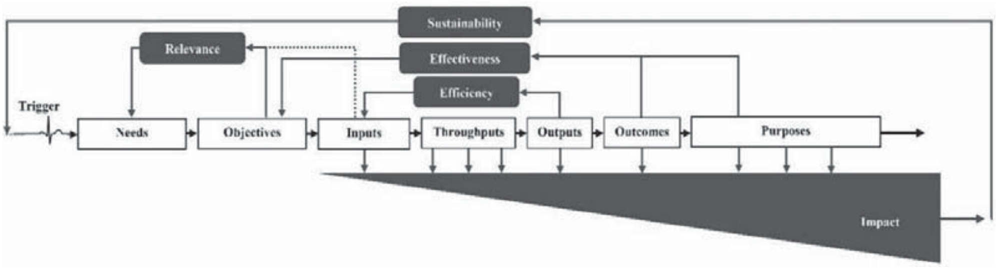

Figure 3.3-1: The logic model and the associated evaluation criteria.

By using circular interplay between the logic model and the project life cycle (Figure 3.3-2), a rational generic project life cycle could be extracted and thereafter a project life cycle defined that met the logic model. This interplay resulted from superposing the two models onto each other to harmonize them in a consistent approach.

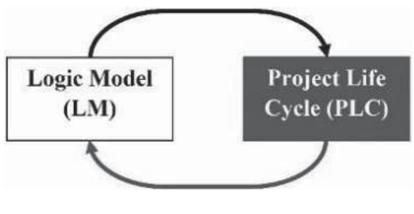

Figure 3.3-2: Circular interplay.

The new elements in the model (see Figure 3.3-2), which did not exist in the pre-existing models, are as follows. In Figure 3.3-3, which is part of the logic model's sequence used by earlier models (e.g., Bennett, 1975; United Way of America, 1996; OECD, 2002; Samset, 2003; Serrat, 2009), “inputs” go through a black box called “activities” to give “outputs.” “Outputs” will lead to “outcomes,” which in turn result in “impacts.”

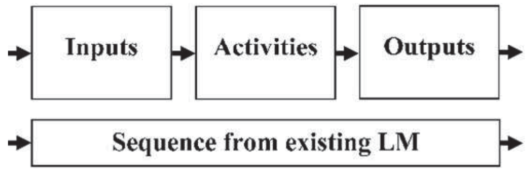

Figure 3.3-3: Sequence of the existing logic models.

In the model in Figure 3.3-1, this logic model has been changed. Since the concept is based on cause and effect, I have the following perception. In the short sequence of the logic model related to “activities” (see Figure 3.3-4), each cause has an effect: a “Trigger” (inputs) results in “Needs” (outputs), “Needs” (become inputs) then result in “Objectives” (outputs) and so forth. Thus, the “outputs” from the previous element become “inputs” for the next element. “Activities” are not part of the logic model but they belong to the project life cycle. Consequently, each element from the logic model always relies on “Activities” to be transformed into the next element. For example, “Needs” as inputs will need a group of activities, which I call the “Conception” phase, in order to be transformed into outputs, which are “Objectives,” and so forth (see Figure 3.3-5). Since the newest element in the logic model sequence is “Throughputs,” it must be defined. Since I could not find a definition in project management sources, I resorted to a definition from business and strategic management and system engineering references. In business and strategic management, throughput is defined as “the movement of inputs and outputs through a production process. Without access to and assurance of a supply of inputs, a successful business enterprise would not be possible” (Besanko *et al.*, 2010). In system engineering, it is defined as “[m]aterial, energy, and/or information that enters the system in one form and leaves the system in another form” (Frame, 1998; Blanchard and Fabrycky, 2011). In my case, the system is the “Project.” Therefore, “Throughputs” are continuous inputs and outputs during the block activities called “Project” (shown in Figure 3.3-5).

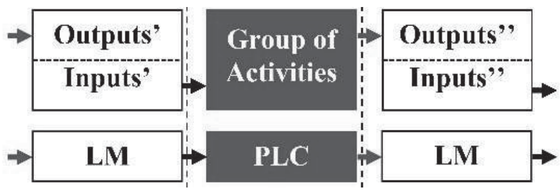

Figure 3.3-4: New interpretation for the logic model.

From the examination of the definitions of the project life cycle (presented in Section 3.1) and by extracting the first phase’s appellation, which differs from one author to another, the most frequently repeated term found was “Conception.” Other authors have used the terms “Concept,” “Conceptual,” “General Conception,” “Opportunity,” “Objective Definitions,” “Identification,” “Idea” and “Analysis.”

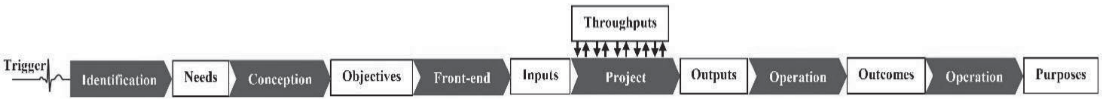

Figure 3.3-5: The logic model combined with the project life cycle.

The project life cycle starts with "Identification." The reason is that before starting the second phase (i.e., "Conception") it is wise to first identify the "Needs," which is the logic behind the life cycle shown in Figure 3.3-5. Hence, first the "Trigger" (e.g., opportunity, threat, problem, idea, society or a parliament) triggers the "Identification" of "Needs." Those "Needs" will cause a decision to be made to start the next phase, which is "Conception." In this phase, "Objectives" are defined. Once the "Objectives" have been defined, the next decision will lead to the "Front-end" analysis phase. Once completed, the project is established with agreed "Inputs." Those "Inputs" become an input to the "Project." During the running of the system called "Project," there will be emergent "Throughputs" that nurture or undermine it. As soon as the system "Project" reaches its end, it will give "Outputs." The most important output is the delivered product. Once it has started functioning during the "Operation" phase, the product will give "Outcomes." The "Operation" phase will keep running because it has "Purposes." The system called "Project" consists of three sequential phases – "Plan and Design," "Construction" and "Closeout" – with a parallel phase called "Procurement." Most authors have regarded procurement as a work package or an activity, but for us it is more than that since it is the most important work package, and since it feeds most of the other packages it is appropriate to upgrade it to a phase. In summary, the generic project life cycle is presented in Figure 3.4-1.

The project life cycle can be divided into three levels (Figure 3.4-1) by setting boundaries for each subsystem. The operational level, which is the inner subsystem, the project itself, is where concerns are more about efficiency measured in terms of cost, time and scope (Samset, 2010). The tactical level reveals the usefulness of the project, such as its relevance, effectiveness and the achievement of its objectives (Samset 2010; Zidane *et al.*, 2015a, 2015c). The strategic level refers to the system or the whole life cycle from the moment when the "Phenomenon" pushes the "Trigger" until the long-term impacts are felt. At this level, the most important aspects to address are the sustainability and the positive or negative economic impacts. In the generic project life cycle model shown in Figure 3.4-1, the addition is the x-axis that represents the timeline. At each time "T_n," a decision "D_n" is taken to start the next phase.

3.4 Practical Examples of PLC and PD

This example is to demonstrate the concepts of project duration and project life cycle from different stakeholders' perceptions. The data used to demonstrate the example were collected based on a large-scale project so that it would cover the maximum number of internal stakeholders of the project (Zidane *et al.*, 2013; Zidane *et al.*, 2015c). Figure 3.4-1 represents the main project life cycle. Strategic level is concerned with the context and the external environment of the project (i.e., the system called Algeria, with its society, government, etc.). Tactical level is related to the sponsor/client/owner and in our case is the telecommunication operator. Operation level is more related to the contractors, subcontractors and suppliers involved in the construction of the telecommunication network. This representation of the project is made from the owner's perspective. While conducting interviews, depending on which department from his/her organization the interviewee belongs to. The interviewee from the marketing department believes that the project for them is a black box and at time T_3 for them is the start of a single phase called "Closeout." However, the project director on the operator, who belongs to the technical department, believes that the project life cycle starts from T_2 and ends at T_6, while the project duration is the same for him. This perception is more related to the involvement of the individual in the project, since the project director on the operator side is assigned once there is a decision from the CEO to start the "Front end" of the project.

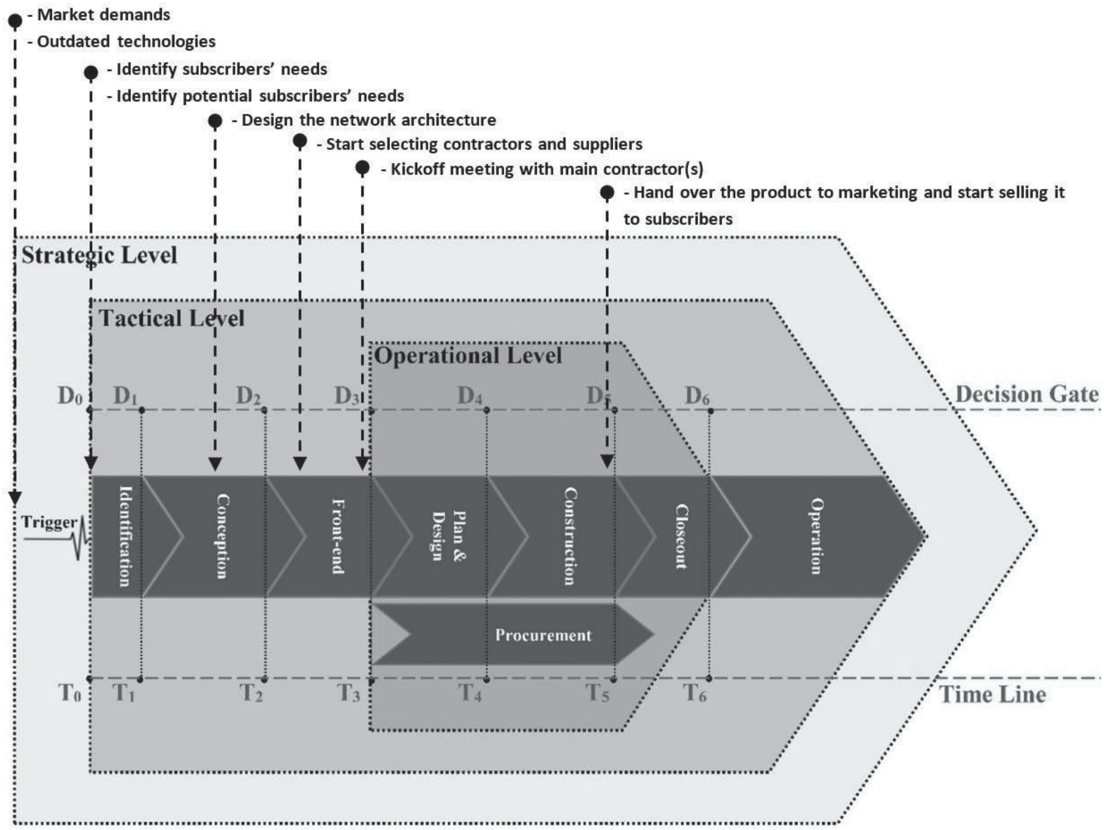

Figure 3.4-1: Project life cycle with decisions made.

The case had a single main contractor. The project director from the main contractor was not interviewed since he is the one conducting this research; instead his colleague, who is a project director for another project, was asked to identify the project life cycle and project duration. The answer was that the project life cycle for his starts at T_2 and ends at T_6, while the project duration is from T_3 to T_6. Lastly, the subcontractor's project manager considers project life cycle and project duration to be synonyms, and for him the project starts when his company receives a purchase order, and ends when the scope in the purchase orders is completed.

All these interpretations are reflected in Figure 3.2-1, where each stakeholder has their own perception of the concepts of project life cycle and project duration.

CHAPTER 4

Brief about Some of the TTMPs for Scheduling & Planning

"We become what we behold. We shape our tools and then our tools shape us."
— *Marshall McLuhan*

"The expectations of life depend upon diligence;
the mechanic that would perfect his work must first sharpen his tools."
— *Confucius*

Different tools, techniques, methods and philosophies have been developed to manage projects efficiently and effectively. From the range of tools, techniques, methods and philosophies, one has to choose the TTMPs (tools, techniques, methods and/or philosophies) that best fit for the organization and type of project. Against this background, this chapter will discuss very briefly some of these important TTMPs for scheduling and planning, and the basic principles behind them. The chapter is divided into two sections: the first section discusses literature regarding a few selected TTMPs, while the second section is about management techniques for reducing project duration and speeding up project delivery. The second section is based on some guides, and according to their authors, these guides suggest the best techniques and good practices to meet this aim (i.e., fast project delivery). This overview of some TTMPs is meant not only to show the awareness of the researcher of their existence, but also for him to use it in the study.

4.1 Scheduling & Planning TTMPs

Merriam-Webster (1984) defines "schedule" as a "program; especially: a procedural plan that indicates the time and sequence of each operation finished on schedule." Stevenson (2010) in the *Oxford Dictionary of English* defines the term "scheduling" as "A plan for carrying out a process or procedure, giving lists of intended events and times". Cleland and Kerzner (1985), in the book *A Project Management Dictionary of Terms*, defines scheduling as "The prescribing of when and where each operation is necessary to complete the task. The determination and assignment of projected time of events and tasks as compared to expected time resulting from the network calculation".

Pinto (2007) claims that project scheduling represents the conversion of project goals into an achievable methodology for their completion. He further elaborates that it creates a timetable and reveals the network logic that relates project activities to each other in a coherent fashion. Scheduling determines when every single activity should be performed in order to finish the project on time (Rolstadås, 2008).

According to Kogan and Khmelnitsky (2013, p.3), "scheduling generally means assigning individual resources to individual products in order to trace the demand along the horizon. Since typically, a large number of possible schedules can be constructed, the problem of scheduling is to select the schedule, which ensures optimal functioning of the production system in terms of a certain performance measure. … At the beginning of the 20th century, simple techniques were used to allocate production tasks to machines in rapidly growing industrial plants. These techniques resulted in a sequence of tasks to be carried out. The sequence was illustrated in a graphic form known as a Gantt chart".

Yalaoui *et al.* (2012, p.203) set the scheduling process in the operation level of the different time frames (see Figure 4.1-1). For them, scheduling comes after planning, where the planning process is part of project management. They added that there are scheduling problems based on the involvement of four fundamental concepts: tasks, resources, constraints and objectives.

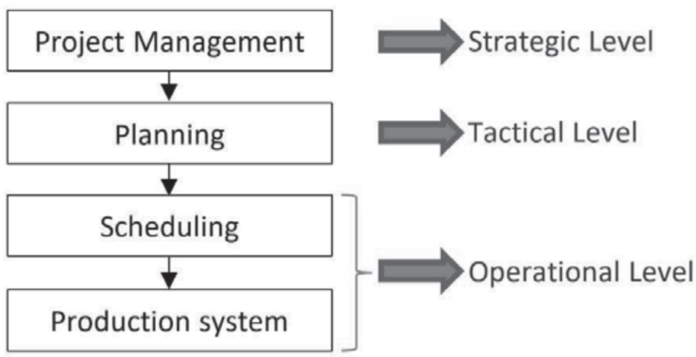

Figure 4.1-1: The different time frames.
(Adopted from: Yalaoui *et al.*, 2012, p.203)

In the PMBOK Guide, project time management includes the processes required to manage timely completion of the project (PMI, 2013). The project time management processes are:

1. Define activities
2. Sequence activities
3. Estimate activity resources
4. Estimate activity duration
5. Develop schedule
6. Control schedule

The PMBOK Guide added that during the development of the project management plan process a tool or methodology is chosen for scheduling, with some of the best methodologies including the critical path method and critical chain (PMI, 2013). Point five from the project time management processes, which is the schedule development process, needs information regarding what activities are to be performed, how long it takes to perform these activities, what resources in what quantity will be required and how these activities interact with each other (i.e., dependencies among activities) (PMI, 2013). However, in this chapter the focus is not on the PMPOK Guide's time management process, but on the existing TTMPs for scheduling and/or shortening PLC/PD. There are a large number of Tools, Techniques, Methodologies and Philosophies available in project management practice for project scheduling and planning (e.g., Pinto, 2007; Hastak *et al.*, 2008; Kerzner, 2009; PMI, 2013). Among these TTMPs, which are frequently cited and discussed by scholars, in my view are:

1. Arrow Diagramming Method (ADM)/Activities on Arrows/Nodes (AOA/AON)
2. Concurrent Engineering (CE)
3. Critical Chain Project Management (CCPM)
4. Critical Path Method (CPM)
5. Cycle Time Analysis (CTA)
6. Fast tracking (FT)
7. Gantt Chart (GC)
8. Graphical Evaluation and Review Techniques (GERTs)
9. Graphical Planning Method (GPM)
10. Just-in-Time Systems (JIT)
11. Last Planner System (LPS)
12. Line of Balance Method
13. Linear Scheduling Method
14. Program Evaluation and Review Techniques (PERTs)
15. Project Management Software
16. Repetitive Scheduling Method (RSM)
17. Simulation Techniques
18. Time-Cost Trade-Offs
19. Value Engineering (VE)

As previously mentioned, the number of tools, techniques and methodologies for project scheduling is not limited to the list above. The list is just a sample of TTMPs. Some of them are more than methods, but are philosophies (e.g., CE, LPS), which are applied not only to meet time targets, but also to improve the overall performances. Some of TTMP are described below.

1. a. Arrow Diagramming Method (ADM):

Also called the ***Activities on Arrows method (AOA)***, this is a method of schedule activity sequencing. The activities are diagrammed on arcs, and nodes represent events. Arrows are used to represent activities and connect them at nodes to show their relationships. It only uses finish to start dependencies and may require the use of dummy relationships called "dummy activities" for showing all relationships properly. Dummy activities are not actual activities and they do not consume any time, they just show relationships between different activities and dotted lines represent them.

b. Activities on Nodes (AONs):

The AON format is used in most project management software packages, such as MS project, Primavera and ProTrack, and with increasing use of computer-based project scheduling. As activities are positioned in nodes and arrows are used just to show relationships, it simplifies the network labeling and makes the AON network easy to read and follow (Pinto, 2007). But in large complex projects with a large number of activities, it is easier to employ the path process used in the AOA method (Pinto, 2007).

2. Concurrent Engineering (CE):

The term "Concurrent Engineering" (CE) was coined in the late 1980s to explain the systematic method of concurrently designing both the product and its downstream production and support processes (Winner *et al.*, 1988). CE was proposed as a means to minimize product development time (Prasad, 1996). This was necessitated by changes in manufacturing techniques and methods, quality management, market structure, the complexity of products, and demands for high-quality and accelerated deliveries at reduced costs. These changes resulted in a shift in corporate emphasis with the result that the ability to rapidly react to changing market needs and time to market became a critical measure of business performance (Constable, 1994). The earliest definition of CE by Winner *et al.* (1988) refers to "integrated, concurrent design of products and their related processes, including manufacture and support" with the ultimate goal of customer satisfaction through the reduction of cost and time to market, and the improvement of product quality.

CE embodies two key principles: integration and concurrency. Integration here is in relation to the process and content of information and knowledge, between and within project stages, and of all technologies and tools used in the product development process. Integrated concurrent design also involves upfront requirement analysis by multidisciplinary teams and early consideration of all life cycle issues affecting a product. Concurrency is determined by the way in which tasks are scheduled and the interactions between different actors (people and tools) in the product development process (Anumba *et al.*, 2007).

The benefits of CE derive from the fact that it is focused on the design phase, which determines and largely influences the overall cost of a product: as much as 80 percent of the production cost of a product can be committed at the design stage (Dowlatshahi, 1994).

Addressing all life cycle issues upfront in the design stage and ensuring that the design is "right first time" should therefore lead to cost savings and products that precisely match customers' needs, and which are of a high quality. The adoption of CE can also result in reductions in product development time of up to 70 percent (Evbuomwan *et al.*, 1994). The success of CE in manufacturing, which is due to the benefits arising from its use, is one of the main motivations for adopting CE in construction (De la Garza *et al.*, 1994). It is also based on the assumption that because construction can be considered a manufacturing process, concepts that have been successful in the manufacturing industry can bring about similar improvements in the construction industry. Furthermore, the goals and objectives of CE directly address the challenges that currently face the construction industry (Anumba *et al.*, 2007).

3. *Critical Chain Project Management (CCPM):*

CCPM is a schedule network analysis technique that modifies the project schedule to account for limited resources (PMI, 2013). Critical Chain scheduling is based upon the Theory of Constraints (TOC) introduced by the physicist Eliyahu Goldratt in 1984, and he adopted TOC in project management in his 1997 book *Critical Chain* (Pacheco *et al.*, 2014).

The Theory of Constraints (TOC) is a common sense management thinking, which believes that in order to improve the performance of any system, one must first find the constraint of the system and then concentrate efforts on elevating the capacity of the constraint (Cook, 1998).

Goldratt (cited in Cook, 1998) claims that every duration estimate has a safety time built into it. This is mainly due to existing incentive systems and the common management practice of cutting all estimates across the board to squeeze a schedule into a given amount of time. The problem with leaving small amounts of buffer time in each task estimate instead of aggregating it is that safety is often wasted at the beginning of the task period, not at the end where it is much needed. Goldratt (cited in: Cook, 1998) identifies three ways in which safety is often wasted:

- Student Syndrome, which refers to the phenomenon that many people will start to fully devote themselves to a task just at the last possible moment before the committed deadline.
- Multiplying effect of multitasking: When a resource is assigned multiple tasks, it is experienced that in order to keep track of each task the resource tends to perform all tasks partially according to their importance and does the remaining part.
- Structures of schedules: When multiple tasks merge at one point, delays occur but gains do not. For example, let us assume a simple network with merging tasks; if any of the tasks are delayed by a few days, the whole project gets delayed. However, if one of the tasks is finished ahead of the planned date, the project will still take the same time. Even if all the tasks are finished earlier than planned, due to the use of scheduled dates, the last task may not be ready to start earlier than planned; this will cause the project to finish as planned and not ahead of the schedule.

According to Sarkar (2012), critical chain scheduling helps to overcome student syndrome and bad multitasking. Moreover, it allows faster completion of projects and the elimination of multitasking, and offers a simple way of tracking and monitoring project progress (Sarkar, 2012). However, there are some limitations to critical chain scheduling as stated by Pinto (2007): (1) due to a lack of milestones, it is problematic to coordinate schedules, especially with external suppliers; and (2) it requires corporate-wide cultural change to successfully implement critical chain scheduling, which is not an easy task.

4. *Critical Path Method (CPM):*

The CPM is a deterministic technique, which, through the use of a network of dependencies between tasks and given deterministic values for task durations, calculates the longest path in the network, called the "critical path." The length of the critical path is the earliest time for project completion (Khodakarami *et al.*, 2007).

The CPM calculates, for each activity, how quickly the task can be completed. Once all these dates have been calculated, the finish date of the project can be determined. With this finish date is known, the CPM then calculates how slowly each task can be completed. The CPM does not take into consideration any resource limitation for this calculation (PMI, 2013).

The CPM provides a graphical view of the project and it predicts the total project duration. Moreover, it identifies which activities are critical in maintaining the schedule (PMI, 2013). The CPM can offer a form of documentation to organizations that can be used for upcoming similar projects. However, it also has some disadvantages. One of the main disadvantages of the CPM is that despite it being easy to understand and use, it does not incorporate time variations, which can have a great impact on the completion time of a project (Stelth *et al.*, 2009).

5. *Cycle Time Analysis (CTA):*

In production, CTA examines all the activities that take place during the production cycle. This includes the white-collar activities that occur when a request order from a customer is taken, product design activities, activities at suppliers of components and raw materials, manufacturing activities and activities associated with shipping products to customers (Miltenburg and Sparling, 1996).

"Cycle Time Analysis is defined as the duration for accomplishing a pre-established set of activities. Therefore cycle time analysis is the formal process of cycle time review to ensure delivery of exactly what is needed, when it is needed, and the amount needed, while eliminating unnecessary activities from all functions of an organization" (CII, 1995, p.18).

Applied to the construction industry, cycle time analysis is the systematic process of examining each step in the process of delivering a project with the objective of eliminating activities and events that add no value to the project with the aim of achieving an overall project schedule reduction (CII, 1996).

6. Fast tracking (FT):

FT "is a technique that sets its basis in concurrency principles to achieve the simultaneous performance of product design and construction. It recurs to the overlapping of project design and construction, thus, early phases of the project are correspondingly under construction while later stages are still under design. This procedure of overlapping the design and construction can substantially reduce the total time required to reach project completion" (Clough *et al.*, 2000, cited in: De la Garza and Hidrobo, 2006, p.71).

Bogus *et al.* (2002) define fast tracking as the compression of the design and construction schedule through overlapping activities or a reduction in activity duration. Fast tracking involves starting construction on a work package before its design is completed.

Eastham (2002) defines fast tracking "as a term, which is generally used to describe something that takes place more quickly than normal, and that is indeed the essence of a fast track project. There are ways in which this reduced project duration can be achieved and it has been normal in the construction/building industry to limit the definition of exceptional ways of executing the activities involved in the creation of a new asset. These exceptional strategies invariably introduce additional risks, which is why they are not more commonly practiced. These risks need to be actively managed to limit their impact on the other aspects of the projects, such as safety, cost or quality."

7. Gantt Chart:

This is one of the popular way of showing activities, tasks and milestones against time. Its name came from an American engineer, Henry L. Gantt. It is one of the oldest methods used in construction planning and was developed by Gantt during World War I in 1910 (Mahdi, 2004). In 1931, Karol Adamiecki created the network-based monogram (Carden and Egan 2008). Gantt charts were primarily used as a production planning tool for planning and managing batch production in manufacturing industries, and they have survived until today despite numerous innovations in the area (Wilson, 2003).

The advantage of a Gantt chart is that it is simple to create, read and understand, and it communicates well even with people not familiar with reading schedules. Yet, it is unable to show precedent relationships between activities; however, this inability is solved by the introduction of the linked Gantt chart, which uses vertical lines to show precedent relationships between activities (Rolstadås, 2008). Another advantage of using a Gantt chart is that it is useful for identifying resource needs and assigning resources to tasks more easily (Pinto, 2007).

8. Graphical Evaluation and Review Techniques (GERTs):

Pritsker was the first to invent this technique in 1966. It was initially developed for managing the Apollo project, which was then widely adopted in project management such as risk management (Ahmed *et al.*, 2007).

A GERT "is a procedure for the study of stochastic networks, with two parts. (1) Analyzing networks that contained activities that had a probability of occurrence associated with them, and (2) treating the plausibility that the time to perform an activity was not a constant, but a random variable … Networks containing these two elements were described by the term stochastic networks" (Pritsker, 1966, p.3). GERTs were developed to handle stochastic network structures with activities that have a probability of occurrence associated with them (Zhou *et al.*, 2016).

9. Graphical Planning Method (GPM):

The GPM is a networking technique that offers the simplest possible scheme of thought to create and optimize a project schedule in the shortest possible time (De Leon, 2009). It is an algorithm used in scheduling and resource control. The GPM represents logical relationships between activities and milestones in a time-scaled network diagram (Mubarak, 2010).

10. Just-in-Time Systems (JITs):

JITs were introduced in order to eliminate inventory-holding costs (Voss *et al.*, 1987; Bulinskaya, 2001). All the processes were supposed to be deterministic and the supply to be organized in such a way that delivery of raw material or spare parts occurred just when it was necessary for the production (or assembly) of a final product (Bulinskaya, 2001). De la Garza and Hidrobo (2006) mentioned that the technique is directly applied in the construction phase of a project. According to the CII (2004, cited in: De la Garza and Hidrobo, 2006), the purpose of this concept is to deliver construction materials and equipment to the workplace just in time when they are needed without having to go to on-site storage before being used or installed. By minimizing storage of the field material and equipment, handling is also minimized, which consumes time and puts the material and equipment at more risk of damage.

11. Last Planner System (LPS):

Ballard (1997) initiated the development of the Last Planner System. According to Ballard (1997, 2000), the Last Planner System is the philosophy, procedures and established tools that facilitate the implementation of shifting the focus of control from the workers to the flow of work that links them together, and consequently proactively managing the production process.

The system has two components: (1) Production unit control makes progressively better assignments to direct workers through continuous learning and corrective action, while (2) workflow control proactively causes work to flow across production units in the best achievable sequence and at the best possible rate (Ballard, 2000). The Last Planner refers to the last individual, typically the supervisor, able to ensure predictable workflow downstream. The LPS is an operating system for project management that is designed to optimize workflow and promote rapid learning (Ballard and Tommelein, 2012). According to Ballard (1997), the idea behind the LPS originated from the need for control, with a strategy of increasing workflow predictability, also known as production system stabilization and increased work plan predictability, through controlling the quality of assignments in weekly work plans.

12. Line of Balance (LOB) Method:

A Line of Balance (LOB) chart provides an overview of the project's overall status by quantitatively representing the cumulative completion of activities at a given point in time (Khisty, 1970). The Goodyear Company initiated the Line of Balance Scheduling Technique in the early forties, and the U.S. Navy established it in the fifties for the programming and control of both repetitive and nonrepetitive projects (Talodhikar and Pataskar, 2015).

It can be used in projects involving activities of a repetitive nature such as high-rise buildings, highway construction, etc., since the construction of projects with repetitive units can be considered the continuous manufacturing of many units requiring a certain period for each unit to be completed (Lumsden, 1968).

The basic concepts of Line of Balance Scheduling were applied in the construction industry as a planning and scheduling method in Finland in the eighties (Harris and McCaffer, 1989; Talodhikar and Pataskar, 2015).

13. Linear Scheduling Method (LSM):

Because of the limitations of the CPM in scheduling linear projects, a new scheduling method, known as the Linear Scheduling Method (LSM), has gradually grasped the attention of academic circles, which maintains the continuity of the resource when applied in linear projects (Hsie *et al.*, 2009; Kannan and Senthil, 2014). In addition, this method is simple and comprehensible (Liu *et al.*, 2016).

The Linear Scheduling Method divides construction project activities into three types: linear, block and bar types, and in turn, the linear-type activity can be further subdivided into continuous linear activity and intermittent linear activity (Harmelink and Rowings, 1998; Tang *et al.*, 2014).

14. Project Management Software:

The adoption and use of Project Management software has grown rapidly along with the rapid development in computer technology. The main incentive behind this is the strong desire for better project planning and control (Ali *et al.*, 2008).

There are significant numbers of Project Management software available with a wide choice of features, functionalities and prices. Most project management software packages deliver project information in the form of a wide variety of graphics and tabular representation, which provides instant access to critical data that can be used (Meredith and Mantel, 2000).

Among the wide range of available Project Management software, three of the popular software packages worth mentioning are Microsoft Project, Primavera and Safran. While all three software packages mentioned above use the critical path analysis approach, there are some software packages, such as ProChain Project Scheduling by ProChain Solutions Inc. and PSNext by the Sciforma Corporation, that use the critical chain approach for scheduling.

15. Program Evaluation and Review Techniques (PERTs):

PERTs were originated by the U.S. Navy in 1958 as a tool for scheduling the development of armament systems. This scheduling technique assumes that the project is an acyclic network of activities (Cottrell, 1999). In the CPM, time estimates are assumed to be deterministic and hence do not incorporate uncertainties, while PERTs incorporate uncertainty in a restricted sense (Khodakarami *et al.*, 2007), by using a probability distribution for each task. Three different estimates (pessimistic, optimistic and most likely) are approximated, instead of having a single deterministic value (PMI, 2013).

16. Repetitive Scheduling Method (RSM):

The RSM was introduced by Harris and Ioannou (1998) as a general unifying repetitive scheduling methodology, like those with discrete repetitive units and those with activities repeating over continuous space (Ioannou and Yang, 2016). The basic key concepts that are formalized in the RSM include: (1) the resource production rate and the unit production rate – two related, but distinct, production measures; (2) the establishment of control points and control links as the fundamental structural elements for scheduling repetitive activities, to eliminate resource idle time; and (3) the establishment of diverging and converging rules for identifying the location of control points (Ioannou and Yang, 2016).

17. Simulation Techniques:

Banks (1998, p.3) defines a simulation as “the imitation of the operation of a real-world process or system over time. Simulation involves the generation of an artificial history of the system and the observation of that artificial history to draw inferences concerning the operating characteristics of the real system that is represented – simulation is an indispensable problem-solving methodology for the solution of many real-world problems. Simulation is used to describe and analyze the behavior of a system, ask what-if questions about the real system, and aid in the design of real systems. Both existing and conceptual systems can be modeled with simulation.” With the rapid development in computer technology, the use of simulation techniques in project management has gained substantial popularity. Van Slyke (1963) introduced simulation as a method for analyzing project networks and introduced the term “Activity criticality indices,” which he defines as “the probability that an activity will lie on a critical path”. According to Hebert (1979), simulation is very useful in estimating the value of certain time-related variables such as activity completion times and project duration, as well as criticality indices.

18. Time-Cost Trade-Offs:

The process of accelerating the duration of a project based on time-cost trade-offs is well-known as “crashing” (De la Garza and Hidrobo, 2006). The idea of project crashing is that expected activity durations are based on using a certain amount of resources to accomplish the task. However, if additional resources are available they can be used in the activity to shorten its duration (Pinto, 2007). Crashing refers to the reduction of activity durations in the execution phase of a project with the objective of reducing the execution schedule duration (Callahan *et al.*, 1992). Additional resources will involve additional cost, so one should consider the associated cost of additional resources for crashing activities (Pinto, 2007). The crashing process uses an assessment of activity variable cost with time, which enables the identification of which activity durations should be reduced to economically minimize the cost of accelerating the construction duration (Callahan *et al.*, 1992). Additional resources may involve overtime, advanced equipment, more personnel or working multiple shifts (Pinto, 2007).

19. Value Engineering (VE):

VE "is a systematic approach to identify a project's V functional objectives with the goal of optimizing design, construction, and future operations. Value engineering studies are conducted by a multidisciplinary team that focuses on a clearly defined scope. While each member of the project team is free to recommend that a value engineering study be undertaken, it is the owner's responsibility to authorize and formally initiate a VE effort" (ASCE, 2012). Another definition of value engineering is "an analysis of the functions of a program, project, system, product, item of equipment, building, facility, service, or supply of an executive agency, performed by qualified agency or contractor personnel, directed at improving performance, reliability, quality, safety, and life cycle costs" (DOD, 2006, cited in: De la Garza and Hidrobo, 2006).

Sum-up: The positions of using each TTMPs within the different project process levels

Most of the TTMPs presented in this section are used at the operational level, in other words, depending on the scale of the project. For example, in a large-scale project, the scheduling engineers will use those tools grouped in the operational level in Figure 4.1-2 and give feedback and input to the project manager and project management team (strategic and tactical levels) with a view to making the right decisions. The TTMPs grouped in the tactical and strategic level are more related to the project manager and project management team. For example, Number 2, which is CE philosophy, cannot be implemented by a team member or even the project manager solely, but it is a philosophy that should be implemented within all the concerned organizations (i.e., clients, contractors, etc.) sharing common projects. The same can be said for Number 6, which is FT, in cases where it is used as an implemented method and not as an ad hoc solution. Some of these TTMPs are described in more detail in some of the upcoming chapters.

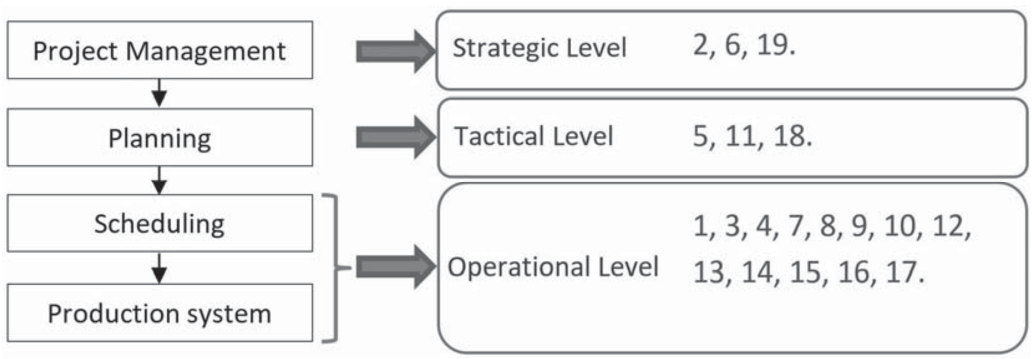

Figure 4.1-2: The use of the 19 TTMPs within project time frames.

4.2 Some Management Techniques to Reduce Project Duration

This section of this chapter summarizes a few reports and guides for achieving reduced delivery times (e.g., Eastham, 2002; De la Garza and Hidrobo, 2006; CII, 2015).

De la Garza and Hidrobo (2006), in their report *Schedule Acceleration Techniques Using a CM* of more than a hundred pages, summarize 15 techniques, which are briefly listed in Table 4.2-1. De la Garza and Hidrobo (2006) explain in their report that each of these techniques fits a certain project delivery method, and they listed four of them: (1) Traditional approach, design-bid-build; (2) Multiple-prime contracting; (3) Design-build; and (4) At-risk construction management – e.g., Time-cost trade-offs technique can be used only for an at-risk construction management. For the first technique, which is a set of 32 practices, each practice can be used in a certain multiple project phase (e.g., pre-planning, design, materials management, construction or start-up). I mentioned in the table under each technique in which level it should be used – i.e., strategic, tactical or operational level, similar to the classification done in Figure 4.1-2.

Table 4.2-1: Schedule acceleration techniques
(Adopted from: De la Garza and Hidrobo, 2006)

Technique	Description
Essential good management practices (32 practices) – All levels	Start-up driven scheduling; Participative management; Resources; Pre-project planning; Alignment; Well-defined organizational structure; Pareto's law management; Employee involvement; Realistic scheduling; Construction-driven scheduling; Concurrent evaluation of alternatives; Avoidance of scope definition shortcuts; Use of electronic media; Constructability; Freezing of project scope; Reusable engineering; Nontraditional drawing release; Supplier/engineer early interaction; Material management; Material coordination; Prioritization of procurement of material; Efficient packaging for transportation; Material I.D. on purchase documentation; Testing/inspection; Multiple suppliers; Supplier submittal control; Field management; Safety in workspace; Aggressive project closeout; Detailed plan; Determination of system testing requirements; Zero-accident techniques.
Freezing of project scope – Tactical Level	Systematic approach to the early identification of major decisions and requirements that may affect the project delivery time.
Constructability review – Tactical level	The optimum use of construction knowledge and experience in planning, design, procurement and field operations to achieve overall project objectives.
Cycle time analysis – Tactical level	The duration for accomplishing a pre-established set of activities; therefore, cycle time analysis (CTA) is the formal process of cycle time review to ensure delivery of exactly what is needed, when it is needed and the amount needed, while eliminating unnecessary activities from all functions of an organization.
Concurrent engineering (CE) – Strategic level	A systematic approach to include all entities affecting or affected by the subject project in the planning, engineering and design of the project.
Overlapping sequential design activities based on CE – Strategic and tactical levels	Overlapping sequential design activities is a strategy developed based on concurrent engineering principles that allows a reduction of the time usually required to complete project design. Reducing design delivery time allows construction to start sooner, thereby leading to a reduction of overall project delivery time. One way to reduce overall project delivery time is by adopting concurrent, overlapped design processes by overlapping dependent activities instead of following traditional sequential processes.

Technique	Description
Lean design – Strategic level	Lean design is the application of lean production principles, to eliminate waste and nonvalue-added activities in the engineering and design process of project development. Lean design considers three perspectives to describe the design process: conversion, flow and value generation.
Value engineering – Strategic level	A formal, logical and analytical process that searches for the best balance between a project's required functions and its life cycle cost, while maintaining or improving the project's value.
Four-dimensional visualization of construction scheduling – Strategic level	Four-dimensional (4D) visualization of construction scheduling. This technology helps optimize construction operations, ultimately aimed at minimizing the time and cost of the overall project.
Overlapping sequential construction activities based on CE – Strategic and tactical levels	Activity overlapping relies on decreasing or even removing the dependencies between activities to allow activities to proceed concurrently or out of sequence to reduce construction time. Construction activity dependencies are determined by different factors including information, resources (equipment, materials and labor), permissions and physical constraints, but typically physical and resource constraints have the most influence in activity dependencies.
Fast track – Strategic level	Technique that has its basis in concurrency principles to achieve the simultaneous performance of product design and construction. It recurs in the overlapping of project design and construction, thus early phases of the project are correspondingly under construction while later stages are still under design. This procedure of overlapping the design and construction can substantially reduce the total time required to reach project completion.
Just-in-time delivery – Operational level	This technique is directly applied in the construction phase of a project. The intention of this concept is to deliver construction materials and equipment to the workplace just in time when they are needed without having to go to on-site storage before being used or installed. By minimizing storage of the field material and equipment, handling is also minimized, which consumes time and puts the material and equipment at more risk of damage.
Lean construction– Strategic level	Lean construction refers to the application of lean production principles to construction. Lean is a production management strategy for achieving significant, continuous improvements in the performance of the total business process of a contractor through the elimination of all wastes of time and other resources that do not add value to the product or service delivered to the customer.
Optimization of construction operations through simulation and genetic algorithms – Tactical level	The process of maximizing information retrieval from simulation analysis without carrying out the analysis for all the combinations of input variables.
Time-cost trade-offs– Tactical level	The process of accelerating the duration of a project based on time-cost trade-offs is usually known as "crashing."

The fast-track technique mostly has the reputation of being a technique that is applied as an ad hoc solution for those projects and programs characterized by urgency. However, this is not always the case. Eastham (2002) developed a guide titled *The Fast Track Manual: A Guide to Schedule Reduction for Clients and Contractors on Engineering and Construction Projects*, which was published by the European Construction Institute. In this guide, he suggests a principle for how to overlap project stages (see Figure 4.2-1). As represented in Figure 4.2-1, nonoverlapped project stages are separated by decision gates (1st sequence). In a fast-tracked project, the stages are overlapped, leading to a shorter project duration (2nd sequence).

According to Eastham (2002), in the concept stage there is high ability to influence the decisions; however, it is vital that those who are responsible for the project at that stage should be aware that: (1) time used to establish the concept will not be recoverable during the later stages; and (2) the opportunity to influence the outcome of the project falls away rapidly over the project phases. This is what some scholars call "project flexibility" (e.g., Olsson, 2006; Cui and Olsson, 2009).

The guide of Eastham (2002) proposes for each of the eight project delivery stages (Concept; Development; Definition; Design; Procurement; Construction; Commissioning; Operation) a proposition for how to deal with some parameters to achieve a better fast-tracked project delivery system. These parameters are people (e.g., stakeholders, teams, motivation, experienced personnel, etc.), scope, strategy (e.g., client business strategy, objectives, etc.), project system and procedures, project risk management and logistics.

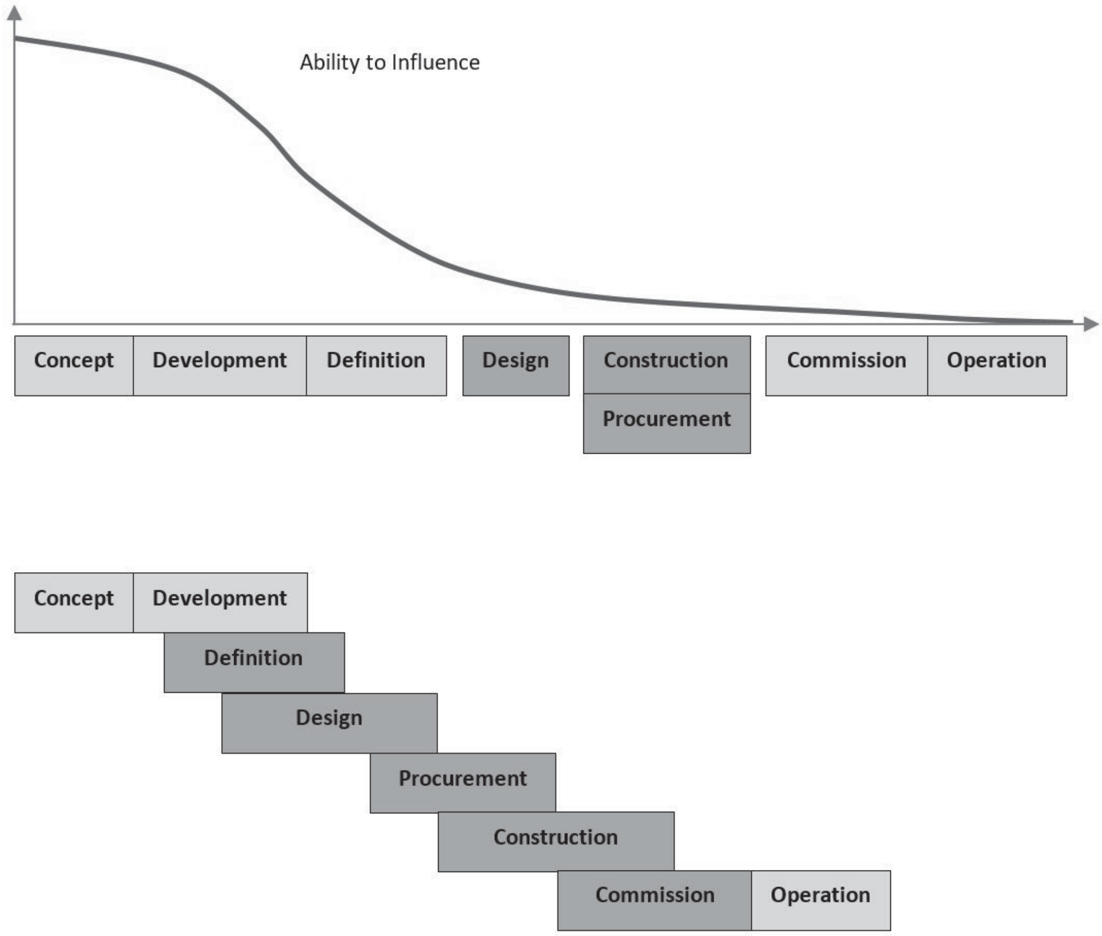

Figure 4.2-1: Ability to influence each project stage.
(Adopted from: Eastham 2002)

Reading through the guide of Eastham (2002), someone can understand that the fast-track technique proposed in the guide is more than a technique, but a philosophy that needs to be implemented and improved while delivering similar projects. This means that there should be a stability at the level of the client/customer to achieve complete success in applying it.

The Construction Industry Institute (1986, 1993a, 1993b, 1995, 1996, 2004) suggested many techniques and propositions in guides and reports on schedule reduction. However, the one selected to discuss here is the report from the Construction Industry Institute (2015) titled "Successful Delivery of Flash Track Projects."

The CII (2015) makes a difference between a fast-track project and a flash-track project. "While fast-track projects are characterized by interphase integration – achieved through overlaps across different phases of engineering, procurement, and construction, flash-track projects demand interphase and intraphase overlaps. This overlapping is enabled by parallel work packaging within each phase. For example, engineering work can be broken down into several work packages that can be performed simultaneously. Such a potentially chaotic approach requires highly coupled coordination and interface management processes."

The flash-track practice from the CII (2015) is a two-tiered structure of 47 essential flash-track practices, which mainly emphasizes planning, execution and organizational considerations, and considers cultural issues, delivery methods and contractual considerations. In addition, they developed an Excel-based flash-track tool, which includes a metric for assessing a project's readiness for flash tracking. Lastly, they implementation innovative strategies for each of the 47 practices; these strategies include barriers to implementation, identification of heightened risks and risk-mitigating strategies.

The practices developed by the CII (2015) include an approach that calls for the earlier engagement, commitment and collaboration of specialty subcontractors at the outset of a project. According to the CII (2015), this earlier involvement of construction personnel will ensure their crucial input into scope definition, conceptual design development and constructability considerations, among other critical project elements. The CII (2015) identified a number of flash-track approaches for business improvement in the construction industry, as well as practices from other industries applicable to construction. The CII (2015) made two general observations on the successful delivery of a flash-track project: 1) project teams need to embrace a different and more innovative approach to project delivery; and 2) project teams should understand the need for exceptional execution of normal project activities (see Figure 4.2-2).

Figure 4.2-2: Keys to successful flash tracking.
(Adopted from: CII, 2015, p.2)

The CII (2015) developed the flash-track project delivery based on these objectives: (1) to develop useful, user-friendly tools for successful execution of flash-track projects; and (2) to re-engineer the project delivery process specifically for flash-track projects. The focus then shifted to building on past studies on fast-track practices and principles, assessing their applicability and adaptability to flash tracking. The Flash Track tool developed by the Construction Industry Institute, with its flash-track readiness metric and implementation guidelines, enables project teams first to determine which projects to flash-track, then how to incorporate the model into project practices and procedures (CII, 2015). Figure 4.2-3 defines and contrasts fast track and flash track.

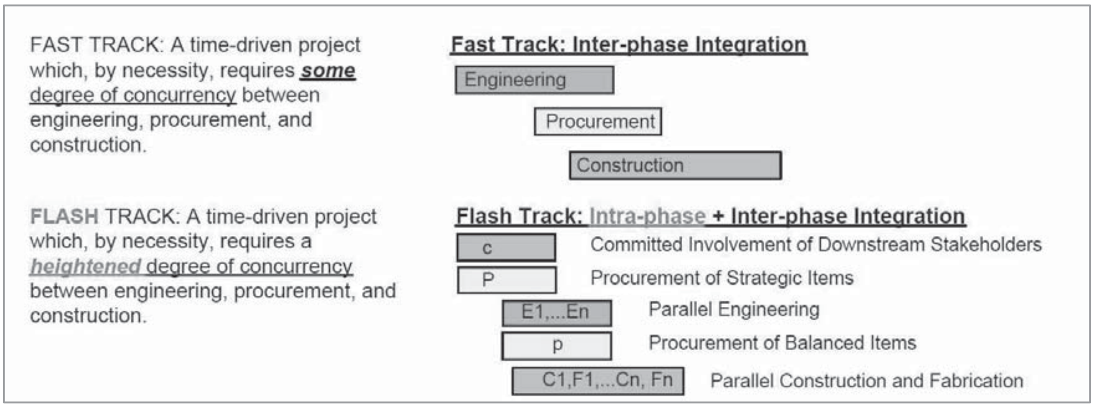

Figure 4.2-3: Fast track vis-à-vis flash track.
(Adopted from: CII, 2015, p.4)

The different tools, techniques, methods and philosophies discussed in this chapter were selected based on two criteria: (1) they are considered the most cited and interesting area of research for most scholars, based on the conducted literature review; and (2) they provide the elements that support the research work conducted to achieve the research objectives mentioned in the first two chapters of this dissertation.

From the range of tools, techniques, methods and philosophies, someone can conduct a deep research on a small part of just one of them. If they are mentioned very briefly in this dissertation it is because some of them are met during the research and they are mentioned in the related chapters (e.g., CE and FT in Chapter 9). During the literature search and review, a significant amount of literature was found regarding a very specific topic within a specific TTMP, such as for concurrent engineering, where there are many researches focusing on just a very limited scope of this philosophy.

The reason for mentioning these TTMPs in general and not diving deeply into one of them is that this research is aimed at seeing the whole picture of managing a large-scale project. This strategic standpoint as a researcher will not allow us to focus on just one of the TTMPs; instead, they should be seen as tools from a single toolbox, and, based on the strategic approach to the problem, recommendations will be given regarding the relevant TTMP for a specific organization and project type.

CHAPTER 5

LSEPs! The Current State of Affairs Vis-à-vis TTD

"…We do what we do best. We improvise…"
— *Brian O'Conner*

The author start to answer the research questions from this chapter. Research question *RQ1* as formulated previously is: What is the current state of affairs and performance vis-à-vis the elapsed time, the time to delivery and other project aspects in samples of large-scale engineering projects? The samples used here to answer *RQ1* are sets of medium- to large-scale projects from the construction industry in Norway. This chapter starts by explaining the context of the sample – i.e., presenting the whole project life cycle, the different stakeholders and their different project life cycles; this will allow a better understanding and the whole elapsed time to be seen within the project instead of just considering one position or a mixture of different standpoints (e.g., client, contractor, etc.). From the point of view of measuring efficiency (time, cost and scope), a comparison of different projects based on their cost at completion, time elapsed at the delivery of these projects, followed by comparing the different sizes of the projects versus the time needed to complete them. The aim of the comparison is to see whether there is a strong direct relationship between time vs cost and time vs scope. The conclusions drawn by the researcher in this chapter are based on observations, which come from the graphs and diagrams from the sample projects.

5.1 PLC – Client Standpoint

The sample presented in this chapter is a set of 70 medium- to large-size construction projects. To enable a better understanding of the analysis proposed in this chapter, the context of the sample is introduced briefly and in general.

Figure 5.1-1 represents the project life cycle at the client level and the different included phases. This is followed by the individual involvement of the consultants, then the contractor, who is involved more in the construction and testing stages, and finally the subcontractors, who are generally involved in the construction stage. This has been discussed in general in Chapter 3 Section 3.2 (see also Figure 3.2-1).

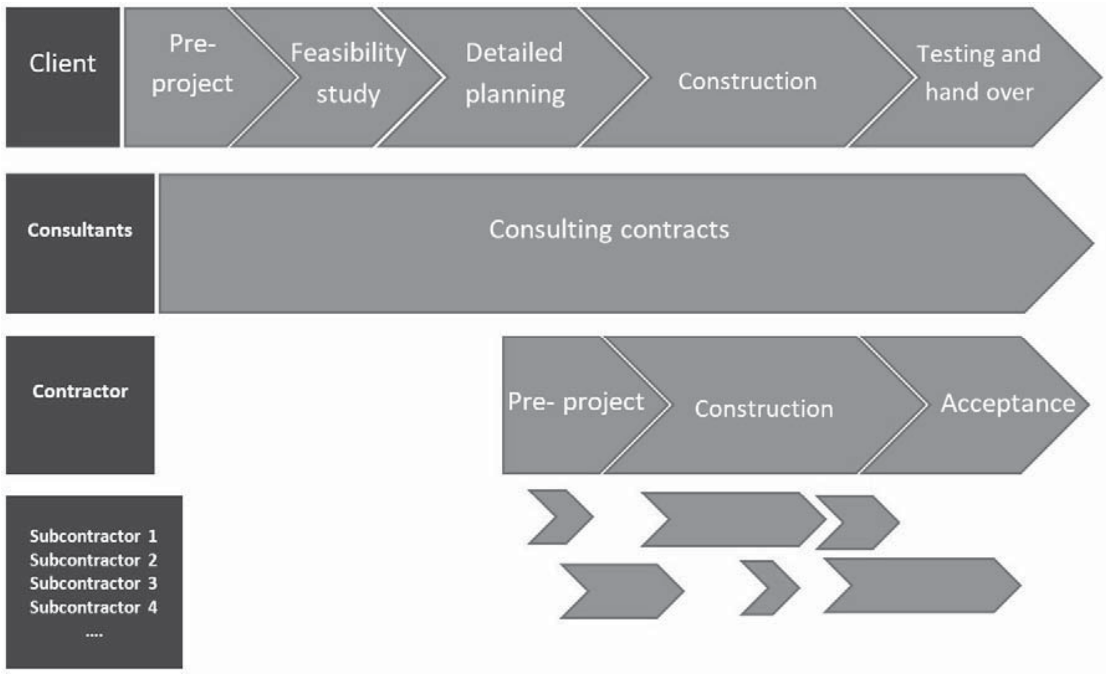

Figure 5.1-1: Most of the parties involved in our project sample.

This depicts the whole project life cycle as it is seen from the client standpoint; and it would be better if the stakeholder (client) initiated the project. Contractors are more involved intensively in the project duration – i.e., the detailed planning stage but mostly the construction stage. To describe the context briefly, the client is a state-owned company that is in charge of delivering medium- to large-scale projects from the feasibility study to the operation stage (handover of the products so they can be used). The phase before, called the "pre-project," is when the sponsor hands the project to the client. In other words, the sponsor has already identified the need and the conception, and once the objectives are clear and well defined, the project will be handed to the client, who will be in charge for the remaining stages, as shown in Figure 5.1-1. In the next section of this chapter the other stakeholders are not considered, since the approach is to observe the patterns regarding time vs cost and time vs scope from the client's standpoint.

The data collection was part of the described research project in the introductory chapter. The type of data collected are numbers concerning: (1) the total elapsed time for each project; (2) the total project cost at the delivery; and (3) the size of the projects – i.e., the scale is interpreted relatively comparing one project to another.

The data were not presented in Chapter 2, since they are very general, as mentioned above: the data are cost data and time-related data of 70 construction projects that were completed in the period 2008–2013 in Norway. The data set came from a large public organization that builds schools and other government facilities on behalf of the government.

Figure 5.1-2 shows the 70 projects' PLCs, which are normalized on a scale of 0% to 100%. Each line represents a project, with the green color representing the feasibility study, planning and detailed planning, while the red color is the construction and handover stages. No color means nothing is happening within that period.

The first observation from Figure 5.1-2 is that there are more blanks than green or red colors. However, some projects were deleted from the figure and replaced by blanks, because they were not completed. More precise figures will be shown in the next section.

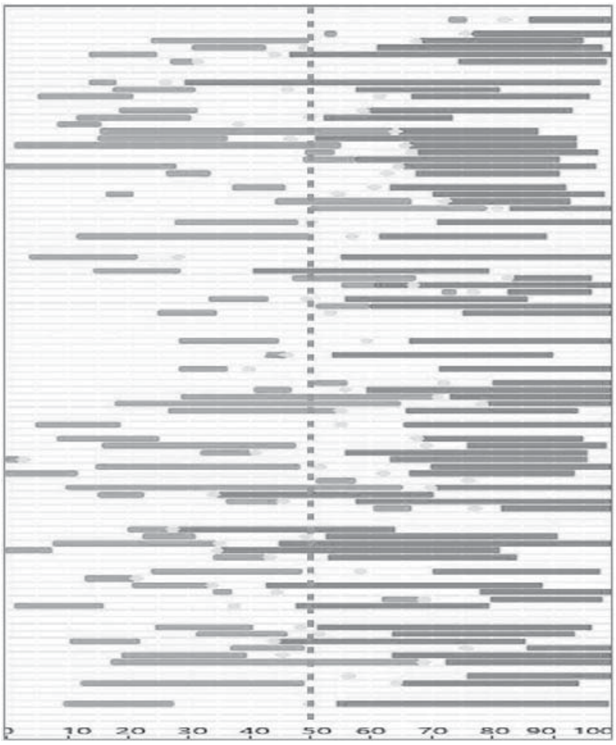

Figure 5.1-2: Normalized project life cycles of the 70 medium to large-scale projects.

One important point is that the efficiency of these projects cannot be measured since there are no data regarding the inputs (i.e., estimated budget, planned time and defined scope) of each project within the data. The only data available are the outputs of each project; thus, the judgement regarding performance vis-à-vis time use will be based on a comparison between the different projects in terms of size, cost and duration.

5.2 Post-Project Perception on Time

The aim in this section is to try to understand the relationships between time and scope, and time and cost, for the selected construction project sample. In other words, the efficiency is measured with the triple-constraint triangle – i.e., time, cost and scope. If you are standing on the “Time” cell (Figure 5.2-1) and work more on the relationship between time and scope, which is the speed of the project. In addition, the relationship between time and cost, is the intensity of the project, and both are discussed further in Chapter 7. Thus, the new measures are speed and intensity from the “time” constraint perspective in relation to the cost and scope.

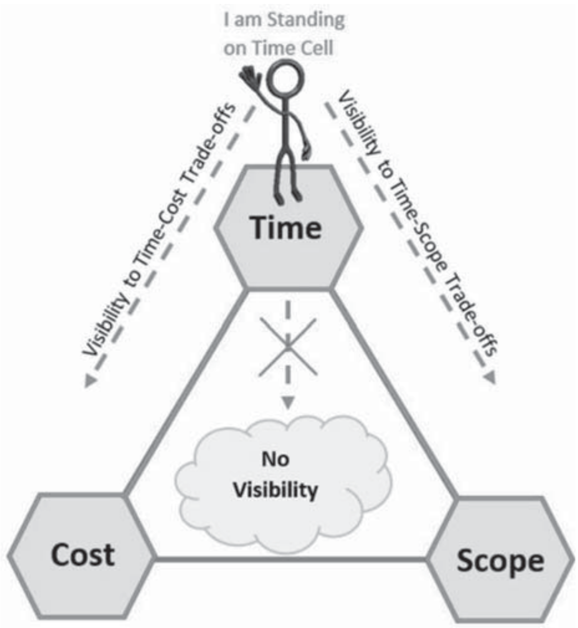

Figure 5.2-1: Iron triangle – time vs others trade-offs.

However, the data available are not from the “monitoring” stage of the projects, which means that talking about the speed and intensity of the project is more related to data coming from monitoring and the daily/weekly/monthly accumulated data about the project. The cases presented here are completed projects, and the only data available are data from the post-project stage (i.e., project outputs).

The post-project standpoint on time versus cost and scope will reflect the real picture of how these constraints had been coexisting in these projects. Since the primary aim and objective of this chapter is to see the time-to-delivery status within large-scale engineering projects (construction in the cases studies here), that is possible by observing the TTD of the cases and the time spent without handing them to operations.

Two other useful observations from this study are concerned with: (1) the total cost for the main work packages (i.e., planning and admin, detailed design, construction and handover); and (2) Where the effective time is spent along the project life cycle, and where are the gaps.

5.2.1 Time vs Cost

There is a strong relationship between a project's time to delivery and its total costs. For some types of costs, the relationship is in direct proportion; for other types, there is a direct trade-off. For the sum of these two types of costs, somewhere on the red curve in Figure 5.2-2, there is an optimum project duration for minimum total costs. By understanding the time-cost relationship, one is better able to predict the impact of a schedule change on project cost. The costs associated with the project can be categorized as direct costs or indirect costs (Kerzner, 2009).

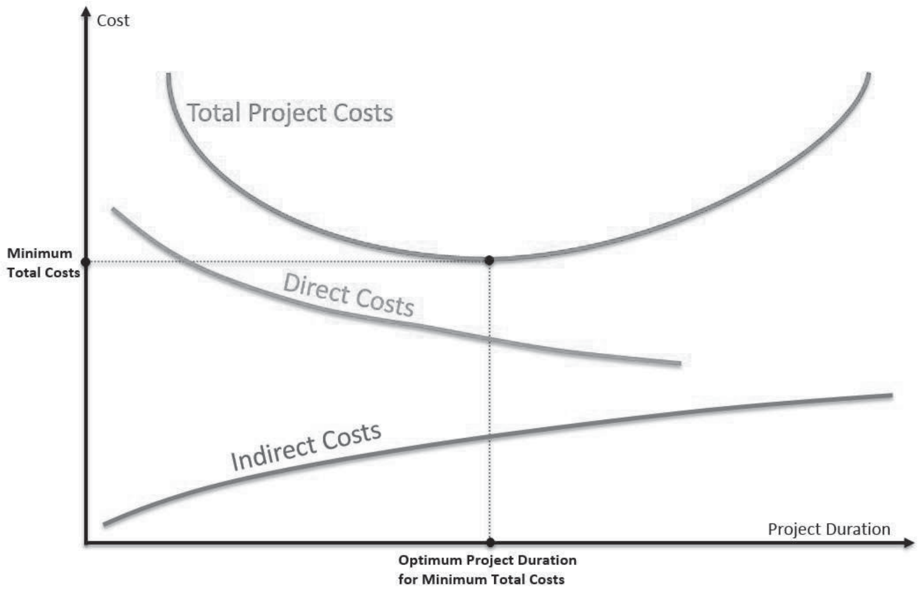

Figure 5.2-2: Time-cost trade-offs.
(Adopted from: Kerzner 2009, p.520)

Direct costs are those directly associated with project activities, for instance salaries, travel expenses, subcontracting and project materials and equipment that has been purchased directly. If the speed of the project is increased in order to decrease project duration, which is called "crashing" the project's activities, the direct cost increases; consequently more resources must be allocated to speed up the project delivery (Kerzner, 2009; PMI, 2013).

Indirect costs are those not directly associated with explicit project activities, for example taxes, costs related to administration and its staff, and office renting. Such costs tend to some extent to be relatively steady per unit of time over the project life cycle. This is not always the case, including for large-scale projects, where their cycles end after several years; here, the net present value should be taken into consideration. In summary, the total indirect costs decrease as project duration decreases.

One basic question that needs to be answered when estimating project costs is whether the estimates will be limited to direct project costs only or whether the estimates will also include indirect costs. Indirect costs are those costs that cannot be directly traced to a specific project and that therefore will be accumulated and allocated equitably over multiple projects by some approved and documented accounting procedure (PMI, 2013). Furthermore, the project cost is the total sum of direct and indirect costs.

Figure 5.2-3 represents the time on the x-axis (the unit is month) and the cost on the y-axis (the unit is million USD). Each dot represents a project. The graph does not indicate that the costs are similar for a similar project duration – e.g., for the project represented by dot 1 and the project represented by dot 2, both of the projects' total project duration is 23 months, however the total project costs are around USD 10 million and USD 37 million, respectively. By checking the scope of the two projects, it seems that the project represented by dot 2 is approximately two and a half times the size of the project represented by dot 1 in the figure.

Again, looking at the projects represented by dot 3 and dot 4, both projects have a total project cost of around USD 18 million. However, the project represented by dot 3 had a project duration of almost 8 months, and the project represented by dot 4 had a project duration of almost 28 months. By comparing the scope, the two project sizes may be considered equivalent, however the first case is a more prefabricated construction (using modularity in construction).

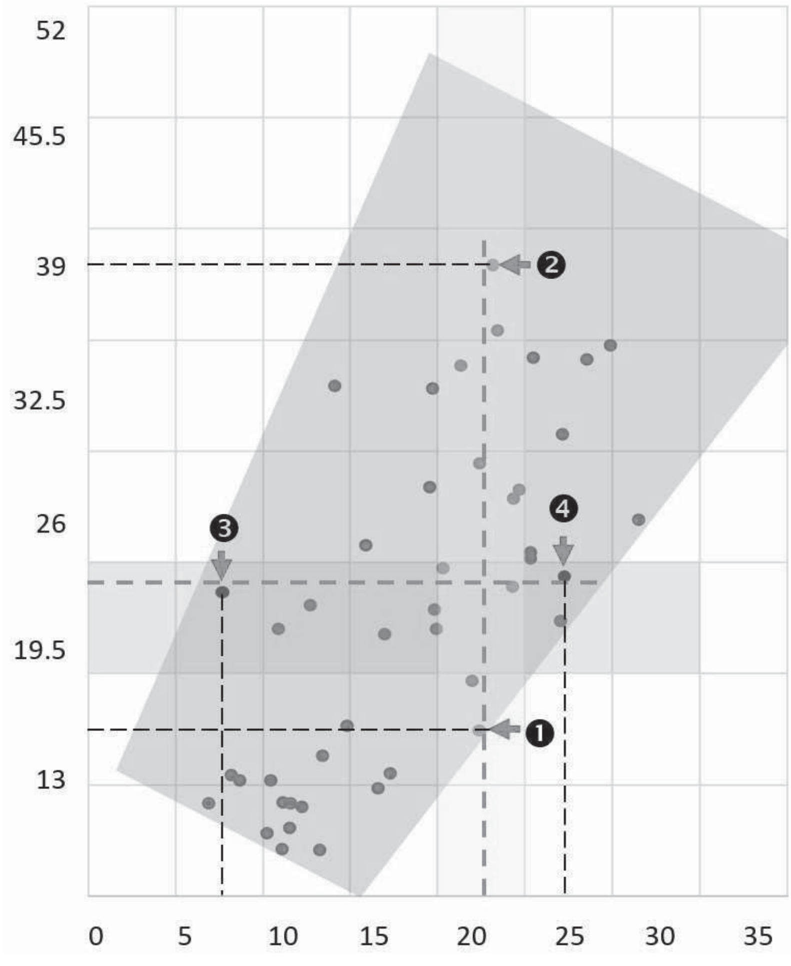

Figure 5.2-3: Time vs cost based on the sample projects

Figure 5.2-3 shows that there is a very weak direct proportionality between time and cost. There are many cases in the diagram where for the same duration there are differences in total project cost and vice versa. However, there is a story behind each project, and it would not be wise to make any judgement based only on the total cost and the project duration.

As this dissertation progresses, it can be seen that there are many factors that contribute to these scenarios, where a small project and very large project can be completed within the time window. So the first statement to make is:

Statement 5.2.1.a*: The total project cost at the end of the project does not automatically reflect the time window needed to complete it, and vice versa.*

Figure 5.2-4 represents as percentages the total costs used before starting the execution of the project in blue (i.e., pre-study, feasibility and front-end stages), and the total costs of the detailed design, engineering, procurement and construction to handover in orange. The sample used here is also from construction projects, but is not the same one described previously; however, the set is from the client, which means it represents the total project and not just the contractor's standpoint.

The findings from these data show that and on average around 90% of the total project cost is spent on the construction and the remaining on average less than 10% is spent on the detailed planning, feasibility study and front-end stages. However, it can be seen that some projects spend more than 15% on the pre-project and less than 85% on the construction; and others spend less than 10% on the pre-project and the rest on construction. The question to ask about the total cost spent on the pre-project is: Will an increase of the total cost in the pre-project stages improve the delivery of the project (i.e., engineering, construction, commissioning and handover)? Unfortunately, this question is not among this study's objectives. It is worth noting that the set is uniform to some extent, because the selected projects were completed, unlike those projects pending or facing obstacles.

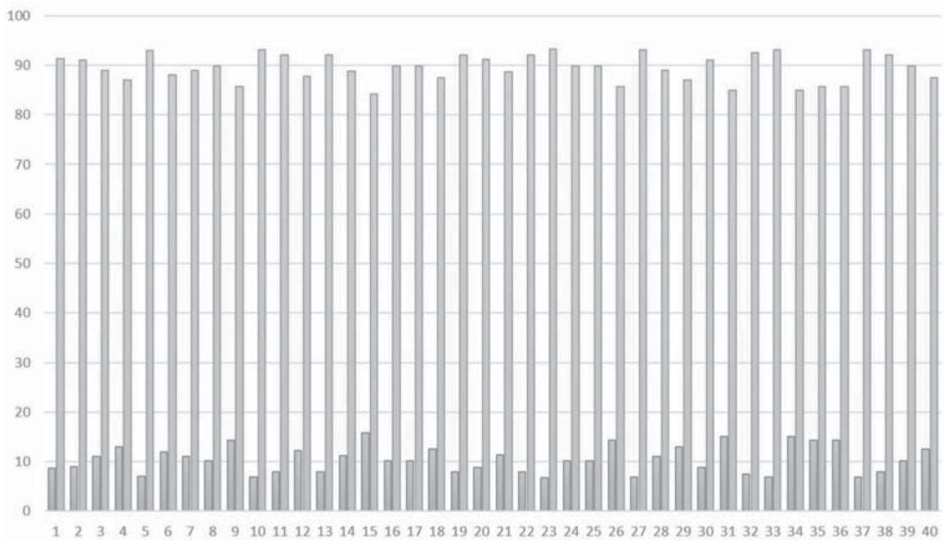

Figure 5.2-4: Cost of planning vs construction.

Statement 5.2.1.b: *Around 90% of the total project cost is spent on the project implementation (i.e., detailed design, engineering, procurement and construction).*

5.2.2 Time vs Scope

The scope of a project is “the work that must be performed to deliver a product, service, or result with the specified features and functions” (PMI, 2013, p.444). In the samples used the scope is more related to the work performed to deliver buildings (schools, hospitals, etc.), roads and railways. The measure used to rank our sample from the smallest to the largest project (i.e., based on project scope) is the cubic meter.

Figure 5.2-5 is similar to Figure 5.1-2 but with all the projects adjusted to the same starting point. Here the horizontal axis is time (in years). The projects are sorted by size. Projects that stand next to each other in the figure are therefore the closest in size. Figure 5.2-5 represents a sample of the projects’ life cycle (client standpoint), with the smallest-scale project at the bottom (line 7) and the largest-scale project at the top (line 1). To minimize judgement mistakes, modular construction is not considered. The modular construction is used partially in Norway. However, I should distinguish between (1) modular construction (i.e., the product) and (2) a modular construction method (i.e., the method of construction – the modularity).

The first is defined by Carswell (2012, p.462) as follows: “[M]odular construction is an industrialized approach to building. Unlike conventional site-built construction, where thousands of elemental parts (e.g., lumber, nails, plywood, plumbing components, electrical components, windows, doors, shingle, siding, insulation, drywall, flooring) are delivered to each construction site, modular construction utilizes large, three-dimensional, factory-built modules for building. Each prefabricated module contains a floor, walls, and a ceiling and roof with plumbing and electrical systems installed and interior and exterior finishes applied. Modular construction is relevant to the discussion of housing because it promises the benefits of industrialization, such as higher quality, faster construction, and lower cost.”

The second modular construction method has another term: “modularity.” “Modularity means that projects are divided into independent subunits. Decision-makers can then make incremental commitments to each subunit at a time. On a micro level, modularization means a decomposition of a product into modules with specified interfaces. Such modularization can reduce the ‘knock-on’ effects of design changes” (Olsson 2006). This second method is more frequently used in road and railway construction. Relatively speaking, the two concepts overlap to a great extent.

So, while considering the scope to be uniform based on what is said above, it is noticeable from Figure 5.2-5 that the project size does not reflect systematically in all the cases the time needed to complete the project. For example, comparing the project life cycle on line 7 with the one on line 5 in Figure 5.2-5, it is very clear that the project on line 5 has a shorter time window. For the project on line 1, its life cycle is 18 months, while the project life cycle on line 7 is around a year. Moreover, the project on line 7 is the shortest when compared to all other projects with less scope. Taking another example, the project on line 6, which has a timeline of almost six years, has a longer life cycle than other projects of a larger size (large-scale projects in the green zone). It is remarkable that the project on line 2, which is large in size, started three years later than the date it was supposed to start, and ended even before the smaller projects.

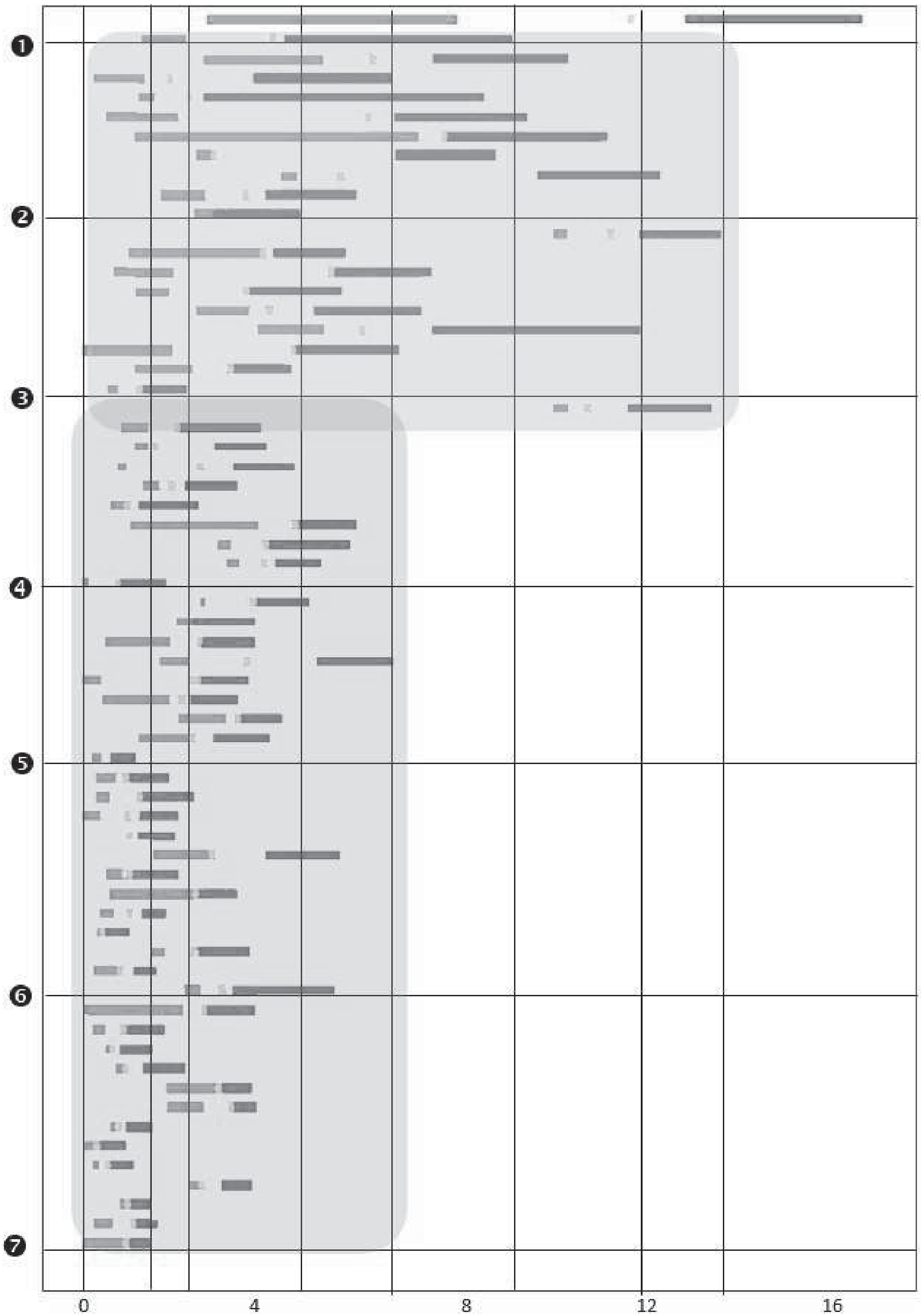

Figure 5.2-5: Project duration vs project scope.

Figure 5.2-5 shows that there is a very weak direct proportionality between time and scope (an increase in one will cause an increase in the other and vice versa). There are many cases from the figure where for the same duration there are differences in the end project scope and vice versa. However, there is a story behind each project as has already been said regarding the relationship between time to cost, and it would not be wise to make any judgement based only on the project scope and the project duration. The story behind each project should be considered, so the next statement to make here is:

Statement 5.2.2.a: *The end project scope at the delivery does not automatically reflect the time window needed to complete it, and vice versa.*

Most scholars argue that the longer the time spent on planning the project, the shorter its execution time (Easa, 1989; Chan *et al.*, 1996; Hegazy, 1999; Gomar *et al.*, 2002; Kandil and El-Rayes, 2006; Pinto, 2007; Hegazy and Menesi, 2008; PMI, 2013); in the present case there is a shorter time window for detailed design and construction. However, it can be seen in the sample that the time ratio of the time used before execution to the time used in construction does not reflect the theory of longer planning = shorter execution. Figure 5.2-6 shows all the projects (the sample used previously). The project life cycle is again normalized from 0% to 100%. The projects are organized from the first construction started to the last construction started. The blue color represents planning, while red is construction and yellow indicates nothing happening.

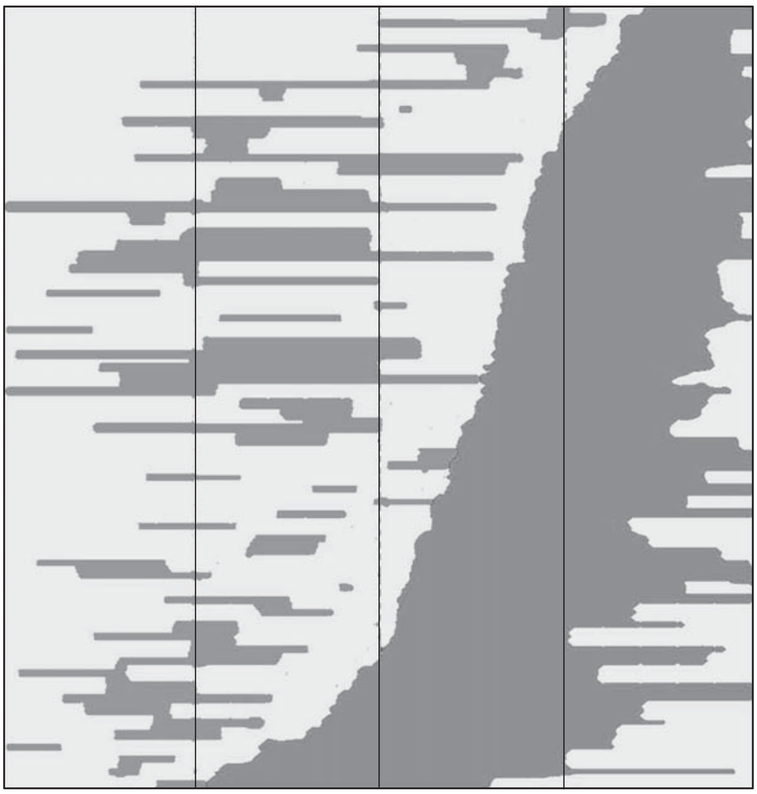

Figure 5.2-6: Where most of the time is spent.

Based on the calculation in the normalized diagram, the time of the project execution represents approximately 3/8 of the total time. The time before the project execution is more than 5/8 of the total time of the sum of all cases. The planning time is in blue and is around 1/8 of the 5/8 of the time before execution; this shows that most of the time is not spent on planning. It is also clear that, for example, as can be seen at the bottom of the figure, where the pre-project stage was short, the project still ended earlier than the projects at the top of the figure.

Statement 5.2.2.b: *The time spent on the pre-project is not inversely proportional to the execution time of the project.*

Another investigation from the SpeedUp research project is described in the introductory chapter. The investigation is about the time used for each project stage from the total project life cycle in a small sample of seven projects from the 70 projects discussed previously. The life cycle cases are represented in Figure 5.2-7, where the first seven rows are the original timeline, and the second seven rows are the timeline after eliminating the gaps between the different project phases. The yellow color represents the feasibility study, green represents the detailed planning, gray is demolition, red is construction and blank means nothing is happening.

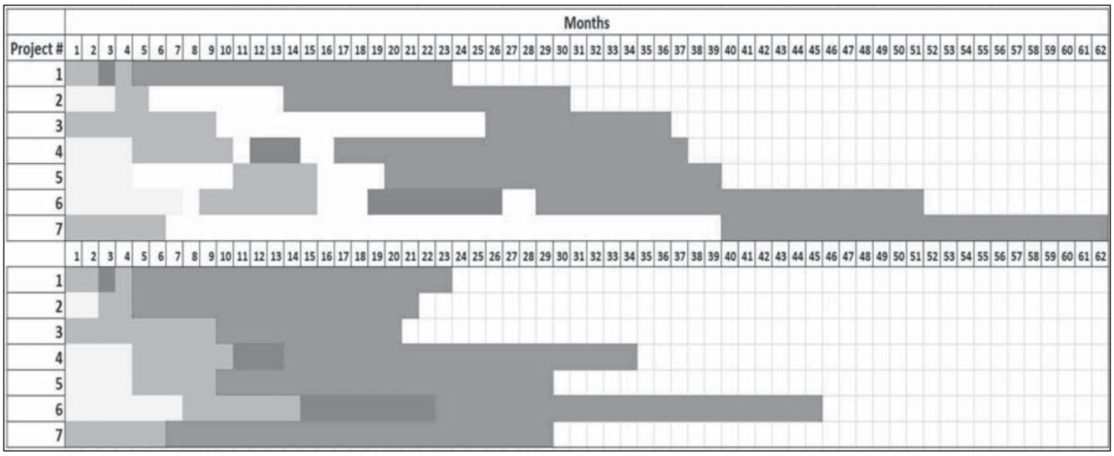

Figure 5.2-7: Seven cases – project life cycle.

The seven cases had approximately equal framework conditions for planning time and project type, but were of varying size – i.e., project costs varied from approx. USD 2.5 million to USD 25.5 million.

For these seven cases, the project documentation was reviewed and interviews were conducted with the project managers to investigate which factors influenced the progress of the seven projects in the case study; the results for these factors are discussed in Chapter 6 and Chapter 8.

Table 5.2-1 summarizes the cases by months and percentage when it comes to the stages before starting construction, construction and the gap between stages. All the cases show that there was less net time in pre-project stages than construction, which can be seen by interpreting the C/P ratio, which is always higher than one.

It is clear from Figure 5.2-8 that most of the time used is on construction, which may again contradict the statement made previously regarding the time spent on the pre-project stages and on construction. However, there is a story behind each project, and there are elements delaying the activities within the project, which are known as factors causing delays.

Table 5.2-1: Seven case details

Project #	Total time months (T)	Feasibility + Planning + Demolition (P)	Construction (C)	Gap (G)	C/P
1	23	4–17 %	19–83 %	0–0 %	4.75
2	30	5–16 %	17–57 %	8–27 %	3.4
3	36	9–36 %	11–31 %	16–33 %	1.23
4	37	13–35 %	21–57 %	3–8 %	1.62
5	39	9–23 %	20–51 %	10–26 %	2.22
6	51	22–43 %	23–45 %	6–12 %	1.1
7	62	6–10 %	23–37 %	33–53 %	3.8

It is important to differentiate between the delays that are represented by the blanks in Figure 5.2-7 and those represented by the gray color in Figure 5.2-8. When it comes to the delays in gray, generally they are caused by a main obstacle (e.g., a decision). The time spent on the construction stage is not a net time for the construction, however, as there are also gaps within the stage. Thus, the last, but not least, statement to make is:

Statement 5.2.2.c: *The time spent within each stage is not the net time, as there are also gaps within the stage itself beside the gaps between stages.*

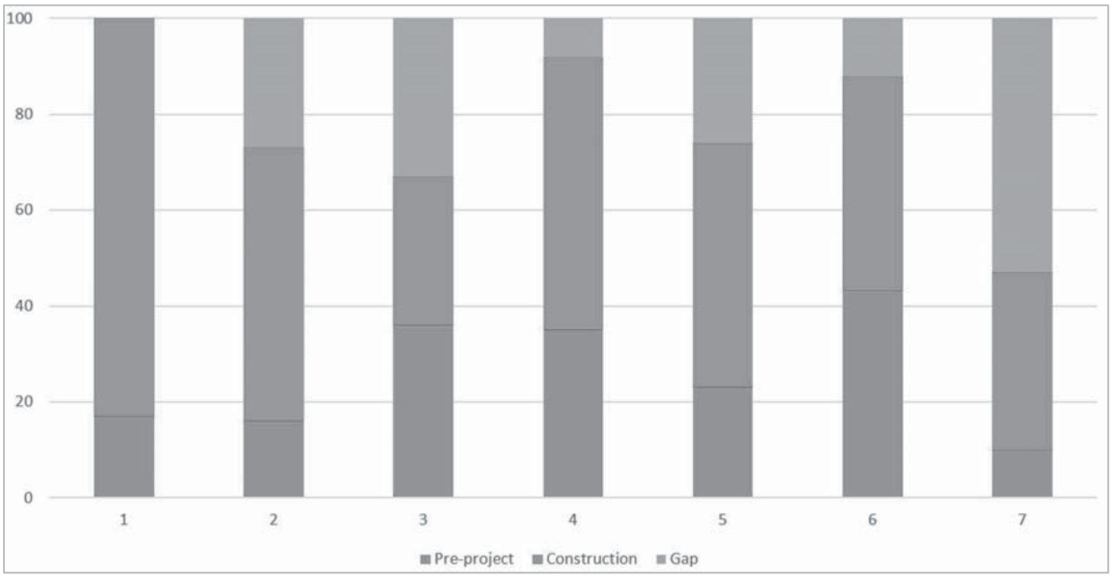

Figure 5.2-8: Time for the seven cases in percentage.

There now follows a brief conclusions on the five formulated statements and their implications for this dissertation and for the coming research questions.

Conclusion—Current State of Affairs and Performance vis-à-vis TTD

The research described in this chapter includes the use of research with of an exploratory nature. The content is based mainly on raw data collected from the sponsor research project. More specific elements of the relationship between time and cost and between time and scope are described in the following chapters. The data presented in this chapter were sources from interviews with the project managers and a review of the archives of each case project. The results of all of the analyses are included in this chapter. The analysis process was performed as follows. First, a general list of the most completed projects was compiled. This formed the basis for formulating and refining the next research questions, as well as which subject would be in focus in the subsequent chapters. This was followed by a period of more comprehensive literature search, which resulted in closer and more detailed knowledge of the issues in focus (mainly time). This approach was repeated to some extent for each of the next chapters. The research question (RQ1) addressed in this chapter answers is:

RQ1: What is the current state of affairs and performance vis-à-vis the elapsed time, the time to delivery, and other project aspects in samples of large-scale engineering projects?

The answer to this question was found by checking the relationship between "time" and both "cost" and "scope" in the management of projects. The answer is provided as a set of statements based on the collected data related to a set of completed projects. Five statements are used to answer the research question, and are presented in the following.

1. *The total project cost at the end of the project does not automatically reflect the time window needed to complete it, and vice versa.*

This statement reflects the relationship between the total project cost and the project duration. From the presented sample, it is apparent that there is a very weak direct proportionality between time and cost. Many cases in the sample with the same duration showed differences in total project cost. However, each project has a story behind it, and it would not be wise to make any judgments based solely on the total cost and the project duration. There are numerous other reasons why the relationship between cost and time was not systematic (see Figure 5.2.2), including the context of the project, which is a source of uncertainties. A good example of a type of uncertainty (risk) is delay, which is discussed in Chapter 6.

2. *Around 90% of the total project cost is spent on the project implementation (i.e., detailed design, engineering, procurement, and construction).*

This statement indicates that the impact of the costs in the ex-ante phase on the total project cost is small. The statement is helpful when investigating what the outputs and the outcomes of a project will be if there is an increase in the ex-ante budget. Furthermore, there is a slight relationship between the statement and Chapter 9, which contains a discussion about the barriers to employing the CE methods, and in which one of the barriers is when more in invested in the early project phases, which will therefore cost more.

3. *The end project scope at the delivery does not automatically reflect the time window needed to complete it, and vice versa.*

The sample showed a very weak direct proportionality between time and scope, and that the statement that "a systematic increase in one will cause an increase in the other and vice versa" is not always true. Additionally, the sample showed that many cases with the same duration differed in their end project scope. However, as mentioned above in connection with the preceding statement (Statement 3) regarding the relationship between time and cost, and it would not be wise to make any judgment based solely on project scope and project duration. Case Study 2 presented in methodology chapter, is a good example of a similar project where it was delivered in a comparatively very short time window. A more detailed discussion about Case 2 can be found in Chapters 8 and 9.

4. *The time spent on the pre-project is not inversely proportional to the execution time of the project.*

This statement relates to the time spent before the decision is made to start implementing the project. Since the sample is from the client's standpoint, where the client is a large public organization that builds on behalf of the government, it means that there is also time spent before this organization takes charge of the project.

A project can be pending for several years before the owner decides to implement it, and for many reasons this will relate to the strategic and tactical reasons for the existence of the project. The portfolio management, the decision process, and particularly the project owner's/sponsor's strategy are some of the key reasons for the duration of the pre-project. Other related points are discussed in Chapters 8 and 9.

5. *The time spent within each stage is not the net time; in addition to the gaps between stages, there are gaps within each stage.*

This statement reflects the gaps and delays during the project implementation. Delays are common within construction projects. Hence, in Chapter 6, I present the results of further investigations into the relationship between time and the gaps between stages, but more importantly between time and the gaps within each stage.

In the next chapter, I draw a more precise picture regarding the delay factors. My investigation is based both on an intensive critical literature, and on multiple empirical sources.

The results of the investigations presented in this chapter are based on the sample projects within the construction industry and to some extent show the relationships between time and cost, and between time and scope. However, since many other factors affect the time required to deliver a project, it would be unwise to draw conclusions regarding the relationships between time and cost, and between time and scope.

This chapter is just an "aperitif" to the topic and an "hors d'oeuvre" to the investigation into the "What" research questions in Chapter 6.

CHAPTER 6

Factors Related to Project Delay

"Lost time is never found again."

— Benjamin Franklin

"You may delay, but time will not."
— Benjamin Franklin

"One day's delay is another day's lack of progress."
— Stuart Bowen

Delays in large-scale engineering projects are not exceptional. There are elements that "steal" time in large-scale projects, and there are factors that cause delays. This chapter consists of three sections. The first section is about the causes of delays in LSEPs and the construction industry in particular from a theoretical perspective. A broad literature review has been conducted that aimed to establish what the most common delay factors mentioned in the literature are; a long list of all possible delay factors is generated from the theory. The second section is about delay factors from empirical studies conducted in Norway based on a survey, and two studies carried out in Algeria, one based on a survey and the other on a case study. The choice of the countries was random (based on opportunities in getting data). The findings from these three studies are about the negative factors. These factors delay project delivery and/or hinder project speed and progress. The last section is a summary of all the delay factors from the literature and the three empirical studies in this chapter. The results provide a list of the most common delay factors, or in other words, the universal delay factors. This chapter unifies all previous studies conducted on delay factors in large-scale projects, mostly construction.

6.1 Delay in Construction Industry – Theoretical Perspective

There are many factors contributing to delays in construction projects. Delays occur in most construction projects and the magnitude of these delays varies considerably from one project to another. It is essential to define the actual causes of delay in order to minimize, mitigate and avoid delay in any construction project. The delay factors are crucial within a construction project and it is vital that all organizations have a certain level of knowledge about this issue in order for the project to be completed effectively and satisfactorily (Wong and Vimonsatit, 2012). So, delays are an inherent risk in most project work and should be addressed in a similar fashion to other risks. Generally, risks can be managed, shared, minimized or accepted, but overall they must not be ignored (Asnaashari *et al.*, 2009). More specifically, the risk of delays can only be minimized when the causes are recognized and actions required to prevent delays are implemented (Naoum, 1994; Pourrostam and Ismail, 2011; Yang *et al.*, 2013).

Delay in the construction industry is a "universal" phenomenon and has become a typical part of a project's construction lifetime (Bubshait and Almohawis, 1994; Sambasivan and Soon, 2007; Sweis *et al.*, 2008). Assaf and Al-Hejji (2006) defined it as "the time overrun either beyond the completion date specified in a contract, or beyond the date that the parties agreed upon for delivery of a project." Trauner *et al.* (2009) define delay in construction projects as: "to make something happen later than expected; to cause something to be performed later than planned; or to not act timely. It is what is being delayed that determines if a project or some other deadline, such as a milestone, will be completed late."

Most construction projects are frequently behind schedule for various reasons. Unfortunately, nowadays, all the advanced technologies, and the good understanding of project management and engineering techniques, have not solved the problem of delays (Sweis *et al.*, 2008; Yang *et al.*, 2013). A study performed by Sweis (2013) shows that 81.5% of construction projects experienced delay in Jordan during the period 1990–1997. According to Assaf and Al-Hejji (2006), 76% of contractors indicated that the average time overrun is between 10% and 30% of the original duration, while about 56% of consultants specified the same percentage. In addition, a study by Faridi and El-Sayegh (2006) revealed that 50% of the construction projects in UAE encountered delays and were not completed on time. Similar researches in the literature investigated delay factors and their effects from 45 countries worldwide (Figure 6.1-1).

Over the last 40 years, significant attention has been given to identifying possible causes of delays (Yang *et al.*, 2013). To identify such causes, some authors (e.g., Chan and Kumaraswamy, 1995, 1997; Assaf and Al-Hejji, 2006; Faridi and El-Sayegh, 2006; Sambasivan and Soon, 2007; Doloi *et al.*, 2012a; Kazaz *et al.*, 2012) have used semi-quantitative methods like surveys and questionnaires, whilst others, such as Asnaashari *et al.* (2009), have employed purely qualitative methods like interviews to identify causes.

A review of project literature shows that causes of delays differ among countries, and the causes are generated from different situations such as the environment, working cultures, management style, methods of construction, geographical condition, stakeholders, government policy, economic situation, availability of resources, political situation and different perspectives of researchers (Asnaashari *et al.*, 2009; Khoshgoftar *et al.*, 2010; Yang *et al.*, 2013). Differences between countries may also cause different frequencies and significances of causes (Asnaashari *et al.*, 2009; Abbasnejad and Izadi Moud, 2013).

Sambasivan and Soon (2007) identified the ten most important causes of delay in Malaysia through a questionnaire survey. Based on their survey results, the most important delay factors are: contractor's improper planning; contractor's poor site management; inadequate contractor experience; inadequate finance of client and payments for completed work; problems with subcontractors; material shortage; labor supply; equipment availability and failure; lack of communication between parties; and mistakes during the construction stage.

Alaghbari *et al.* (2007) carried out a similar study in Malaysia with a list of 31 delay factors. The major delay factors from their survey results are: financial difficulties and economic problems; contractor financial problems; late supervision and slowness in making decisions; material shortages; poor site management; construction mistakes and defective work; delay in delivery of materials to site; and consultant lacking experience. However, Al-Momani (2000), in a research on construction delays, and based on 130 public projects in Jordan, found that weather, site conditions, late deliveries, economic conditions and an increase in quantity are the critical factors that cause construction delays in Jordan's construction industry.

Chan and Kumaraswamy (2002) conducted a survey in Hong Kong to determine and evaluate the relative importance of the significant factors affecting construction delays. They ranked the main factors affecting the construction time, and classified them into two groups: the role of the parties in the local construction industry and the types of projects. Based on their survey results, they indicated that there were five major causes of delays.

Almost all the delay factors/causes from the literature are summarized in Table 6.1-1, and most studies about construction delays are listed in Table 6.3-1 and shown in Figure 6.1-1.

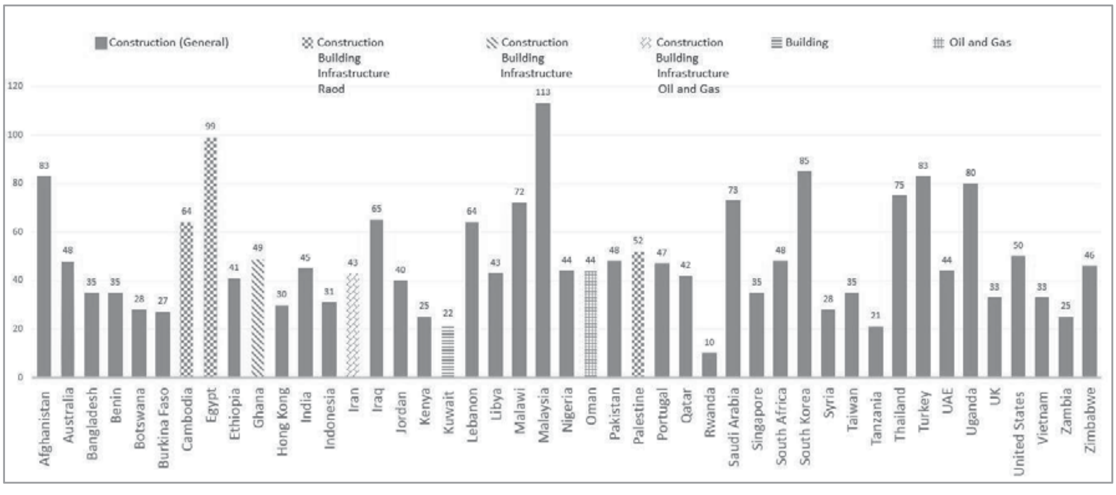

Figure 6.1-1: Classification of delay factors/causes by countries and numbers.

6.1.1 The Types of Project Delay

There are four general basic ways to categorize delays (Ahmed *et al.*, 2003a, 2003b; Trauner *et al.*, 2009):

- Critical or noncritical
- Excusable or nonexcusable
- Compensable or noncompensable
- Concurrent or nonconcurrent

Figure 6.1-2 is a presentation of project delay and most of its factors (origins, categories and timing).

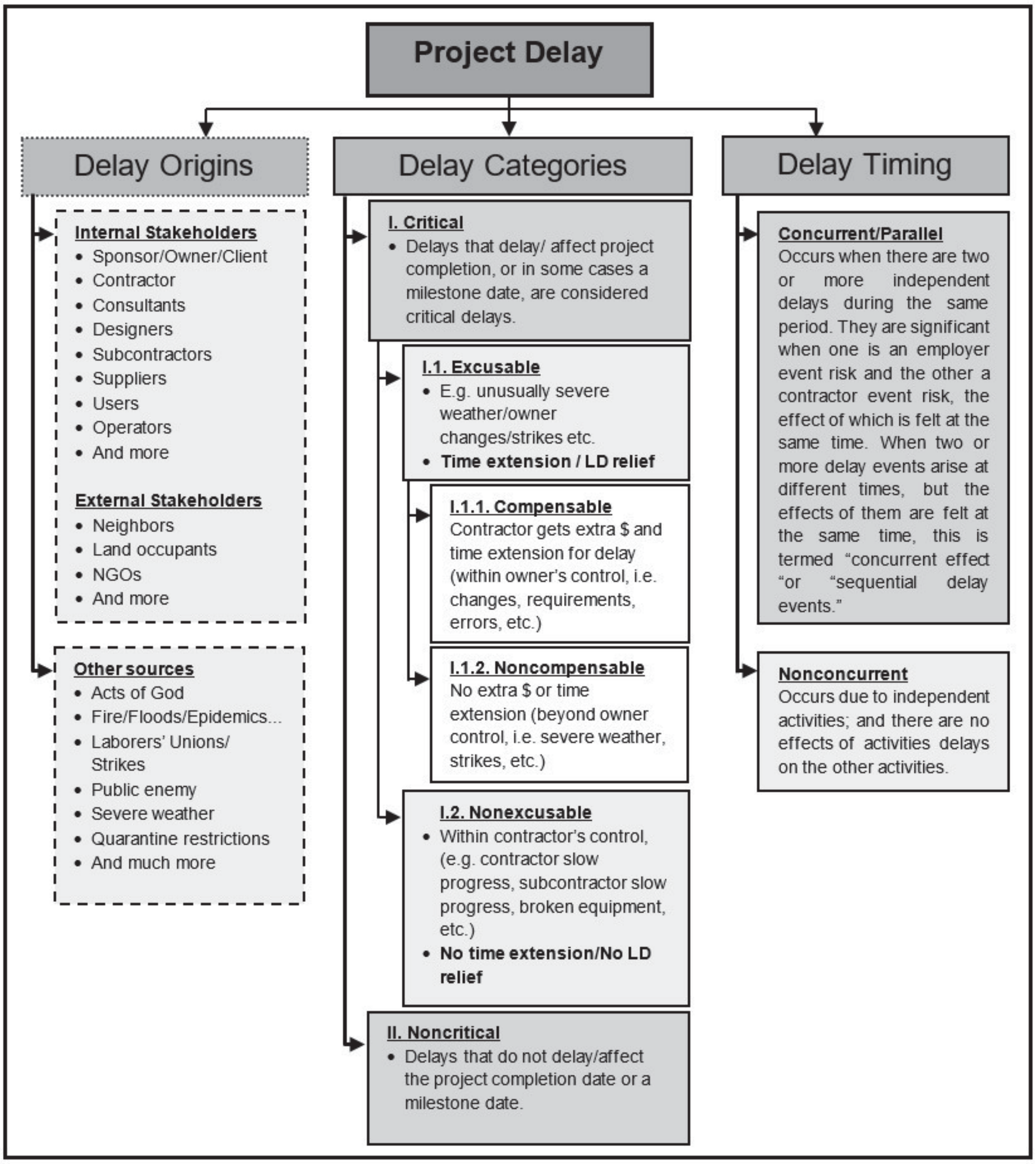

Figure 6.1-2: Project delay types – origins, categories and timing.
(Adopted from: Keane and Caletka, 2015, p.89; Trauner *et al.*, 2009, pp.25–35)

When it comes to delay categories based on the classification criteria "Critical/(Non)Excusable/(Non)Compensable" in Figure 6.1-2, the interpretation (based on excusability and compensability) can vary, depending on the contract (Trauner *et al.*, 2009). The concepts "internal stakeholders" and "external stakeholders" should be clarified. In this interpretation (Figure 6.1-2), internal stakeholders are all the organizations taking part and contributing to the planning and project execution towards its success. External stakeholders are those involved accidentally or because of the context (e.g., neighbors, etc.).

6.1.2 The most Common Delay Factors/Causes in Construction Projects

Fugar and Agyakwah-Baah (2010) studied the causes of delays in building construction projects in Ghana. They identified 32 possible causes of delay and further categorized these into nine major groups. The list of the causes of delay was incorporated into a questionnaire survey, which included 130 respondents who participated in the survey.

Based on their analysis, they concluded that the top ten most important factors affecting construction time were: (1) delay in honoring certificates; (2) underestimation of the costs of projects; (3) underestimation of the complexity of projects; (4) Difficulty in accessing bank credit; (5) poor supervision; (6) underestimation by contractors of time needed to complete projects; (7) material shortage; (8) poor professional management; (9) fluctuation of prices/rising cost of materials; and (10) poor site management.

The study of Abd El-Razek *et al.* (2008) was carried out to determine the causes of delay in building construction projects in Egypt. A questionnaire survey was carried out to confirm the causes and to identify the most important delay factors. Based on the survey results, the top five delay causes are: (1) financing by contractor during construction; (2) delays in owner paying contractor; (3) design changes by owner or his agent during construction; (4) partial payments during construction; and (5) nonutilization of professional construction management.

Sweis *et al.* (2008), in a similar study carried out in Egypt, also concluded that financial difficulties faced by the contractor and too many orders changed by the owner are the leading causes of construction delay. Both research outcomes showed that financial difficulties were important factors causing delays in Egypt.

Tumi *et al.* (2009) studied the delays in construction projects in Libya. They concluded that the main causes of delay in construction projects were improper planning, followed by a lack of effective communication, material shortage, design errors and financial problems.

Alwi and Hampson (2003) conducted a similar study on the causes of delays in building construction projects in Indonesia. A questionnaire survey was carried out targeting only the contractors. The respondents were asked to assess the effects of the 31 potential delay factors on their projects. The delay factors were grouped into six major groups.

The results showed that the top five most important delay causes are: (1) slow decision-making; (2) design changes; (3) poor distribution of labor; (4) inappropriate construction methods; and (5) poor coordination among project participants.

Kaming *et al.* (1997) carried out a research to study the impact factors on 31 high-rise projects in Indonesia and it was found that time overrun is less severe than cost overruns. The significant factors that lead to cost overrun are material fluctuation, inaccurate material estimation and degree of complexity, whereas design changes, poor labor productivity, inadequate planning and resource shortages are marked as time overruns.

Mezher and Tawil (1998) carried out a research to find out the causes of delays in the construction industry in Lebanon. Sixty-four causes of delay were identified through a research in which a client, a contractor and a consultant were involved the study. All three parties generally agreed on the ranking of the major categories of delay factors. Owners had more concerns with regard to financial issues, while contractors ranked contractual relationships highest, and finally, consultant firms ranked project management highest. These causes were categorized into ten main groups: materials, labor, equipment, financing, changes, government relations, project management, site conditions, environment and contractual relationships.

Le-Hoai *et al.* (2008) conducted a study to find out the causes of delays and cost overrun in Vietnam and seven critical factors were identified:(1) slowness and lack of constraint; (2) incompetence; (3) design; (4) market and estimates; (5) financial capability; (6) government; and (7) workers.

Assaf *et al.* (1995) identified 56 main causes of delay and their relative importance in Saudi large building construction projects. 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.

Assaf and Al-Hejji (2006) conducted a study within Saudi as well, and they found 73 factors that cause construction delays. They categorized these factors into nine groups.

Some of the most important causes of delay included: (1) approval of shop drawings; (2) delays in contractors' payment by owners; (3) design changes by owners; (4) cash problems during construction; (5) the slowness of the owners' decision-making process; (6) design errors; (7) excessive bureaucracy in project-owner organization; (8) labor shortages; and (9) inadequate labor skills.

Koushki *et al.* (2005) carried out a research in Kuwait and identified estimates of time delays and cost increases and their causes. The three main causes of delays were changing orders, owners' financial constraints and owners' lack of experience. In addition, the three biggest causes of cost overruns were contractor-related problems, material-related problems and owners' financial constraints.

Table 6.1-1 shows the most common factors of delays in construction projects. There are several ways of grouping the delay factors; the number of factors differs in each group but there are overlaps among them. It would be subjective to try to list all the groupings based on all the studies, and it would be more objective to list all the delay factors/causes under 13 selected groupings from choice.

Table 6.1-1: List of delay causes from literature.
(Check Table 6.3-1 for references)

Categories	No.	Delay Factors/Causes
1. Sponsor-/ owner-/client-related factors	1	Change in specifications, change orders, extra works, variations in quantities
	2	Delay/late in issuance of change orders, and/or oral change orders
	3	Delay in approving design documents, shop drawings, specifications, sample materials
	4	Rework due to change of design or deviation, design changes
	5	Delay in furnishing and delivering the site to the contractor
	6	Suspension of work
	7	Postponement of project
	8	Delay/late date of notice to proceed, commencement, giving instructions
	9	Delay in approval of completed work
	10	Delay in paying compensation (landowners)
	11	Delay in running bill payments to contractor and financial difficulties of sponsor/owner/client
	12	Delays in resolving contractual issues
	13	Delay in the approval of contractor submissions
	14	Conflicts/failure to coordinate/poor communication with the parties/with government authorities
	15	Conflicts among joint owners of the project
	16	Estimation errors or unrealistic time estimation and unreasonable project period
	17	Excessive bureaucracy in the sponsor/owner/client's administration
	18	Improper study and inadequate information during project feasibility study
	19	Lack of capable representative and insufficient inspectors
	20	Interference by the sponsor/owner/client in the construction operations
	21	Lack of sponsor/owner/client experience
	22	Sponsor/owner/client's personality
	23	Time-consuming and slowness/late/delays in decision-making
	24	Work interference between various contractors
2. Contractor-related factors	25	Rework due to bad quality of contractor's work/defective work/construction mistakes and errors
	26	Cash-flow constraints lead to difficulties in financing project and intermittent stoppage of work
	27	Conflicts and/or poor communication between contractor and other parties
	28	Contractor shortage of manpower (skilled, semi-skilled)
	29	Contractor's staff are not properly trained in professional construction/experience of project team
	30	Delay in site mobilization and field survey
	31	Contractor is not well organized and ineffective control of the project progress
	32	Safety rules and regulations are not followed within the contractor's organization
	33	Contractor inefficiency in handling subcontractors and lack of coordination
	34	Inadequate planning/scheduling of subcontractors' work and conflicts in work schedules of subcontractors
	35	Late nomination of subcontractors and/or delays in subcontractors' work
	36	Multiple and high number of contracts and projects by the same contractor/monopoly
	37	Delays/irregular/late payments of subcontractors
	38	Improper planning of contractor during bidding stage
	39	Improper technical study by contractor during the bidding stage
	40	Inadequate experience of contractor
	41	Ineffective planning and scheduling of project
	42	Improper construction methods/use of improper or obsolete construction methods
	43	Delay in material procurement
	44	Misunderstanding of owner's requirements
	45	Poor site management and supervision/and quality control (QC)
	46	Inadequate planning and scheduling
	47	Low bidding of contractor
	48	Failure to utilize tools to manage project symmetrically and ineffective management techniques
	49	Unrealistic time schedule and specifications in contract submitted by contractor
	50	Unreasonable risk allocation
	51	Unsuitable leadership style of construction/project manager
3. Consultant-related factors	52	Absence of consultant's site staff
	53	Consultant/developer interference in client's decisions
	54	Consultant or architect's reluctance for change
	55	Inflexibility (rigidity) of consultant
	56	Conflict between consultant and other parties
	57	Delay/Late in reviewing and approving drawings/design documents
	58	Delay in approving sample materials
	59	Delay in approving major changes in the scope of work
	60	Delay in conducting inspection/testing, and quality control
	61	Slow/delay in performing final inspection and certification of completed works
	62	Delay in preparing interim payment certificates
	63	Delay in the approval of contractor submissions
	64	Poor qualification of consultant. Lack or inadequate experience of consultant
	65	Poor communication and coordination between consultant and other parties
	66	Poor contract management
4. Bidding/ contract/ contractual relationships/legal issues-related factors	67	Breach of contract by the sponsor/owner/client, contractor, subcontractors, etc.
	68	Lack of incentives for contractor to finish ahead of schedule/ineffective delay penalty provisions in contract
	69	Contract modifications/breach or modification of contract by the owner
	70	Poorly written/inconsistency/incomplete/errors/mistakes and discrepancies in the contract document

Categories	No.	Delay Factors/Causes
	71	Unfavorable contract clauses and mode of financing and payment for completed work within the contract
	72	Poor contract management and means of contracting, and late contract award
	73	Inadequate project duration defined in the original contract
	74	Dispute (variation in order) and negotiations between parties/contractual claims/variations in quantities
	75	Legal disputes between project participants/between various parties
	76	Unrealistic inspection and testing methods proposed in contract
	77	Complications/lack of clear tendering process method and bureaucracy in bidding process
	78	Project awarded to the lowest bidder, due to high competition or tendering system requirement
	79	Long period between design and time of bidding/tendering
	80	Poor understanding of scope of work during tendering
	81	Selecting inappropriate contractors for the bidding
	82	Unrealistic schedule (bid duration is too short)
5. Design-related factors	83	Accepting inadequate design drawings
	84	High complexity, ambiguities, mistakes and inconsistencies in specifications and drawings
	85	Changes in drawings, designs and specifications
	86	Conflicting design information, drawings and specifications, dimensional inaccuracies
	87	Design errors due to unfamiliarity with local conditions and environment
	88	Design errors and omissions, defective designs/drawings, unclear and inadequate details in drawings
	89	Delay/late in producing design documents
	90	Delay/late in preparation and approval of drawings during construction work
	91	Delay/late in reviewing and approving design changes
	92	Frequent design changes during construction
	93	Decision during development stage
	94	Design errors and discrepancies in contract documents
	95	Improper study of design affects estimated quantity
	96	Inadequate design team experience
	97	Inadequate site assessment by the designer during design phase
	98	Impractical//ncomplete designs/drawings/specifications/documents
	99	Insufficient data collection and survey before design
	100	Lack of involvement of design team during construction stage
	101	Lack of standardization in design
	102	Legal disputes between designer and owner
	103	Low constructability of design
	104	Misunderstanding of owner's requirements by designers
	105	Misinterpretation of drawings and specifications
	106	Overdesigning increasing the overall design time
	107	Poor design management
	108	Nonuse/poor use of advanced engineering design software and tools
	109	Re-engineering of different units caused by poor basic design package
6. Subcontractor-related factors	110	Contractual issues, variations, claims
	111	Delay caused by domestic subcontractors/nominated subcontractors
	112	Frequent change of subcontractors because of their inefficient work
	113	Incompetent/immature subcontractors and poor subcontractor performance
	114	Labor problems from subcontractors
	115	Lack of competent subcontractors
	116	Subcontractor turnover
	117	Slow response from subcontractors
	118	Unreliable subcontractors
7. Material-related factors	119	Changes in material types and specifications during construction
	120	Damage of materials in storage/improper storage of materials
	121	Damage to structure
	122	Defective materials provided by client
	123	Delay in delivery of materials
	124	Delay in manufacturing materials, or special manufactured imported materials
	125	Delay in material procurement by contractor
	126	Delay in test samples of materials
	127	Inadequate material quality/material quality problems
	128	Material management problems
	129	Lack and/or nonavailability of materials on market
	130	Shortage of materials required on site and in time needed
	131	Unreliable suppliers
8. Equipment-related factors	132	Unavailability of equipment on request/insufficient equipment/shortage of equipment, machinery and tools
	133	Frequent failure/breakdown of construction plant and equipment
	134	Improper/inadequate modern equipment used for the works/lack of high-technology mechanical equip
	135	Inefficient use of equipment/lack of equipment efficiency
	136	Lack of skilled operators for specialized equipment
	137	Late delivery/slow mobilization of equipment
	138	Wrong selection and/or allocation of equipment on site
	139	Theft of machines/machine parts
9. Construction site-related factors	140	Delay in site delivery
	141	Site pollution and noise, difficult site terrain to work and poor ground condition and soil quality
	142	Inconvenient site access, unavailable/restricted site access, congestion at site entry/exit points
	143	Different site conditions, differing or unexpected geotechnical conditions during construction
	144	Limited construction area and poor site storage capacity

Categories	No.	Delay Factors/Causes
	145	Security measures, poor safety rules/conditions on site
	146	Poor site arrangement, management and supervision and traffic control and restrictions on job site
	147	Slow site clearance
	148	Poor site layout
	149	Problems with neighbors
	150	Unavailability/delay in providing services from utilities (such as water, electricity, telephone, etc.)
10. Labor-related factors	151	Wages
	152	Labor absenteeism/supervisor absenteeism
	153	Discipline of workers
	154	Inadequate skill of laborers
	155	Insufficient and shortage of laborers
	156	Unavailability of local labor
	157	Lack of labor supervision
	158	Labor camp issues
	159	Labor strikes
	160	Low motivation and morale of laborers
	161	Laborer injuries on site
	162	Lack of skilled labor/technical personnel
	163	Low productivity level of laborers
	164	Personal conflicts among laborers and management team
	165	Noncooperation of labor unions
	166	Nationality of laborers/different nationalities of workforce on site
	167	Presence of unskilled laborers, unqualified workforce
	168	Slow mobilization of laborers
11. Project-related factors	169	Poor understanding of the project, confusing and ambiguous project
	170	Ambiguity in specifications and conflicting interpretation by parties
	171	Project complexity (scope complexity (buildability), project size/scale, project type, etc.)
	172	Project management issues
	173	Project objectives and goals are not very clear/defined
	174	Type of construction contract (turnkey, construction only, etc.)
	175	Type of project bidding and award (negotiation, lowest price, etc.)
	176	Lack of IT use for information, coordination and interface management
	177	Lack of effective interorganizational communication and slow information flow between parties
	178	Work interference between various contractors or other parties
12 Economic and financial-related factors	179	High interest rate
	180	Unforeseeable local or global, financial and economic conditions/problems/crises
	181	Market inflation
	182	Changing of banker's policy for loans
	183	Shortage of foreign currency (importation of materials and equipment)
	184	Financial difficulties of one or multiple project parties
	185	Financial indiscipline/dishonesty
	186	Price escalation/fluctuation of exchange rate/of prices, material, laborers, equipment, machines
	187	Changes in market conditions
13. Miscellaneous-related factors	188	Severe overtime and shifts
	189	Unclear lines of responsibility and authority
	190	Overestimation/underestimation of productivity
	191	Irregular attending of weekly meetings
	192	Lack of top management commitment
	193	Negligence
	194	Nonvalue-added works
	195	Impact on people's land during the road construction project and problem with neighbors
	196	Problems with local community
	197	Vandalism of works (in progress or finished)
	198	Fraudulent practices and kickbacks; different tactics, patterns for bribes
	199	Corruption tendencies
	200	Effect of social and cultural factors, religious factors
	201	Geopolitical and regional stability; security, conflict, war, public enemy, revolution and public strikes
	202	Industrial action (strike/sit-in)
	203	Official and nonofficial holidays
	204	Inappropriate government policies
	205	Routine of government authorities and approvals
	206	Government/public interruptions
	207	Changes in government regulations and laws
	208	Poor government judicial system for construction dispute settlement
	209	Slow coordination and seeking of approval from concerned authorities
	210	Building codes
	211	Multicultural and multilingual environment causing ineffective communication
	212	Adversarial/confrontational/controversial culture
	213	Working environment (working hours, ambient noise, ambient light conditions, welfare and bureaucracy)
	214	Failure of plan for work application
	215	Difficulties in obtaining work permits
	216	Delay in obtaining permits from authorities/provincial/municipality/urban bureau/foreign laborers bureau
	217	Accidents of all types (fatal, serious injuries, minor injuries) due to lack of safety measures or negligence
	218	Environment restrictions and natural hazards/disasters (fire, flood, hurricane, earthquake, landslides, etc.)

Categories	No.	Delay Factors/Causes
	219	Unforeseen, unfavorable, severe weather conditions (rains, hot/cold temperatures, etc.)
	220	User changes
	221	Warlords influence
	222	Disturbance of public activities
	223	Fossils
	224	Acts of God and *force majeure*

The 224 delay factors listed in Table 6.1-1 above are a combination of an intensive literature review on delay factors based on 104 studies that cover 45 countries (see Table 6.3-1). Based on the new selection, the factors were grouped into 13 groups. There were other groups but these were gathered here in the selected groups (e.g., political-related factors and cultural-related factors were grouped in Miscellaneous, etc.). Other, not listed groups were all gathered in the last grouping, which is the "13. Miscellaneous" group. The authors related to each delay factor (from the 224 delay factors) are not listed in Table 6.1-1. However, all the authors are listed in the coming section, 6.3, within Table 6.3-1; the section discusses the universal delay factors. The reason for not listing the authors for each factor each time is to avoid having a table with more than 20 pages in this doctoral dissertation.

Something should also be mentioned before going further, and that is the grouping of factors within the same factor, e.g., factor number 190 "Overestimation/underestimation of productivity". This factor is all about wrong estimation regarding productivity: Instead of having two different factors, one about underestimating and the other about overestimating, it was preferable to have them both in one as mentioned.

Customized/tailored delay factors are not included in the table and will not be discussed anywhere in this dissertation, since they are related to a very specific area (e.g., in two of the studies by Ahmed *et al.* (2003a and 2003b), the authors mentioned the restrictions and laws related to building in coastal areas, which is most related to Florida State, in the United States). There are many of these tailored delay factors/causes in literature.

6.2 Delay Factors/Causes – Empirical Study

This section includes findings from three studies that I conducted during my three years of Ph.D. work. The first two are from surveys, and the last is based on a conducted case study; all three are described in Chapter 2. The first survey was conducted in Norway, while the second survey and the case study were conducted in Algeria. More details about each of the studies, including the methods, and a discussion with respect to the literature can be found in the three upcoming subsections.

6.2.1 Causes of Delays in Major Norwegian LSEPs – Survey 1

As mentioned in the methodology chapter, the identification of delay factors in Norwegian projects is based on a qualitative questionnaire (see Figure 6.2-1). This work also examines the delay factors influencing the construction period for a sample of the Norwegian construction industry. This survey was developed to assess the perceptions of clients, consultants and contractors on the relative delay factors in the industry. The data collected through questionnaire surveys were analyzed and ranked based on their frequency.

An open questionnaire, shown in Figure 6.2-1, was designed and sent to 300 practitioners from Norwegian companies involved in an ongoing research project, based on their having had active involvement in the planning and follow-up of construction projects. This survey was developed to assess the perceptions of clients, consultants and contractors on the relative delay factors in the industry.

There were 202 respondents out of 300 participants, which gives a return rate of approximately 67%. Most of the respondents were from the private sector with a percentage rate of 60% and the remaining 40% were from the public sector. Half of the respondents had more than ten years of construction industry experience. Most of the respondents (54%) were project managers and 40% were team members (Figure 6.2-2).

SPEEDUP Questionnaire Date.../........./........

1- Company / Organization:

Public sector	Private sector

2- Project experience

<1 year	1 to 5 years	5 to 10 years	More than 10 years

3- What role have you had in your last three projects?

Project owner	Project Manager	Project member	Other role

4- Give examples of the top 3 time-thieves and Bottlenecks in your projects

Time-thieves	1. 2. 3.
Bottlenecks	1. 2. 3.

5- Where are the biggest time-thieves/ bottlenecks in the projects you have worked with[1]-

	Plan Phase / Definition Phase	Implementation phase / Procurement phase	Suggested actions
Internal Time-thieves / bottlenecks			
External Times-thieves/ bottlenecks			

[1] Internal bottlenecks are bottlenecks that the project itself can handle, external bottlenecks outside the project that the project either cannot control or only partially control / influence.

Figure 6.2-1: The questionnaire for delay causes and remedies.

It is important to mention that the participants represent clients, owners, sponsors, contractors, subcontractors and suppliers. The years of working experience of the participants and their role in the projects play an important part in answering the survey; by drawing on respondents in all the layers of the construction project, I will have a more complete picture of all the different perspectives of delay factors.

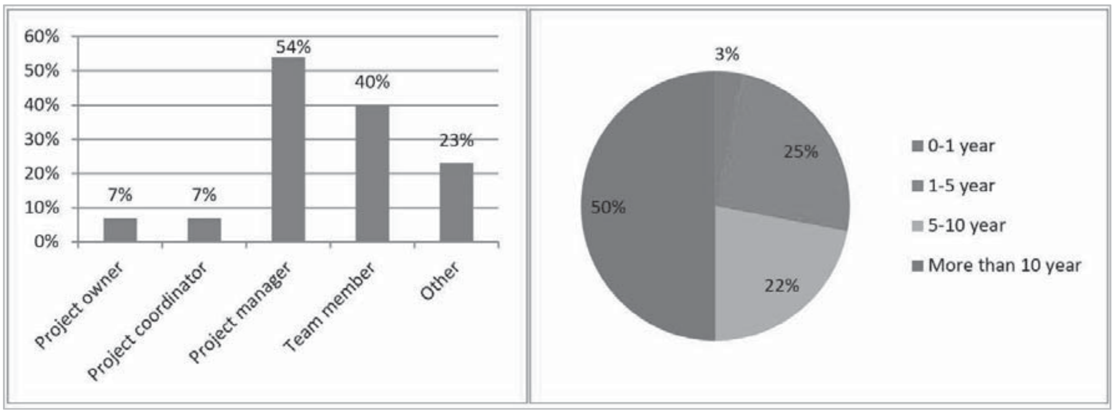

Figure 6.2-2: The respondents' experiences.

With the exception of the background data, the questions were formulated as open-ended questions, allowing the respondents to write their answers in free text. The analysis of the data was performed through these steps:

1. Coding the collected data.
2. First-pass analysis, grouping identical or near-identical responses and assigning frequencies of response to each delay factor.
3. Second-pass analysis, grouping related responses and identifying the dominant delay factors.
4. Third-pass analysis, looking for differences in response across project role, length of experience and sector.

Following the analysis of the data collected, the author grouped commonly identified delay factors into 11 groups; each group had subgroups with the same interpretation (e.g., poor planning and scheduling, which is a summing up of the five subgroups; last-minute tasks; unclear demands from the project manager; poor project planning; lack of or no delegation; and poor project management performance). A similar approach was used for the remedies that were suggested by the respondents as discussed further in Chapter 9. Finally, the results emerging from our data were compared with existing literature to verify whether the identified delay factors were in accordance with previous findings, or if they deviated from them.

It is important to state that the findings from this survey cannot be generalized. Although the study covered projects across the country, the findings are based on using a clustering analysis of qualitative survey data. Again, the study is based on self-reported perception of delay factors by project parties (namely clients, owners, sponsors, contractors, subcontractors and suppliers), which tends to vary, and may not always be reliable. Furthermore, the study did not distinguish between rankings by individual project parties. However, the findings are consistent with similar studies assessing the causes of delay in construction projects.

It should be noted that analyzing a large population of respondents that have been asked open questions can be challenging due to the vague findings it might lead to. This survey presents 44 delay factors clustered into 11 groups and ranked based on the frequency of their occurrence (Table 6.2-1).

Table 6.2-1: Major delay factors in major Norwegian projects

Ranking	Freq.	Norwegian major delay factors (Grouping)	No.	Delay factors in Norwegian construction industry
1	189	Poor planning and scheduling	1	Last-minute tasks
			2	Unclear demands from project manager
			3	Poor project planning
			4	Lack of or no delegation
			5	Poor project management performance
2	123	Slow/poor decision-making process	6	Late decisions
			7	Wrong decisions
			8	Replay on decisions
3	109	Internal administrative procedures and bureaucracy within project organizations	9	Administrative demands – hour list – file list – accountability
			10	Unnecessary or unclear reporting
			11	Search for documents for archives
			12	Annual budgeting – political management agendas
			13	Administrative systems – access – filing system
4	107	Resources shortage (human resources, machinery, equipment)	14	Lack of tools or equipment
			15	Lack of personnel
			16	Lack of structured subcontractors
			17	Too many projects
			18	Workload – project management level
			19	Workload – engineering level
			20	Shortage of human resources
			21	Lack of senior/key players
			22	Absence and sickness
5	103	Poor communication and coordination between parties	23	Poor interdisciplinary communication
			24	Bad or wrong communication (by email, phone, etc.)
			25	Unstructured colleagues
			26	Unstructured meetings – so many and useless meetings – irrelevant meetings
6	85	Slow quality inspection process of the completed work	27	Slow control of production
			28	Slow quality check
			29	Slow internal QA
			30	Slow external QA
7	60	Design changes during construction/change orders	31	Unnecessary changes and many changed orders
8	51	Sponsor/owner/client lack of commitment and/or clear demands (goals and objectives)	32	Unclear demands from client
			33	Lack of delegation from owner
			34	Unclear demands from sponsor/owner
9	41	Office issues	35	Software troubles
			36	Working conditions
			37	Office noise and disruption
			38	Too much traveling
10	29	Late/slow/incomplete/improper design	39	Poor/incomplete documentation (designs, engineering documents)
			40	Missing or error in documentation during construction
			41	Errors and mistakes in engineering part causing changes
			42	Poor quality in designs and materials causing changes
11	13	User issues	43	Short questions from users
			44	Late/new demands from users

It is important to mention again that the participants are both from public and private sectors (i.e., clients, owners, sponsors, contractors, subcontractors, suppliers, etc.). The identified major causes of delay and the 11 most important factors based on their rankings are: (1) poor planning and scheduling; (2) slow/poor decision-making process; (3) internal administrative procedures and bureaucracy within project organizations; (4) resources shortage (human resources, machinery, equipment); (5) poor communication and coordination between parties; (6) slow quality inspection process of the completed work; (7) design changes during construction/changed orders; (8) sponsor/owner/client lack of commitment and/or clear demands (goals and objectives); (9) office issues; (10) late/slow/incomplete/improper design; (11) users' issues.

Comparing the major delay factors in Norwegian construction projects to the delay factors present in other countries, it is found that most of them are similar to other studies' results in other countries. To avoid wide-ranging discussion, the comparison is oriented toward the most critical delay factors of other studies, or in other words, the top ten major delay factors of other similar studies (presented in Section 6.3). The discussion of the findings from this survey will be in turn used in the study of the universal delay factors in Section 6.3. The reason for leaving the discussion to after Section 6.3 is that the findings are also part of the universal delay factors, as well as the next two subsections. The following subsections will present findings from a survey and from a case study. However, the findings from the following studies come from another context (country) and content (industry).

6.2.2 Factors Causing Delay in the Algerian Telecom Industry – Survey 2

As mentioned in the methodology chapter, the identification of delay factors in the Algerian telecommunication industry is based on a final quantitative survey. However, the whole process went through three major steps.

1. The first step was collecting the most common delay factors from the literature; this led to the identification of 224 delay factors/causes, which are summarized in Table 6.1-1.
2. The next step was discussing those factors with some experts in the Algerian telecommunication industry. Two experts were from the telecom operators (owner/client) and three from the main contractor (client's contractor); this second step allowed new delay factors to emerge (e.g., user delay factors-related group) and the list to be reduced almost by half.
3. The last step was to get those selected factors sent to, and ranked by, the respondents, and then to calculate their ranking index based on that. The final list of delay factors is in Table 6.2-2; there are 123 of them.

A five-point Likert scale ranging from 1 (not important) to 5 (extremely important) was adopted to capture the importance of causes of delays. Figure 6.2-3 shows one line out of 123 delay factors to rank.

Before distributing the questionnaire via emails, a small pilot study was conducted using five experts from management in the Algerian telecommunication industry (two from operators, three from the main contractor). The basic purpose of the pilot study was to verify the completeness of the questionnaire in capturing the factors relevant for the Algerian telecommunication industry. All the respondents gave feedback about which factors to keep and those to eliminate from the main proposed list of 224 delay factors.

The questionnaires were distributed through my network and my network's networks working in the Algerian telecommunication industry, from operator (client) to main contractor, consultants, subcontractors, suppliers, government (Ministry of Telecommunications) and the Algerian telecommunication regulator. It should be mentioned that the sample of this study is very small, with only 33 respondents, and half of them did not complete the questionnaire because they did not select (grade) all the delay factors (which may also indicate that those delay factors are of no importance in their view). The respondents from the contractors' side belong to only one main contractor (the only available resources on hand for this study).

	Very Important	Important	So-So	Less Important	Not Important
1. Change in specifications, change orders, extra works	○	○	○	○	○

Figure 6.2-3: One line of the questionnaire on delay factors.

Calculation of the Overall Ranking Index (ORI): Kometa *et al.* (1994) used the relative importance index method to determine the relative importance of the various causes and effects of delays. The same method, but slightly modified, is adopted in this study without separating the various groups (e.g., clients, consultants, contractors, etc.). The five-point scale, ranging from 1 (not important) to 5 (extremely important), was adopted and transformed to the Overall Ranking Index (ORI) for each factor as follows:

$$ORI = \frac{F}{A * N} \sum_{i=1}^{F} W_i$$

Equation 6.2-1: Overall Ranking Index for delay factors – telecoms survey.

Where F is the frequency of the appearance of each factor (e.g., the factor "Shortage of foreign currency (importation of materials and equipment)" was ranked 23 times, which means its frequency is 23 out of the 33 total number of respondents).

W_i is the weighting given to each factor by the respondents (ranging from 1 to 5 and i ranges from 1 to F). A is the highest weight (i.e., 5 in this case), and N is the total number of respondents (i.e., 33 in this case).

The results of the calculation of the overall ranking index for the 123 delay factors are listed in Table 6.2-2. The listing is not based on the ORI, but on the way the survey was designed. However, there is a column showing the ranking of each delay factor. The ORI shows that there are some factors that can be ignored.

Table 6.2-2: Delay factors in the Algerian telecommunications industry

Factors group	No	F.	W.	ORI	R.	Delay factors in the Algerian telecoms industry
1. Client related factors	1	33	152	30,4	1	Change in specifications, change orders, extra works
	2	33	145	29	6	Time-consuming and slowness/ late/delays in decision-making
	3	33	113	22,6	12	Delay to furnish and deliver sites
	4	33	149	29,8	3	Delay in approval of completed work
	5	11	17	1,133333	52	Excessive bureaucracy in the Client's administration
	6	10	16	0,969697	65	Improper study and inadequate information during project feasibility study
	7	8	14	0,678788	77	Client's representatives personality
	8	33	148	29,6	4	Unrealistic time estimation and unreasonable project period
	9	33	147	29,4	5	Delay in running bill payments to contractor and financial
2. Contractor related factors	10	11	17	1,133333	53	Rework due to bad quality of work / mistakes and errors, defective work
	11	33	110	22	13	Delay in material procurement
	12	9	15	0,818182	66	Misunderstanding of owner's requirements
	13	33	150	30	2	Poor site management and supervision/ and Quality Control (QC)
	14	9	15	0,818182	67	Unsuitable leadership style of contractor project manager
	15	33	144	28,8	7	Contractor Shortage of human resources (Skilled, semi-skilled)
	16	9	15	0,818182	68	Late nomination of subcontractors and/ or delays in subcontractors work
	17	11	17	1,133333	54	Contractor inefficiency in handling subcontractors and lack of coordination
	18	9	15	0,818182	69	Contractor is not well organized and ineffective control of the project progress
	19	32	112	21,72121	14	Inadequate planning/scheduling and conflicts of subcontractors' work
	20	33	143	28,6	8	Delays/ Irregular/ Late payments of subcontractors
	21	33	119	23,8	11	Multiple and high number of contracts and projects by the same contractor/
	22	9	15	0,818182	70	Delay in site mobilization and field survey
	23	11	17	1,133333	55	Lack of top management commitment
	24	9	15	0,818182	71	Safety rules are not followed within the contractor's organization
3. Consultant related factors	25	33	106	21,2	15	Absence of consultant's sites engineer
	26	31	91	17,09697	20	Delay in conducting inspection/ testing, and quality control
	27	9	15	0,818182	72	Poor communication and coordination between consultant and other parties
	28	11	17	1,133333	56	Poor qualification of consultant. Lack/ or inadequate experience of consultant
	29	9	15	0,818182	73	Inflexibility (rigidity) of consultant
	30	11	17	1,133333	57	Consultant interference in client's decisions
	31	29	89	15,64242	21	Poor technical and managerial skills/ unqualified consultant
4. Subcontractor related factors	32	19	58	6,678788	40	Cash-flow constraints lead to finance difficulties and intermittent stoppage of work
	33	9	15	0,818182	74	Frequent change of subcontractors because of their inefficient work
	34	18	55	6	42	Incompetent/ immature subcontractors and poor subcontractors performance
	35	9	15	0,818182	75	Labor problems from subcontractors
	36	25	77	11,66667	29	Lack of competent subcontractors
	37	9	15	0,818182	76	Slow response from subcontractors
	38	18	53	5,781818	43	Unreliable subcontractors
5. Bidding/ Contract/ contractual relationships/ Legal issues related factors	39	13	19	1,49697	50	Breach of contract by the Sponsor/ Owner/ Client, contractor, subcontractors, etc.
	40	7	13	0,551515	79	Lack of incentives for contractor to finish ahead of schedule/ Ineffective delay penalties provisions
	41	7	13	0,551515	80	Poor contract management and means of contracting, and late contract award
	42	16	45	4,363636	46	Unrealistic schedule (bid duration is too short)
	43	7	13	0,551515	81	Poor understanding of scope of work during tendering
	44	11	17	1,133333	58	Project award to the lowest bidder, due competition or tendering system requirement
	45	12	18	1,309091	51	Long period between design and time of bidding/tendering
	46	7	13	0,551515	82	Lack of clear tendering process method and bureaucracy in bidding process
	47	7	13	0,551515	83	Type of project bidding and award (negotiation, lowest price, etc.)

Factors group	No	F.	W.	ORI	R.	Delay factors in the Algerian telecoms industry
	48	11	17	1,133333	59	Fraudulent practices and kickbacks; different tactics patterns for bribes and corruption tendencies
	49	15	43	3,909091	47	Type of construction contract (Turnkey, construction only, etc.)
6. Sites related factors	50	28	86	14,59394	23	Inconvenient/ unavailability/ restricted of the site access, congestion at site entry/exit points
	51	7	13	0,551515	84	Limited site area and poor site storage capacity
	52	7	13	0,551515	85	Security measures, poor safety rules/ conditions on site
	53	33	137	27,4	9	Poor site layout
	54	7	13	0,551515	86	Theft of tools/ equipment/ materials from sites
	55	7	13	0,551515	87	Problems with local community
	56	11	17	1,133333	60	Vandalism of works (in progress or finished)
7. Project related factors	57	6	13	0,472727	88	Work interference between various contractors or other parties
	58	13	41	3,230303	48	Technology complexity due to the integration with existing running telecommunication networks
	59	6	13	0,472727	89	Project objectives and goals are not very clear/ defined
	60	18	47	5,127273	45	Lack of effective inter-organizational communication and slow information flow between parties
8. Material and Equipment related factors	61	33	99	19,8	16	Shortage of materials required on site and on time needed
	62	6	13	0,472727	90	Unreliable suppliers
	63	22	67	8,933333	36	Lack and / or non-availability of materials on local market
	64	33	97	19,4	17	Delay in manufacturing materials, or special manufactured imported materials
	65	33	93	18,6	18	Delay in delivery of materials to sites
	66	6	13	0,472727	91	Unavailability/ Insufficient / Shortage of machinery, and tools
	67	6	13	0,472727	92	Improper/ Inadequate modern equipment used for the works/ lack of high-technology tools
	68	11	17	1,133333	61	Inefficient use of tools/ Lack of tools efficiency
9. Design and drawings/ network architecture/ engineering documents – related factors	69	33	128	25,6	10	Accepting inadequate design drawings
	70	32	92	17,84242	19	High complexity, mistakes, and inconsistencies in engineering documents and network architecture
	71	6	13	0,472727	93	Changes in drawings, designs and specifications
	72	6	13	0,472727	94	Conflicting design information, the drawing and specification, dimensional inaccuracies
	73	11	17	1,133333	62	Design errors due to unfamiliarity with local conditions and environment
	74	6	13	0,472727	95	Delay/ late in reviewing and approving design changes
	75	6	13	0,472727	96	Inadequate design team experience
	76	6	13	0,472727	97	Inadequate sites assessment and survey by the designer during design phase
	77	11	17	1,133333	63	Insufficient data collection and survey before design
	78	5	10	0,30303	99	Misinterpretation of drawings and specifications
	79	5	10	0,30303	100	Delay/ late in producing design documents
	80	4	8	0,193939	113	Un-use/ Poor use of advanced engineering design software and tools
10. Economic and financial related factors	81	5	5	0,151515	114	Unforeseeable, local or global, financial and economic conditions/ problems/ crises
	82	4	4	0,09697	118	Market inflation
	83	23	70	9,757576	34	Shortage of foreign currency (importation of materials and equipment)
	84	2	2	0,024242	121	Financial difficulties of one and/ or multiple project parties
	85	3	3	0,054545	119	Financial indiscipline/dishonesty
	86	18	57	6,218182	41	Price escalation/ Fluctuation of exchange rate/ of prices, material, labors, equipment, machines
11. Labors/ Employees/ Staffs related factors	87	5	10	0,30303	101	Different nationalities Multicultural and multilingual environment causing ineffective communication
	88	18	50	5,454545	44	Wages
	89	28	85	14,42424	24	Absenteeism in all levels
	90	20	59	7,151515	39	Discipline of workers
	91	23	71	9,89697	33	Ownership
	92	20	62	7,515152	38	Delegation
	93	5	10	0,30303	102	Presence of unskilled employees
	94	5	10	0,30303	103	Insufficient and shortage of labors/ skilled employees
	95	13	20	1,575758	49	Low motivation and morale
	96	5	10	0,30303	104	Low productivity level of labors

Factors group	No	F.	W.	ORI	R.	Delay factors in the Algerian telecoms industry
	97	27	81	13,25455	27	Personal conflicts among labors, and management team
	98	5	10	0,30303	105	Lack of labor supervision
	99	5	10	0,30303	106	Unavailability of local labor
	100	23	72	10,03636	32	Adversarial/confrontational/controversial culture
	101	5	10	0,30303	107	Severe overtime and shifts
	102	28	84	14,25455	25	Negligence
	103	28	82	13,91515	26	Unclear lines of responsibility and authority
	104	5	5	0,151515	115	Irregular attending of weekly meetings
	105	5	7	0,212121	111	Non-value added works
	106	5	7	0,212121	112	Working Environment (working hours, ambient noise, ambient light conditions, welfare)
	107	5	8	0,242424	110	Lack of skilled labor/ technical personnel
12. Telecoms Regulator and Government related factors	108	20	65	7,878788	37	Inappropriate government policies
	109	1	1	0,006061	123	Delay in obtaining permits from authorities/provincial/municipality
	110	2	2	0,024242	122	Difficulties/ Failure in obtaining work permits
	111	3	3	0,054545	120	Government/ public interruptions
	112	11	17	1,133333	64	Official and non-official holidays
	113	7	7	0,29697	108	Routine of government authorities and approvals
	114	8	8	0,387879	98	Changes in government regulations and laws
	115	23	73	10,17576	31	Poor government judicial system for dispute settlement
13. Users related factors	116	5	5	0,151515	116	Users new requirements
	117	7	7	0,29697	109	Users excessive complains
	118	22	69	9,2	35	Exceed the number of users capacity which lead to increase to project scope and more extensions
14. Miscellaneous – related factors	119	25	79	11,9697	28	Accidents all types (Fatal, serious, minor injuries) due to lack of safety measures or negligence
	120	29	87	15,29091	22	Traffic jam/ congestion effects on all project activities at all the levels
	121	10	10	0,606061	78	Environment restrictions and natural hazards/ disasters (fire, flood, earthquake, landslides, etc.)
	122	25	75	11,36364	30	Unforeseen, unfavorable, severe weather conditions (rains, hot/ cold temperatures, etc.)
	123	5	5	0,151515	117	Acts of God and force majeure

It should be mentioned that the sample of this study is very small, with only 33 respondents, and half of them did not select any delay factors. The respondents from the contractors' side belong to only one main contract. As mentioned before, the other thing seen from the results is that each stakeholder tried to undervalue the factors related to them.

This kind of bias in weighting the factors may have a negative effect, of course, on the obtained results. This kind of study in general needs a large sample with multiple stakeholders to increase the reliability and validity of the findings (the major delay factors in the Algerian telecommunication industry are listed in Table 6-2.3).

According to the findings, the 20 most significant delay factors in the Algerian telecoms projects are: (1) change in specifications, changed orders, extra works; (2) poor site management and supervision and quality control (QC); (3) delay in approval of completed work; (4) unrealistic time estimation and unreasonable project period; (5) delay in running bill payments to contractor and financial dificulties; (6) time-consuming and slowness/late/delays in decision-making; (7) contractor shortage of human resources (skilled, semi-skilled); (8) delays/irregular/late payments of subcontractors; (9) poor site layout; (10) accepting inadequate design drawings; (11) multiple and high number of contracts and projects by the same contractor; (12) delay in furnishing and delivering sites; (13) delay in material procurement; (14) inadequate planning/scheduling and conflicts of subcontractors' work; (15) absence of consultant's site engineer; (16) shortage of materials required on site and in time needed; (17)

delay in manufacturing materials, or special manufactured imported materials; (18) delay in delivery of materials to sites; (19) high complexity, mistakes and inconsistencies in engineering documents and network architecture; (20) Delay in conducting inspection/testing, and quality control.

Table 6.2-3: Major delay factors in the Algerian telecommunications industry

No.	Delay factors in the Algerian telecoms industry	Rank
1	Change in specifications, changed orders, extra works	1
13	Poor site management and supervision and quality control (QC)	2
4	Delay in approval of completed work	3
8	Unrealistic time estimation and unreasonable project period	4
9	Delay in running bill payments to contractor and financial	5
2	Time-consuming and slowness/late/delays in decision-making	6
15	Contractor shortage of human resources (skilled, semi-skilled)	7
20	Delays/irregular/late payments of subcontractors	8
53	Poor site layout	9
69	Accepting inadequate design drawings	10
21	Multiple and high number of contracts and projects by the same contractor/	11
3	delay to furnish and deliver sites	12
11	Delay in material procurement	13
19	Inadequate planning/scheduling and conflicts of subcontractors' work	14
25	Absence of consultant's site engineer	15
61	Shortage of materials required on site and in time needed	16
64	Delay in manufacturing materials, or special manufactured imported materials	17
65	Delay in delivery of materials to sites	18
70	High complexity, mistakes and inconsistencies in engineering documents and network architecture	19
26	Delay in conducting inspection/testing, and quality control	20
31	Poor technical and managerial skills/unqualified consultant	21
120	Traffic jam/congestion effects on all project activities at all levels	22
50	Inconvenient/unavailable/restricted site access, congestion at site entry/exit points	23
89	Absenteeism at all levels	24
102	Negligence	25
103	Unclear lines of responsibility and authority	26
97	Personal conflicts among laborers and management team	27
119	Accidents all types (fatal, serious, minor injuries) due to lack of safety measures or negligence	28
36	Lack of competent subcontractors	29
122	Unforeseen, unfavorable, severe weather conditions (rains, hot/cold temperatures, etc.)	30
115	Poor government judicial system for dispute settlement	31
100	Adversarial/confrontational/controversial culture	32
91	Ownership	33
83	Shortage of foreign currency (importation of materials and equipment)	34
118	Exceed user capacity, which leads to an increase in project scope and more extensions	35
63	Lack of and/or nonavailability of materials on local market	36
108	Inappropriate government policies	37
92	Delegation	38
90	Discipline of workers	39
32	Cash-flow constraints lead to finance difficulties and intermittent stoppage of work	40
86	Price escalation/fluctuation of exchange rate/of prices, material, labor, equipment, machines	41
34	Incompetent/immature subcontractors and poor subcontractor performance	42
38	Unreliable subcontractors	43
88	Wages	44
60	Lack of effective interorganizational communication and slow information flow between parties	45
42	Unrealistic schedule (bid duration is too short)	46
49	Type of construction contract (turnkey, construction only, etc.)	47
58	Technology complexity due to the integration with existing running telecommunication networks	48

Looking closely at these first 20 delay factors, it can be seen that all of them are related directly to the internal project stakeholders (i.e., the main players and parties involved directly in the projects, who are mainly the client, the contractor, the subcontractors, the consultants and the suppliers). To check the remark on the large number of delay factors I extracted the 48 most highly ranked delay factors, and they are listed in Table 6.2-3. Their Overall Ranking Index varies from 30.4 (0.921/1) to 3.23 (0.097/1); the ORI values under this range can be ignored.

Based on Table 6.2-3 and on the 48 most highly ranked delay factors, here again I can see that most of the delay factors' origins and generators are the internal stakeholders of the project. There are some exceptions, such as "Inappropriate government policies," ranked 37, and "Poor government judicial system for dispute settlement," ranked 31, which are external to the project. However, they are factors generated from key stakeholders in the telecommunication industry.

There are two delay factors that are caused by external factors from the industry. These two factors are "Traffic jam/congestion effects on all project activities at all levels," ranked 22, and "Unforeseen, unfavorable, severe weather conditions (rains, hot/cold temperatures, etc.)," ranked (30). These two factors are out of the control of all the internal stakeholders to the industry. These kinds of factors, which are more related to the context and environment, ought to be considered and treated as risks rather than delay factors.

6.2.3 Causes of Delays in the Algerian Highway Megaproject – Case 1

The identification of major delay factors in the Algerian highway megaproject differs from the first two studies above due to the type of data collection strategy, which was based on a case study. In this, the delay factors collected are considered major factors, since they were the only ones mentioned by the participants. However, this will make the list short and will exclude many other delay factors that played a role in delaying the delivery of this megaproject.

The case study selected for this study is *Case 1: Algerian East-West Highway Megaproject*. Details about the case were given in the methodology chapter, but here are a few reminders. The cost of the Algeria East-West Highway megaproject was $US 11.2 billion, with a cost overrun of $US 4.2 billion. It was scheduled for completion in the fourth quarter of 2009, but was delivered five years behind schedule. The megaproject is a six-lane toll highway that is 1,216 km long. It was developed along Algeria's borders with Morocco and Tunisia.

The megaproject was a disaster if measured in terms of its efficiency (cost, time and scope). The project was completed five years behind schedule; the initial plan was to finish the project within three years, but because of the complexity of the project and the many technical obstacles encountered, it was impossible to achieve the target date. In addition, there was a cost overrun of US$ 4.2 billion compared to the initial estimated budget.

An explanatory single embedded case study is used for this (causes of delay) and other purposes (coming chapters). This single case was selected because it provides an opportunity to observe and analyze a phenomenon that few have considered before. In the methodology chapter, Yin (2013) distinguishes among four case study strategies based on two discrete dimensions: single case versus multiple cases, and holistic case versus embedded case. If a study contains more than a single case, then a multiple-case study is required. However, there is an important question to ask here: What is the difference between a holistic case study and one with embedded units? According to Yin (2013), holistic designs include a single unit of analysis, the aim is to study the global nature of the phenomenon and no logical subunits can be identified. Embedded designs include multiple units of analysis, and the study may include main and smaller units on different levels (i.e., looking for consistent patterns of evidence across units, but within a case), where the "unit of analysis" is the actual source of information (e.g., individual, organizational document, artifact, etc.).

A case study may use qualitative or quantitative research methods; however, most of the case studies mix both of these methods to collect and analyze data (Yin, 2013). In case studies, typically a combination of techniques is used in data collection, such as archives, interviews, questionnaires and observations. The data may be qualitative (e.g., words), quantitative (e.g., numbers) or both. For my case project I used a qualitative method, with primary data (interviews) and secondary data (materials and data obtained internally from the project sponsor's website, database and official archived documents, as well as externally from other websites and media archives with numerical audiovisual records).

Primary data, which are newly collected data, are collected by the researcher for the purpose of answering the research questions. Between the middle of the third quarter and the end of the fourth quarter of 2014, more than 30 interviews were held with users, contractors and other stakeholders (internal and external to the case). These were unstructured and in-depth interviews.

When it comes to the nature of the research, in-depth interviews and semi-structured interviews fit qualitative research better with their exploratory nature and inductive approach. The interviews were mainly one to one, interviewer to interviewee, although some of them were one to many, known as "group interviews." Most of the interviews were conducted as virtual interviews by conference calls or phone calls (telephone-, Internet- and intranet-mediated interviews (electronic)).

During the same period, observations were conducted, where data were also collected during on-site inspections (more than five visits to some of the sites of activity). The data collection followed a predefined protocol that incorporated information and facts such as transcription of the interviews, gathered data and codification of the results. Those interviews were held to investigate and evaluate the success or failure of the megaproject in terms of efficiency, effectiveness, impact, relevance and sustainability. However, the case study also covered the main issues in the case, which are the cost and time overruns.

The list of the delays came from the interviewees when they were asked about the reasons behind the project time overrun and factors that caused delays for this megaproject. However, when it comes to ranking them, the approach was subjective since it was only the reflections of the interviewees about each factor. From the researcher's viewpoint, priority was given to the interviewees from the virtual enterprise in charge of the project on behalf of the Ministry of

Civil Works (client), then staff from the main contractors, and finally the subcontractors and suppliers.

Here is a list of the 17 major delay factors and causes for this megaproject:

(1) Interference by sponsor (then owner/client): The minister of the Ministry of Civil Works (Ministère des Travaux Publics et des Transports (MTP)) was making all the key project decisions within the project at tactical and operation levels, which meant the virtual enterprise had to follow his demands. The government (represented by the Ministry of Civil Works) involved itself in all levels of the megaproject (which, as a result, had a negative effect on the schedule and budget). Some key decisions, which should have been made by the virtual enterprise (megaproject management organization), supported by expertise from the consultants and main contractors, were made by the government at the operational level and hence led to a redoing of the work. For example, according to an evaluation conducted by Zidane *et al.* (2015b, 2016), rather than filling the lower layers of the road with the correct type of soil, which should have been brought from a distant site, the government asked the project to use soil from the nearest hill to speed up the delivery. Once the road had been completed, the work needed to be redone. This increased costs and required more time. On the other hand, the government is a major player of this megaproject at tactical and strategic levels, and was involved before the decision to start implementing the project and the decision to start operating the product. However, at the operational level, the government has no power in the internal management. The project owner has to delegate power to the project management team regarding the internal management of the megaproject. Interference by the sponsor created serious delays for this megaproject. This issue was reported as major in some studies (e.g., Odeh and Battaineh, 2002; Assaf and Al-Hejji, 2006; Al-Kharashi and Skitmore, 2009; Akinsiku and Akinsulire, 2012; Kazaz *et al.*, 2012; Rahsid *et al.*, 2013).

(2) Optimistic (unrealistic) estimation of project duration and cost: This was one of the major reasons for delay and not meeting the target date. The delivery date was decided by the minister of the Ministry of Civil Works (Ministère des Travaux Publics et des Transports (MTP)) based on his own decision and his requests, without reflecting on the real world. This led the virtual enterprise to follow the instructions of the project owner, and as the virtual enterprise is in charge of delivering the project, they obliged their contractors to submit their schedules based on that final target date. In addition, the project owner had made wrong assumptions regarding cost, time and scope. Optimism in scheduling and planning was a major issue in other countries: From the 107 studies in Table 6.3-1, 38 mentioned this issue as a major one. The example of Australia is based on the study of Wong and Vimonsatit (2012), while Fugar and Agyakwah-Baah (2010) and Frimpong *et al.* (2003) focused on Ghana, Lo *et al.* (2006) on Hong Kong, Doloi *et al.* (2012a, 2012b) on India, Kaming *et al.* (1997) on Indonesia, Abbasnejad and Izadi Moud (2013) and Fallahnejad (2013) on Iran, and Bekr (2015) on Iraq.

(3) External stakeholders (media, landowners, users, etc.): A good example illustrating the wrong timing of involving the stakeholders is the landowners, the inhabitants who could be affected by the construction of the road (Zidane *et al.*, 2015b). These categories of stakeholders were involved only in the construction phase, after the planning and engineering phases had

been completed. What happened? All those stakeholders refused to sell their properties at the standard price; they negotiated the standard unit price hundreds of times. The government was obliged to negotiate, and thus more time and more money were spent in solving the issue. Early involvement of this type of stakeholder will prevent, or at least reduce, the negative effects caused by these stakeholders. Of course, it is impossible to identify exactly where the road should pass and how it should be built in the conception phase. However, accomplishing this identification progressively may reduce the risk enormously. Other external stakeholders who contributed to the failure at the operational level are associations and NGOs, who are mainly defenders of the environment and natural reserves. This was the case where the defenders of the environment were concerned. Their only concerns were the lakes, the trees, the forest, the animals and so on. However, they never gave any importance to other positive impacts of the project. Of course, these NGOs appeared in the construction phase, when they observed the negative effects of the project (as perceived by them) on the environment. The mobilization of citizens against some parts of the project by the NGOs halted the progress for months, even years. More than 20 studies mentioned external stakeholders as a factor causing delay, with 14 studies mentioning it as a major delay factor (e.g., Kaming *et al.*, 1997; Frimpong and Oluyowe, 2003; Fugar and Agyakwah-Baah, 2010; Fallahnejad, 2013; Bekr, 2015; Santoso and Soeng, 2016)

(4) Site handover/site change: As mentioned in the previous delay factor, i.e., external stakeholders, the delay in obtaining the lands to construct the highway from the landowners caused a delay in the handing over of the sites to the contractors. In addition, the NGOs caused the project owner to make decisions in changing sites, which led to a delay in carrying out the technical studies and starting construction. This delay factor was found to be major in other studies, such as Yang *et al.* (2010, 2013), Omoregie and Radford (2006), Al-Momani (2000), Nkado (1995) and Mansfield *et al.* (1994).

(5) Poor contract management/bidding process: The bidding process for this megaproject did not have its correct time window or sufficient time schedule to follow the right procedures (even skipping some in some cases). The shortening of the conception and front-end phases led to urgency in the bidding process, and that led to not following the process correctly and bad contract quality. This delay factor was mentioned in more than 60 studies, with some studies being dedicated exclusively to this factor. Among the studies considering this factor to be major are Marzouk and El-Rasas (2014), Frimpong *et al.* (2003) and Mansfield *et al.* (1994).

(6) Inadequate contractor experience/building methods and approaches: Contractors had no experience with this scale of project in terms of human resource capacity, machinery and accumulated experiences from previous projects. Among the studies where this issue was found to be major are Rahsid *et al.* (2013), Akinsiku and Akinsulire (2012), Kazaz *et al.* (2012), Al-Kharashi and Skitmore (2009), Assaf and Al-Hejji (2006) and Odeh and Battaineh (2002).

(7) Poor communication and coordination between parties: Because of the size of this megaproject and the high number of organizations (contractors, subcontractors, suppliers, municipalities, authorities, etc.), the communication between all these stakeholders was one of the major challenges (Zidane *et al.*, 2013). This delay factor is mentioned in 37 studies as one

of the top ten critical delay factors, and as the number one delay factor in a study conducted by Luu *et al.* (2015) in Vietnam.

(8) Delays in contractors' payment: The contractors were delayed in their payment; the reason for this delay was related to another delay factor, i.e., the delay in carrying out inspection of the completed work. Almost all of the studies listed in Table 6.3-1 have reported this issue as a major delay factor.

(9) Poor site management and supervision: There were not enough skilled site managers and supervisors; the contractors hired less experienced supervisors, which made the quality of the supervision very bad. More than 50 studies found that this factor was a major cause of delay.

(10) Poor planning and scheduling: The tight time window for the project duration made all the schedules for the work packages tighter and even exaggerated in the deadlines and milestones. This delay factor is cited in the top ten critical delay factors in 64 studies and classified as number one in six studies: Adeyemi and Masalila (2016) in Botswana; Aiyetan *et al.* (2011) in South Africa; Tumi *et al.* (2009) in Libya; Sweis *et al.* (2008) in Jordan; Alaghbari *et al.* (2007) in Malaysia; and Mezher and Tawil (1998) in Lebanon.

(11) Resources shortage (human resources, machinery and equipment): The shortage of resources is partly due to the project size, but more to the urgency of the delivery of this megaproject. This is mentioned in 50 studies as a critical delay factor, and ranked as the top delay factor in the three studies carried out by Baloyi and Bekker (2011), Assaf and Al-Hejji (2006) and Al-Khalil and Al-Ghafly (1999).

(12) Design changes during construction/changed orders: Because of the rush and short time spent in the front-end phase, there were many errors in the pre-study technical reports, which led to changes to the designs, and thus increased the number of changed orders. This is mentioned in 77 studies, and classified as number one in ten of them (Koushki *et al.*, 2005; Abdul-Rahman *et al.*, 2006; Zaneldin, 2006; Yang and Wei, 2010; Kikwasi, 2012; Motaleb and Kishk, 2013; Muya *et al.*, 2013; Yang *et al.*, 2013; Ahmed *et al.*, 2014; Tafazzoli, 2017).

(13) Slow quality inspection process of the completed work: Because of missing resources and consultants for the completed work, this also caused other delay factors such as delays in contractors' payments, and then in subcontractors' and suppliers' payments. This was cited in 41 studies as a top ten critical delay factor, and as the number one delay factor in the study of Muhwezi *et al.* (2014) from Uganda.

(14) Poor labor productivity and shortage of skills: Again, because of the size of the megaproject and the rush in delivering it, the shortage of resources led to hiring unexperienced labor. This factor was reported by 50 studies as a major delay cause.

(15) Shortage of materials: There were often shortages of materials for completing the highway (e.g., bitumen). This factor was reported as being in the top 10 delay causes from 40 studies. Moreover, it was mentioned in more than 90 studies as a delay cause.

(16) Weather conditions: Weather played a role in delaying the progress of the work, especially in winter. Heavy rain, and sometimes snow in some areas, not only stopped the work but even postponed it for weeks. More than 50 studies reported this delay factor, and in some countries it is considered the number one delay factor, because, for example, of heavy rain. Examples include Santoso and Soeng (2016) in a study conducted in Cambodia, Mydin *et al.* (2014) in a study in Malaysia and Kaming *et al.* (1997) in Indonesia.

(17) Unforeseen geological conditions: Unforeseen geological conditions played a role in delaying the work in some parts of the construction of the highway, especially when it came to tunnel building and digging through different types of rocks. In addition, the type of soil under layers and landslides caused some rework because of its bad quality. This factor was reported from more than 70 studies, with 20 of them considering it as one of the top ten delay causes.

It should be emphasized that the number of studies about delay causes is not limited only to those listed in Table 6.3-1, and the filters mentioned in the methodology section about the choice of studies to include in this paper resulted in the list as it is given in this study.

Another point worth noting relates to the countries listed in the table. There was no filter regarding the choice of countries. All countries were considered without exception, although of course, the studies still had to meet the conditions listed in the methodology section. Someone may notice that the only studies conducted in the European continent were those of Arantes *et al.* (2015) and Couto and Teixeria (2007), both in Portugal.

The 17 delay factors reported in this subsection are considered to be the major causes of delay for this megaproject, which was delayed by five years and had a cost overrun of more than US$ 4.2 billion. Although the interviewees mentioned other delay factors, the interviewer did not consider these delay factors, because of the frequency of the appearance of these factors on the one hand, and the importance of their reported impact on the other. Other types of factors that are not reported in this paper are those specifically tailored to the case.

6.3 The Universal Delay Factors/Causes

Many studies have been carried out worldwide to determine the delay factors in construction projects. From the existing studies, 104 articles were found, covering 45 countries worldwide. Table 6.3-1 summarizes the existing studies based on countries and authors. The reason why this section is here instead of expanding Section 6.1 is that the universal delay factors are built on the literature study of Section 6.1 and the findings from Section 6.2 of the empirical studies, with all the results being summed up in Table 6.3-2.

Some authors have studied, for example, the magnitude of construction project delays and their relation to the organizational culture (e.g., Arditi *et al.*, 2017). Aibinu and Jagboro (2002) conducted an empirical study about the effects of construction delays on project delivery in the Nigerian construction industry and the possibility of minimizing their negative effects. Some authors have studied construction project delays and the various aspects of delay analysis methods (Shi *et al.*, 2001; Kim *et al.*, 2005; Arditi and Pattanakitchamroon, 2006, 2008;

González *et al.*, 2014). Enshassi *et al.* (2010) studied the causes of variations in orders in construction projects in the Gaza Strip, which they consider one of the major delay factors. The study by Gould (2012) was more about the responsibility for delay of contractors, as was the study performed by Keane and Caletka (2015).

Table 6.3-1: Countries and authors of the existing studies on delay factors

Country	Authors
Afghanistan	Gidado and Niazai (2012)
Australia	Wong and Vimonsatit (2012)
Bangladesh	Rahman *et al.* (2014)
Benin	Akogbe *et al.* (2013)
Botswana	Adeyemi and Masalila (2016)
Burkina Faso	Bagaya and Song (2016)
Cambodia	Durdyev *et al.* (2017); Santoso and Soeng (2016)
Egypt	Aziz and Abdel-Hakam (2016); Marzouk and El-Rasas (2014); Ezeldin and Abdel-Ghany (2013); Aziz (2013); Abd El-Razek *et al.* (2008)
Ethiopia	Zewdu (2016)
Ghana	Amoatey *et al.* (2015); Fugar and Agyakwah-Baah (2010); Frimpong *et al.* (2003); Frimpong and Oluyowe (2003)
Hong Kong	Lo *et al.* (2006)
India	Doloi *et al.* (2012a); Doloi *et al.* (2012b)
Indonesia	Alwi and Hampson (2003); Kaming *et al.* (1997)
Iran	Saeb *et al.* (2016); Abbasnejad and Izadi Moud (2013); Fallahnejad (2013); Pourrostam and Ismail (2012); Pourrostam and Ismail (2011); Khoshgoftar *et al.* (2010)
Iraq	Bekr (2015)
Jordan	Sweis (2013); Sweis *et al.* (2008); Odeh and Battaineh (2002); Al-Momani (2000)
Kenya	Seboru (2015)
Kuwait	Koushki *et al.* (2005)
Lebanon	Mezher and Tawil (1998)
Libya	Shebob *et al.* (2011); Tumi *et al.* (2009)
Malawi	Kamanga and Steyn (2013)
Malaysia	Mydin *et al.* (2014); Tawil *et al.* (2013); Alaghbari *et al.* (2007); Sambasivan and Soon (2007); Abdul-Rahman *et al.* (2006)
Nigeria	Akinsiku and Akinsulire (2012); Aibinu and Odeyinka (2006); Omoregie and Radford (2006); Odeyinka and Yusif (1997); Mansfield *et al.* (1994); Dlakwa, and Culpin (1990); Okpala and Aniekwu (1988)
Oman	Ruqaishi and Bashir (2013)
Pakistan	Gardezi *et al.* (2014); Rahsid *et al.* (2013); Haseeb *et al.* (2011a); Haseeb *et al.* (2011b)
Palestine	Mahamid (2013); Mahamid *et al.* (2012); Enshassi *et al.* (2009)
Portugal	Arantes *et al.* (2015); Couto and Teixeria (2007)
Qatar	Gündüz and AbuHassan (2016); Emam *et al.* (2015)
Rwanda	Amandin and Kule (2016)
Saudi Arabia	Elawi *et al.* (2015); Al-Kharashi and Skitmore (2009); Assaf and Al-Hejji (2006); Al-Khalil and Al-Ghafly (1999)
Singapore	Hwang *et al.* (2013); Ayudhya (2011)
South Africa	Oshungade and Kruger (2017); Aiyetan *et al.* (2011); Baloyi and Bekker (2011)
South Korea	Acharya *et al.* (2006)
Syria	Ahmed *et al.* (2014)
Taiwan	Yang *et al.* (2013); Yang and Wei (2010); Yang *et al.* (2010)
Tanzania	Kikwasi (2012)
Thailand	Toor and Ogunlana (2008); Ogunlana *et al.* (1996)
Turkey	Gündüz *et al.* (2013a); Gündüz *et al.* (2013b); Kazaz *et al.* (2012); Arditi *et al.* (1985)
UAE	Motaleb and Kishk (2013); Ren *et al.* (2008); Faridi and El-Sayegh (2006); Zaneldin (2006)
Uganda	Muhwezi *et al.* (2014) ; Alinaitwe *et al.* (2013)
UK	Elhag and Boussabaine (1999); Nkado (1995)
United States	Tafazzoli (2017); Ahmed *et al.* (2003a); Ahmed *et al.* (2003b)
Vietnam	Kim *et al.* (2016); Luu *et al.* (2015); Luu *et al.* (2009); Le-Hoai *et al.* (2008)
Zambia	Muya *et al.* (2013); Kaliba *et al.* (2009)
Zimbabwe	Nyoni and Bonga (2017)

Sepasgozar *et al.* (2015) investigated the major delay causes in Iranian construction projects and came up with a top nine list: (1) contractor organization factors; (2) labor shortage; (3)

external factors; (4) material deficiencies; (5) design issues; (6) owner attributes; (7) technology restrictions; (8) consultant attributes; and (9) project attributes.

Compared to many other studies, some of these factors are broader in description (e.g., contractor organization attributes, which may mean poor planning, site management etc., and in many other studies these factors were not grouped under the contractor attributes as a single set; the same goes for owner attributes).

Al-Momani (2000), in a research on construction delays in a sample of 130 public projects in Jordan, found that weather, site conditions, late deliveries, economic conditions and an increase in quantity are the critical factors that cause construction delays in the Jordanian construction industry.

Chan and Kumaraswamy (2002) identified the factors affecting the construction time in Hong Kong, and classified them into two groups: the role of the parties in the local construction industry, and the types of projects. Based on their survey results, they indicated that the five major causes of delays were: poor site management and supervision, unforeseen ground conditions, low speed of decision-making involving all project teams, client-initiated variations and necessary work variations.

The literature review shows that causes of delays are different among countries. Different situations such as construction environment, working cultures, management style, methods of construction, geographical condition, stakeholders, government policy, economic situation, availability of resources, political situation and also different perspectives of researchers are some of the reasons for the variation in delays in the literature (Asnaashari *et al.*, 2009; Khoshgoftar *et al.*, 2010; Yang *et al.*, 2013).

Different concepts among countries can also cause some delays but with a different significance and frequency (Asnaashari *et al.*, 2009; Abbasnejad and Izadi Moud, 2013). For example, Yang *et al.* (2013) from Taiwan mentions "changes" as the most important reason for delay. However, "changes" are ranked differently in Sweis *et al.* (2008) from Jordan, Pourrostam and Ismail (2011) from Iran, and Abd El-Razek *et al.* (2008) from Egypt.

Ramanathan *et al.* (2012) and Yang *et al.* (2013) confirm this difference. The effects of delays in construction projects can be country-specific or even region-specific (Sambasivan and Soon, 2007; Ramanathan *et* al, 2012). Even within the same country, the causes of delay may differ from one study to another. The extreme is where it varies within studies conducted by similar authors (e.g., Haseeb *et al.* (2011a) and Haseeb *et al.* (2011b)).

Ramanathan *et al.* (2012) propose that there is no universal root cause. On the other hand, reviewing the body of literature, factors causing delays in construction projects are mostly identical across developing countries, but with different rankings in terms of importance (Toor and Ogunlana, 2008).

Analysis by Akogbe *et al.* (2013) shows that factors such as the country's income and the growth of GDP have a great impact on project delay, and comparisons between developing countries and developed countries show that financial difficulties are the most common factor of delay. Other causes of delay are very similar for developing countries and related to a lack of technology, management, and the skills and competencies of project participants (Akogbe *et al.*, 2013).

Based on the conducted intensive literature review, the top ten rankings of construction delay factors in various countries and based on different studies are summarized in Table 6.3-2. The reason why there are 33 delay factors in Table 6.3-2 is that after extracting the top ten delay factors for each study separately, their overall overlapping gave those 33 delay factors. On the other hand, this does not mean that those 33 factors are major in each country. There are many other studies that are not mentioned in Table 6.3-1.

While extracting the delay factors in each study, I avoided repetitions in listing the factors (e.g., "poor subcontractor performance," "late presence of subcontractor on site," etc. All these factors will be in the category "problem related to subcontractors"). Or I used similar factors when it may reflect the same meaning between one study and another (e.g., "complex project seen from contractor perspective," "inexperienced contractor," "poor building methods," etc. These will be in the category "inadequate contractor experience/building methods and approaches").

The number of sources and research studies used in the summing up in Table 6.3-1 is 105 articles, as shown in Table 6.3-1. I grouped Doloi *et al.* (2012a) with Doloi *et al.* (2012b), and Ahmed *et al.* (2003a) with Ahmed *et al.* (2003b) since they presented the same results. The number of delay factors that appeared more than once is 33.

The top ten universal delay factors in Table 6.3-2 based on 105 studies from 47 countries (Figure 6.3-1, after adding the studies from Algeria and Norway) are:

(1) Design changes during construction/changed orders;

(2) Delays in contractor's payment;

(3) Poor planning and scheduling;

(4) Poor site management and supervision;

(5) Incomplete or improper design;

(6) Inadequate contractor experience/building methods and approaches;

(7) Contractor's financial difficulties;

(8) Sponsor/owner/client's financial difficulties;

(9) Resource shortage (human resources, machinery, equipment); and

(10) Poor labor productivity and shortage of skills.

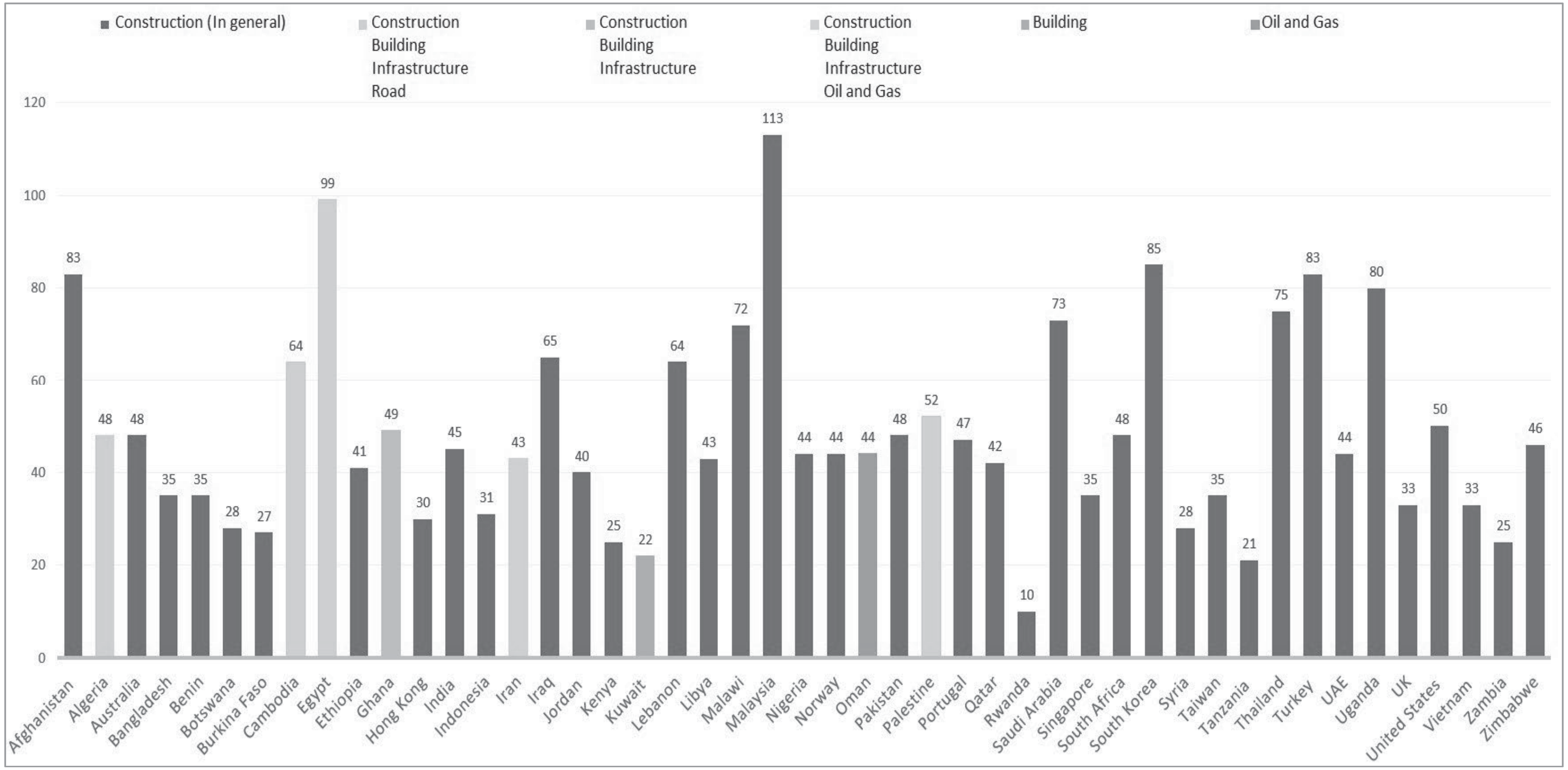

Figure 6.3-1: The second classification of delay factor numbers by countries.
(Including the empirical studies: Norway and Algeria)

Table 6.3-2: Major delay factors classified by countries, then by authors

Country	Authors	Delay Factors																																
		1- Sponsor/0wner/client's financial difficulties	2- Interference from sponsor/owner/client	3– Site handover/site change/site location/site-related problems	4- Optimistic (unrealistic) estimation of project duration and cost	5– Slow/poor decision-making process	6- Delays in contractor's payment	7- Late/slow delivery of materials	8- Design changes during construction/changed orders	9- Late/slow or incomplete or improper design	10- Slow quality inspection process of the completed work	11- Poor contract management/bidding process	12- Slow progress/underestimation of deadlines/many projects	13- Inadequate contractor experience/building methods and approaches	14- Contractor's financial difficulties	15- Poor communication and coordination between parties	16- Poor planning and scheduling	17- Poor site management and supervision	18- Poor labor productivity and shortage of skills	19- Equipment failure/equipment less productive based on estimations	20- Problems related to subcontractors	21- Shortage of materials	22- Resource shortage (human resources, machinery and equipment)	23- Unforeseen geological conditions	24- Weather conditions	25- Difficulties in obtaining permits and excessive bureaucracy	26- Economic problems (e.g., inflation, fluctuation)	27- External stakeholders	28- Corruption/fraudulent practices	29- Security and/or unstable political situation	30- Forces majeure/Acts of God	31- Internal administrative procedures and bureaucracy within project organizations	32- Office issues (e.g., IT troubles, noise and disruption, many useless trips, etc.)	33- Sponsor/owner/client lack of commitment, clear demands (goals and objectives)
Afghanistan	Gidado and Niazai (2012)						❹					❼		❾	❽		❻	❺	❸		❿								❷	❶				
Algeria	Zidane and Hussein (2018) – paper 15			❾		❻	❺		❶	❿	❸						❹	❷	❼		❽													
	Zidane (2018) – paper 16		❶	❹	❷		❽					❺		❻		❼	❿	❾										❸						

Australia	Wong and Vimonsatit (2012)				❹	❾				❿			❽		❷	❼		❻	❶				❸	❺										
Bangladesh	Rahman *et al.* (2014)						❻	❾						❽	❼			❹	❸		❺		❿				❶			❷				
Benin	Akogbe *et al.* (2013)	❶							❺	❾	❼				❷		❻		❿		❸	❹	❽											
Botswana	Adeyemi and Masalila (2016)						❹		❿					❸		❾	❶	❷	❼		❺	❻	❽											
Burkina Faso	Bagaya and Song (2016)	❷					❹							❽	❶		❻	❿			❺		❸	❾	❼									
Cambodia	Durdyev *et al.* (2017)							❸	❽					❺			❷	❿	❹		❾	❶	❻		❼									
	Santoso and Soeng (2016)						❾					❹		❽				❻	❿				❺	❼	❶			❸			❷			
Egypt	Aziz and Abdel-Hakam (2016)	❶							❾	❻				❸				❿		❺	❽	❹	❷	❼										
	Marzouk and El-Rasas (2014)	❽				❿	❺		❸		❹	❶					❷	❻	❼					❾										
	Ezeldin and Abdel-Ghany (2013)					❶	❿	❻								❷	❾		❸				❺	❼		❽	❹							
	Aziz (2013)						❶		❼					❽			❺	❻	❾	❹			❸				❿		❷					
	Abd El-Razek *et al.* (2008)	❹				❽	❷	❻	❸	❿		❺			❶	❼	❾																	
Ethiopia	Zewdu (2016)				❽		❾	❺		❶						❿	❸	❷				❼	❻		❹									
Ghana	Amoatey *et al.* (2015)	❸					❶		❹	❼				❾	❺	❽										❻	❷			❿				
	Fugar and Agyakwah-Baah (2010)				❷		❶						❸	❽		❺	❻	❿				❼					❾	❹						
	Frimpong *et al.* (2003)	❻			❾		❶	❿				❷			❺		❼					❸			❽		❹							
	Frimpong and Oluyowe (2003)	❶					❽					❺			❷		❻						❼		❹		❸	❾	❿					
Hong Kong	Lo *et al.* (2006)				❼				❿			❸		❹	❶	❺		❻						❷	❽	❾								
India	Doloi *et al.* (2012a); Doloi *et al.* (2012b)				❽	❻		❶	❹	❷				❿	❸			❼	❾							❺								
Indonesia	Alwi and Hampson (2003)					❶		❼	❷	❿	❽			❹		❺	❻		❸			❾												
	Kaming et al. (1997)				❷				❾				❻				❼		❽	❸		❹	❺		❶			❿						
Iran	Saeb *et al.* (2016)						❷		❼			❺	❿	❸			❹		❽	❻	❾						❶							
	Abbasnejad and Izadi Moud (2013)	❶			❿		❷			❹	❺			❼		❸	❻		❽				❾											
	Fallahnejad (2013)				❷		❼	❸	❺			❻			❶		❿				❾					❽		❹						
	Pourrostam and Ismail (2012)					❹	❶		❷	❾	❻				❺		❽	❸			❼				❿									
	Pourrostam and Ismail (2011)					❻	❷		❸	❼	❽	❾			❺		❹	❶			❿													
	Khoshgoftar *et al.* (2010)						❶		❿			❹		❾		❺	❷	❸		❼	❻	❽												
Iraq	Bekr (2015)				❾		❽		❺	❻		❹		❸												❷	❿	❼		❶				
Jordan	Sweis (2013)					❻	❼		❺	❽		❸		❾			❹		❶				❷		❿									
	Sweis *et al.* (2008)					❼			❸			❾		❺	❷	❻	❶	❿	❽				❹											
	Odeh and Battaineh (2002)		❸		❺		❷							❶			❾	❻	❹	❽	❼	❿												
	Al-Momani (2000)			❼	❷			❺	❾	❿				❶						❸				❻	❽		❹							
Kenya	Seboru (2015)					❷	❶	❿	❼			❸		❹						❾			❽	❺	❻									
Kuwait	Koushki *et al.* (2005)	❷			❹				❶	❺				❾	❸			❿	❽			❻			❼									
Lebanon	Mezher and Tawil (1998)	❸							❹			❷					❶			❻		❼	❺	❾	❿	❽								

Libya	Shebob *et al.* (2011)					❺		❷	❸	❾	❽						❼	❻	❶			❿	❹											
	Tumi *et al.* (2009)	❻				❺	❼		❽	❸						❷	❶	❾				❹				❿								
Malawi	Kamanga and Steyn (2013)	❷					❽	❺							❹			❿	❾	❼		❶	❻				❸							
Malaysia	Mydin *et al.* (2014)									❹	❽	❼		❿	❻	❾		❸	❺					❷	❶									
	Tawil *et al.* (2013)	❶					❷		❻		❸	❹						❾				❺	❿		❼		❽							
	Alaghbari *et al.* (2007)	❷				❹		❽		❿	❸		❺	❾				❼				❻					❶							
	Sambasivan and Soon (2007)						❹		❿					❸		❾	❶	❷		❽	❺	❻	❼											
	Abdul-Rahman *et al.* (2006)								❶	❸	❼						❽	❾		❻		❺	❹									❿		❷
Nigeria	Akinsiku and Akinsulire (2012)	❶	❿				❹	❽	❸	❼		❾			❷								❺				❻							
	Aibinu and Odeyinka (2006)	❷						❺	❻	❸	❽		❹		❶					❾					❿		❼							
	Omoregie and Radford (2006)			❹	❻		❷		❼			❸									❽	❺			❾		❶		❿					
	Odeyinka and Yusif (1997)								❽	❻	❾			❼		❸		❹	❶						❷					❺	❿			
	Mansfield *et al.* (1994)			❸	❽		❷	❺	❹	❿	❾	❶									❻						❼							
	Dlakwa and Culpin (1990)	❸			❽				❺	❼					❷		❹			❾		❻					❶	❿						
	Okpala and Aniekwu (1988)						❷	❽	❹			❸		❻				❺			❼	❶		❾	❿									
Norway	Zidane and Andersen (2018)					❷			❼	❾	❻					❺	❶						❹									❸	❿	❽
Oman	Ruqaishi and Bashir (2013)				❿	❽			❼			❾		❸		❺	❹	❶			❷	❻												
Pakistan	Gardezi *et al.* (2014)	❹			❾		❼		❸	❻								❺								❿	❽		❷	❶				
	Rahsid *et al.* (2013)		❷			❽		❶	❾	❺				❼					❿			❹	❸		❻									
	Haseeb *et al.* (2011a)	❶			❷		❹				❼									❽		❸	❻	❺	❾						❿			
	Haseeb *et al.* (2011b)	❶				❷	❾			❹			❽				❸					❼	❺		❿			❻						
Palestine	Mahamid (2013)	❿					❸					❾			❺	❻	❼	❽		❹								❷		❶				
	Mahamid *et al.* (2012)					❺	❸				❼	❷				❽		❾	❻	❹			❿							❶				
	Enshassi *et al.* (2009)						❻	❺		❼	❽	❿							❾			❸	❹					❷		❶				
Portugal	Arantes *et al.* (2015)				❸		❻	❿	❷	❶		❺			❹	❽	❼									❾								
	Couto and Teixeria (2007)						❸		❼	❶			❽	❿		❾	❻		❹				❺			❷								
Qatar	Gündüz and AbuHassan (2016)					❶		❻	❹	❾				❽			❿	❷	❼			❸	❺											
	Emam *et al.* (2015)				❽	❺	❿		❷	❻	❼		❹				❸						❾			❶								
Rwanda	Amandin and Kule (2016)	❷					❶		❾	❿					❸		❽	❼				❺	❻				❹							
Saudi Arabia	Elawi *et al.* (2015)	❷				❼			❻		❹	❽		❶			❸	❺				❾				❿								
	Al-Kharashi and Skitmore (2009)	❷	❾			❿	❶		❸	❻	❺				❹	❽		❼																
	Assaf and Al-Hejji (2006)		❿						❾			❻		❹			❸	❼	❷				❶	❽	❺									
	Al-Khalil and Al-Ghafly (1999)						❿					❻	❸	❺	❾	❷	❼	❽	❹				❶											
Singapore	Hwang *et al.* (2013)	❻			❾	❸			❺					❿	❽		❹	❶	❼								❷							
	Ayudhya (2011)				❿		❶			❼	❹				❸	❾			❽						❷		❻				❺			
South Africa	Oshungade and Kruger (2017)					❸			❿	❼	❽	❶				❷	❻		❾				❺							❹				
	Aiyetan *et al.* (2011)								❾	❻	❽						❶	❷	❺					❹	❿		❸			❼				

	Baloyi and Bekker (2011)					❾			❺	❽	❼					❻	❷		❹				❶				❸			❿				
South Korea	Acharya *et al.* (2006)				❹				❿	❺					❾		❼				❽		❻	❷		❸		❶						
Syria	Ahmed *et al.* (2014)				❺	❿	❼		❶			❸		❽			❾	❻				❹					❷							
Taiwan	Yang *et al.* (2013)			❷	❾				❶		❹				❿			❽						❺	❸	❼		❻						
	Yang and Wei (2010)	❽			❹	❺			❶	❸	❿			❼	❾	❷	❻																	
	Yang *et al.* (2010)	❸		❺					❼	❻			❿		❹		❾									❶	❽	❷						
Tanzania	Kikwasi (2012)	❹					❷	❽	❶			❻		❿		❸	❼	❺								❾								
Thailand	Toor and Ogunlana (2008)				❺		❾		❿	❶		❼		❷	❻			❽	❸		❹													
	Ogunlana *et al.* (1996)								❽	❺		❹	❷		❾		❼			❻		❶	❸	❿										
Turkey	Gündüz *et al.* (2013a)						❿	❺	❾	❹	❼			❶			❷	❸	❽		❻													
	Gündüz *et al.* (2013b)						❿	❺	❾	❹	❼			❶			❷	❸	❽		❻													
	Kazaz *et al.* *(2012)*	❷	❿		❻		❶		❺			❹		❽	❸				❼				❾											
	Arditi *et al.* (1985)						❷		❼					❹	❸		❾	❿	❻			❶	❽			❺								
UAE	Motaleb and Kishk (2013)	❾			❽	❹			❶		❺			❿		❷		❻					❸				❼							
	Ren *et al.* (2008)				❶		❸		❼	❹	❺	❻			❽	❿	❷	❾																
	Faridi and El-Sayegh (2006)					❸	❿	❼		❶					❾		❷	❺	❻				❹			❽								
	Zaneldin (2006)				❺	❸	❹		❶		❷			❼	❾		❽		❿		❻													
Uganda	Muhwezi *et al.* (2014)						❽		❼	❸	❶			❹	❷			❿					❾	❻	❺									
	Alinaitwe *et al.* (2013)						❺		❻			❿				❼	❽	❾	❹	❶		❷	❸											
UK	Elhag and Boussabaine (1999)				❸			❾	❹	❶	❼		❻	❽		❺	❿	❷																
	Nkado (1995)			❺	❶					❻			❹	❸			❷	❿	❽		❾		❼											
United States	Tafazzoli (2017)				❻	❷	❾		❶	❸	❹	❺				❽								❿		❼								
	Ahmed *et al.* (2003a); Ahmed *et al.* (2003b)				❻	❼			❷	❸	❺	❹	❽			❾										❶	❿							
Vietnam	Kim *et al.* (2016)	❶						❿	❸		❼			❹		❾		❷	❻	❽	❺													
	Luu *et al.* (2015)	❺								❼	❷	❿		❹	❽	❶	❻	❸					❾											
	Luu *et al.* (2009)	❶					❻		❽		❺	❼		❷	❹			❾				❸			❿									
	Le-Hoai *et al.* (2008)	❸			❽		❼		❺	❿					❹		❷	❶				❾		❻										
Zambia	Muya *et al.* (2013)						❹		❶	❸	❾				❷		❻		❺		❽	❿			❼									
	Kaliba *et al.* (2009)	❷					❶		❼			❹			❸			❿		❾		❻	❽				❺							
Zimbabwe	Nyoni and Bonga (2017)	❹			❾		❶			❸	❷	❽			❻				❼	❿			❺											

To identify the ranking of the universal delay factors, I considered the frequency of the 33 repeated delay factors in the 105 studies, then, based on the original ranking (from 1 to 10), I calculated the new universal ranking. The results are presented in Table 6.3-2.

The calculation of the overall ranking index for the 33 delay factors in Table 6.3-3 is based on Equation 6.3-1:

$$ORI = \frac{1}{F} \times \sum_{i=1}^{10} (N_i) \times \sum_{i=1}^{10} \left(\frac{N_i}{i}\right)$$

Equation 6.3-1: Overall Ranking Index – universal delay factors

where *ORI* is the overall ranking index. The number F is the number of rows (the total number of studies, which is equal to 105 based on 107 articles). The number i is the actual ranking (from 1 to 10 since all the rankings are in the top ten). The number N_i represents the frequency of each rank in one column (e.g., column one for the delay factor "Sponsor/owner/client's financial difficulties," and for the value of the rank $i = 1$, I will have $N_1 = 10$; column eight for the delay factor "Design changes during construction/changed orders," and for the value of the rank $i = 7$, I will have $N_7 = 12$, etc.). The overall ranking is based on the value of *ORI*: the higher the *ORI*, the better the ranking of the delay factor.

The number one universal delay factor, which is "Design changes during construction/changed orders," can indicate that the clients are always responsible for delay because of changes during construction. This delay factor appeared in many studies, even those not listed in this study. On the other hand, many studies regarding design changes and changed orders show a strong correlation between delay factors and causes of changes. As an important contribution to the intensive literature review on the top ten delay factors based on 105 studies that cover 45 countries, based on the findings, I ranked the most cited delay factors, of which there are 33, and came up with the top ten universal delay factors in the construction industry.

The top ten universal delay factors in the construction industry are: (1) Design changes during construction/changed orders; (2) Delays in contractor's payment; (3) Poor planning and scheduling; (4) Poor site management and supervision; (5) Incomplete or improper design; (6) Inadequate contractor experience/building methods and approaches; (7) Contractor's financial difficulties; (8) Sponsor/owner/client's financial difficulties; (9) Resource shortage (human resources, machinery, equipment); (10) Poor labor productivity and shortage of skills.

If I go back to the number one universal delay factor, which is "Design changes during construction/changed orders," it makes sense. I do not know whether I would call it a coincidence, since the literature related to it is not included sufficiently to suggest otherwise. However, comparing this topic, i.e., delay factors, with the topic of causes change in construction projects, I may get a huge surprise. I will have the feeling that "delays" and "changes" are synonyms. Two examples of studies where I can see this strong overlapping between the two topics are Wu *et al.* (2005) and Sun and Meng (2009).

Table 6.3-3: Ranking of the universal delay factors

Gr. #	Delay Factors	Fr.	ORI	Overall Ranking
1	8 – Design changes during construction/changed orders	78	18.39014	1
	6 – Delays in contractor's payment	65	15.72651	2
	16 – Poor planning and scheduling	66	13.10197	3
	17 – Poor site management and supervision	63	9.627619	4
	9 – Incomplete or improper design	59	9.073870	5
	13 – Inadequate contractor experience/building methods and approaches	53	7.254751	6
	14 – Contractor's financial difficulties	46	6.896871	7
	1 – Sponsor/owner/client's financial difficulties	37	6.634550	8
	22 – Resource shortage (human resources, machinery and equipment)	50	6.067838	9
	18 – Poor labor productivity and shortage of skills	47	5.313700	10
	11 – Poor contract management/bidding process	45	5.232993	11
	21 – Shortage of materials	39	4.369150	12
2	4 – Optimistic (unrealistic) estimation of project duration and cost	39	3.758061	13
	10 – Slow quality inspection process of the completed work	42	3.658095	14
	15 – Poor communication and coordination between parties	39	3.463277	15
	5 – Slow decision-making process	33	3.131757	16
	26 – Economic problems (e.g., inflation, fluctuation)	29	2.922468	17
	24 – Weather conditions	30	2.193764	18
	7 - Late/slow delivery of materials	28	1.779894	19
	25 – Difficulties in obtaining permits and excessive bureaucracy	21	1.263810	20
	20 – Problems related to subcontractors	26	1.111731	21
	19 – Equipment failure/equipment less productive based on estimations	23	1.010574	22
	23 – Unforeseen geological conditions	21	0.849603	23
3	29 – Security and/or unstable political situation	12	0.833469	24
	27 – External stakeholders	14	0.593862	25
	12 – Slow progress/underestimating of deadlines/many projects	15	0.450000	26
	2 – Interference by sponsor/owner/client	7	0.157963	27
	3 – Site handover/site change	8	0.151413	28
	28 – Corruption/fraudulent practices	5	0.080952	29
	30 – *Forces majeures*/Acts of God	4	0.034286	30
	33 – Sponsor/owner/client lack of commitment and clear demands	2	0.011905	31
	31 – Internal bureaucracy within project organizations	2	0.008254	32
	32 – Office issues (IT troubles, noise/disruption, many useless trips, etc.)	1	0.000952	33

Going back to the study performed in Norway and based on the survey, similar delay factors are discussed in relation to our findings, as follows:

(1) "Poor planning and scheduling" is cited in the top ten critical delay factors in 64 studies and classified as number one in six studies: Adeyemi and Masalila (2016) in Botswana; Sweis *et al.* (2008) in Jordan; Mezher and Tawil (1998) in Lebanon; Tumi *et al.* (2009) in Libya; Alaghbari *et al.* (2007) in Malaysia; and Aiyetan *et al.* (2011) in South Africa.

(2) "Slow/poor decision-making process" is listed as one of the top ten delay factors in 32 studies, and number one in three of them. The authors of the studies ranking it number one are Ezeldin and Abdel-Ghany (2013), Alwi and Hampson (2003) and Gündüz and AbuHassan (2016).

(3) “Internal administrative procedures and bureaucracy within project organizations” appeared as a delay factor in the study conducted by Abdul-Rahman *et al.* (2006) in Malaysia. In their study, this delay factor was ranked tenth on the list. Bureaucracy was mentioned in many other studies, if not in most of them; however, this referred to the excessive bureaucracy within the authorities’ administration, and difficulties in obtaining all kinds of permits.

(4) “Resource shortage (human resources, machinery, equipment)” is mentioned in 50 studies as a critical delay factor, and ranked as the first delay factor in the three studies carried out by Assaf and Al-Hejji (2006), Al-Khalil and Al-Ghafly (1999) and Baloyi and Bekker (2011).

(5) “Poor communication and coordination between parties” is mentioned in 37 studies as one of the top ten critical delay factors, and as the number one delay factor in a study performed by Luu *et al.* (2015) in Vietnam.

(6) “Slow quality inspection process of the completed work” was cited in 41 studies as a top ten critical delay factor, and as the number one delay factor in the study of Muhwezi *et al.* (2014) from Uganda.

(7) “Design changes during construction/changed orders” is mentioned in 77 studies, and classified as number one in ten of them (Koushki *et al.*, 2005; Abdul-Rahman *et al.*, 2006; Zaneldin, 2006; Yang and Wei, 2010; Kikwasi, 2012; Motaleb and Kishk, 2013; Muya *et al.*, 2013; Yang *et al.*, 2013; Ahmed *et al.*, 2014; Tafazzoli, 2017).

(8) “Sponsor/owner/client lack of commitment and/or clear demands (goals and objectives)” appeared in only one previous study, conducted by Abdul-Rahman *et al.* (2006) for the Malaysian construction industry, in the critical delay factors and among the top ten. Here I should distinguish between the lack of commitment resulting from the conclusion of the study by Abd El-Razek *et al.* (2008) and confirmed by Doloi *et al.* (2012a); both considered a lack of commitment to be the most critical delay factor. However, it would be very broad to group multiple factors from multiple stakeholders and consider all those in a single group called “lack of commitment.” The lack of commitment I mentioned here is more related to the stakeholder driving the project; the client is the one driving the project.

(9) The “Office issues” delay factor appeared nowhere in any of the studies mentioned as a critical delay factor. Our study regarding the delay in Norway is therefore an exception when it comes to this special critical factor.

(10) “Late/slow/incomplete/improper design” is mentioned as a top ten critical delay factor in 58 studies, and as the number one critical delay factor in the studies conducted by Zewdu (2016), Arantes *et al.* (2015), Couto and Teixeria (2007), Toor and Ogunlana (2008), Faridi and El-Sayegh (2006) and Elhag and Boussabaine (1999).

(11) One of the major delay factors appeared only in our study as critical, which was “User issues,” but this only appeared with a small frequency (13 out of 202, and ranked as the last one, the 11th). This last factor appeared because of some types of construction projects (e.g.,

hospitals, office facilities, etc.) where the end users are concerned about the final delivered product more than its sponsor/owner/client.

Comparing the findings from the survey in Norway with all previous studies listed in this chapter, it can be seen that there is a close similarity in the overall critical delay factors with the study findings of Al-Kharashi and Skitmore (2009) from Saudi Arabia. There were six critical delay factors in common within the list of the first ten in both studies. However, the delay factor "Poor planning and scheduling," which is number one in this study (Norway), was classified among the bottom 50 in their list. Another similarity was observed, this time with the study of Rahsid *et al.* (2013) from Pakistan, which showed five similar delay factors from the top ten list in each of the two studies. Again, the number one delay factor in our study was not among their critical delay factors; however, several were, including the third and the fifth from our study.

The delay factors in the Algerian telecommunication industry were based on two phases. The first phase was after selecting the most common delay factors based on the perception and advice of experts in the field, where 123 delay factors were selected from 224 delay factors extracted from the literature. The second phase was based on a quantitative survey, where 48 delay factors with high rankings were selected based on the 123 delay factors.

The top ten delay factors from the survey were: (1) Change in specifications, changed orders, extra works; (2) Poor site management and supervision/quality control (QC); (3) Delay in approval of completed work; (4) Unrealistic time estimation and unreasonable project period; (5) Delay in running bill payments to contractor and financial difficulties; (6) Time-consuming and slowness/late/delays in decision-making; (7) Contractor shortage of human resources (skilled, semi-skilled); (8) Delays/irregular/late payments of subcontractors; (9) Poor site layout; (10) Accepting inadequate design drawings. It is clear that all these delays are also part of the 33 delay factors, with most of them being from the top ten universal delay factors.

The top ten delay factors from the megaproject case study and based on interviews are: (1) Interference by sponsor (then owner/client); (2) Optimistic (unrealistic) estimation of project duration and cost; (3) External stakeholders (media, landowners, users, etc.); (4) Site handover/site change; (5) Poor contract management/bidding process; (6) Inadequate contractor experience/building methods and approaches; (7) Poor communication and coordination between parties; (8) Delays in contractor's payment; (9) Poor site management and supervision; (10) Poor planning and scheduling.

The top delay factor in this study is the interferences from the sponsor (client); this delay factor was in the top three in the studies of Odeh and Battaineh (2002) from Jordan, Akinsiku and Akinsulire (2012) from Nigeria, Rahsid *et al.* (2013) from Pakistan, Rahsid *et al.* (2013) and Assaf and Al-Hejji (2006) from Saudi Arabia, and Kazaz *et al.* (2012) from their study in Turkey. The same can be said for the other delay factors, all of which were mentioned in at least three studies.

In Table 6-3.3, some of the delay factors, even those with a high frequency compared to the precedent delay factor, are ranked lower (e.g., 6 – "Delays in payment of contractors," with a frequency of 61, and 16 – "Poor planning and scheduling," with a frequency of 64), and the reason for this is that the calculation of the "Overall Ranking Index" takes into consideration both the frequency and the original ranking of the delay factor. If I have a close look at the delay factors with a frequency higher than 20, the list of the top 23 critical delay factors may be in any country and any project case; these are standard and are not tailored to a specific country or a special context. However, as regards the remaining ten factors, some of them fit only a special context and country (e.g., 29 – "Security and/or unstable political situation" and 28 – "Corruption/fraudulent practices," etc.).

Another observation regards the delay factors with a frequency higher than 30. These top 16 delay factors may be described as the universal internal delay factors; the reason behind calling them "internal" is that the types of stakeholders behind the origin of these delay factors are internal to the project (i.e., mostly sponsor/client/owner, consultants, designers and contractors).

I might say that if the list was extended to the top 20 or 30 delay factors for each study, the final list would certainly exceed the 33 delay factors. However, the number of studies would be reduced almost by half, since there were many authors who limited their list to ten delay factors or slightly higher. For example, in our survey I generated only 11 delay factor groups.

Conclusions—Factors Related to Project Delay

The research described in this chapter was based mainly on raw data collected from three different sources, and based on two strategies (survey and case study). Quantitative methods were used in the two surveys and a qualitative method was used in the case study. Specific findings are briefly described in the chapter and the results of all analyses are presented in this summary. The research question addressed in this chapter is:

RQ2: What are the factors that cause delays in large-scale engineering projects?

The answer to this question is based on four main sources, and both the sources and the findings are:

1. The first source is a questionnaire (based on open questions) sent to potential participants from Norwegian organizations working in the field of construction. The results of the study led to the identification of 44 delay factors, which were grouped into 11 major delay factors in LSEPs in Norway.
2. The second source is based on a quantitative survey. The participants were mainly project managers in the telecommunications industry and they were in charge of managing medium-scale to large-scale telecommunications infrastructure projects. The results from the study were based on 224 delay factors extracted from 104 similar studies, resulted in the ranking of those 224 delay factors and a list of the 48 highest ranking delay factors.

3. Third source is based on a case study. The case study is described in both Chapter 2 and this chapter. The research was exploratory in nature and a qualitative method was used. The case study resulted in a list of the 17 major delay factors in the megaproject (Case 1).

4. Fourth used to answer the research question is all studies worldwide to date that relate to delay factors in LSEPs, including the three studies presented previously and extract the list of the most repeated delay factors. The result is list of 33 delay factors. The top 16 delay factors may be described as universal internal delay factors. The reason for referring to them as "internal" is that the types of stakeholders behind the origin of these delay factors are internal to the project (i.e., mainly sponsors/clients/owners, consultants, designers, and contractors). The results derived from this fourth source have generated a list of the most common delay factors—the universal delay factors.

This chapter unifies all previous studies conducted on delay factors in large-scale engineering projects. From a close look at the universal delay factors with a frequency higher than 20, the top 23 critical delay factors are standard and thus may be found in any country and any project case. However, with regard to the remaining 10 factors, some of them fit only a particular context and country (e.g., 29 – "Security and/or unstable political situation" and 28 – "Corruption/fraudulent practices").

Delays in large-scale engineering projects are not exceptional. From the studies presented in this chapter, it is clear that delays are universal and that all projects are exposed to the factors in those delays. Thus, it is necessary to treat them as threats and risks.

The exploration of delay factors and delay causes will help the identification of the effects of delays. As a preliminary assumption, delays are considered negative and therefore it is necessary to eliminate or reduce them in order to reduce negative effects. The two points regarding (1) the effects of delays (cf. RQ4 "Is faster better? If so, why?") and (2) how to deal with delays (part of RQ5, "How can projects be delivered faster?") are discussed in Chapter 8 and Chapter 9, respectively. Similar sources of data are used to extend the examination of the why and how sequence.

The next chapter, Chapter 7, relates more closely to the concept of project speed and its relationship with the other concepts in project management, namely project flexibility, uncertainty, and complexity. Since speed is closely related to the distance traveled per unit of time, the speed of a project is closely related to deliverables per unit of time. This concept and other are discussed and defined in the next chapter. The aim of the third "What" question, which is answered in the next chapter, is to see the problem from another recognized standpoint, instead of checking the problem from a single standpoint due to the uniqueness of the project. I discuss this issue further in Chapter 7.

CHAPTER 7

Factors Related to Project Speed

"One of the things people did best at the office was to use flexibility to its last atom."
— Pawan Mishra

"Exploring the unknown requires tolerating uncertainty."
— Brian Greene

"The art of simplicity is a puzzle of complexity."
— Douglas Horton

"The speed of the boss is the speed of the team."
— Lee Iacocca

To create a clear context to answer the research question *RQ3*, the first step in the first section is to define project speed and pace; there is no clear definition of what project speed, pace and velocity mean. Many scholars have used these concepts without any clear meaning or definition. The definitions adopted in this dissertation are an extension of a scholar who gave clear definitions to these concepts. The next thing is to briefly define the concepts "flexibility," "uncertainty" and "complexity" from the literature. Based on conducted interviews with project managers and by reflecting their experiences in managing medium- to large-scale telecoms projects, the relationship between project speed and these three concepts is determined. This identification is meant for the decision-making process at the tactical and strategic levels.

7.1 "Iron Triangle" – Project Speed, Intensity & Value

Many discussions have occurred over how best to describe the fundamental constraints that underpin project success, and that is since Martin Barnes came up with the famous "iron triangle" circa 1969. He argued that making a change to one (cost, time and scope) affects the other two. Many modifications ensued, including output being variously renamed as "quality," "scope" or "performance." Others preferred the terms "budget," "schedule" and "scope," or as used nowadays, "cheap," fast and good (Langston, 2013). The cost, time and scope are considered measures of project efficiency during the project execution. Recent literature distinguishes between project efficiency and overall project success (Belassi and Tukel, 1996; Chan, 1996; Munns and Bjeirmi, 1996; Cooke-Davies, 2002; Lam *et al.*, 2007; Shenhar and Dvir, 2007; Toor and Ogunlana, 2010; Hussein *et al.*, 2015). Project efficiency includes the things that must be done to complete a project (Jugdev and Müller, 2005; Zidane *et al.*, 2016b).

Some authors consider quality to be one of the pillars of project efficiency; but I enquire further into the concept of "quality" by asking the question: Is it the quality of the delivered product itself once the project is over or is it the quality of the project management? Zidane *et al.* (2017, 2016c, 2015a, 2012) define project efficiency as doing things right and producing project outputs in terms of the agreed scope, cost, time and quality (Figure 7.1-1). They added that quality is not a constraint *per se*, but often a by-product of the other three factors (scope, time and cost), and one that generally suffers when the others are not properly managed. Since the literature is about project management and not engineering management or technical management, academicians in the project management arena need to think more management. Thus, quality as a pillar of efficiency should be seen as the quality of management and not as a technical term (i.e., quality of the product and the service, technical specifications, etc.).

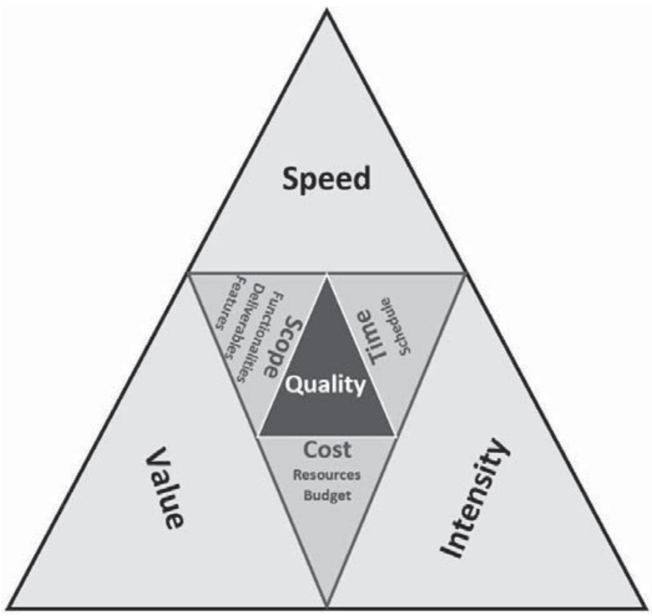

Figure 7.1-1: Iron triangle.
(Adopted from: Langston, 2013; Zidane *et al.*, 2016a)

Martinsuo *et al.* (2013) defined project efficiency as short-term interests. Such a definition is very broad since it does not reflect the perceptions (e.g., of the owner, sponsor, users, contractors, etc.); each stakeholder may see the short-term interests in a different way from another stakeholder. This will bring us to a dynamic elastic understanding of project efficiency, which will make it harder and more complex to measure. Some authors refer to project efficiency as project management success (e.g., Pinto and Slevin, 1988; Ssegawa and Muzinda, 2016). This means that project management as a mechanism and process exists only during the project implementation and not in the phases that happen before the decision to start the project, or in what occurs after the end of the project. Our concern with this definition is the part "project management success"; this is a narrow view of projecting management. Limiting project success to project efficiency will close all the doors to academicians seeing project and project management as a whole (holism school). Project management success is beyond project efficiency. Literature on project management covering topics like post-project evaluation, *ex ante* evaluation, value management and project front end emphasizes such a perspective.

The conformist wisdom suggests that if more scope is added, then cost and/or time will be systematically increased. If completion needs to be accelerated, then more budget and/or less scope must follow. If cost is lowered, then less scope and/or less time are implied. According to Langston (2013), there are examples where scope has been increased, cost efficiencies found and completion times not affected. The PMBOK Guide (PMI, 2013, p.35) states: "Since projects are temporary in nature, the success of the project should be measured in terms of completing the project within the constraints of scope, time, cost, quality, resources, and risk as approved between the project managers and senior management. … project success should be referred to the last baselines approved by the authorized stakeholders… the project manager is responsible and accountable for setting realistic and achievable boundaries for the project and for accomplishing the project within the approved baselines." Since the interests in this dissertation are more concerned with the relationships between time and scope, and time and cost, it is necessary to define those relationships, which are project speed, i.e., between scope and time, and project intensity, i.e., between cost and time (see Figure 5.2-1 and Figure 7.1-1).

a. *Project Speed & Project Pace*

Based on a course of physics (Physics Classroom 2016), the motion of objects can be described by words. Even a person without a background in physics has a collection of words that can be used to describe moving objects. Words and phrases such as "going fast," "stopped," "slowing down," "speeding up" and "turning" provide a sufficient vocabulary for describing the motion of objects. In physics, these words are used along with many more, such as "distance," "displacement," "speed," "velocity" and "acceleration." These words are associated with mathematical quantities that have strict definitions. Superposing the concepts from physics (since they are well framed, aligned and defined) on project management, project speed and pace will be defined based on how they are used in this doctoral dissertation. In physics, speed is a scalar (scalars are quantities that are fully described by a magnitude (or numerical value) alone) quantity that refers to "how fast an object is moving." Speed can be thought of as the rate at which an object covers distance. A fast-moving object has a high speed and covers a relatively large distance in a short amount of time. Contrast this to a slow-moving object that has a low speed: It covers a relatively small amount of distance in the same amount of time. An object with no movement at all has a zero speed (Physics Classroom 2016).

In project management, to the best of my knowledge, no academicians in the field of project management have defined "project speed," "project pace" and "project velocity." Exceptions can be made for software development projects (e.g., Czarnacka-Chrobot, 2014), innovation and new product development projects, and production management (e.g., Midler, 1993; Zeng *et al.*, 2007; Yaghootkar and Gil, 2012). The concept has been mentioned by other authors (e.g., Ben Mahmoud-Jouini *et al.*, 2004). However, Langston (2013) gave an explicit definition to project speed. He has defined project speed as "the ratio of scope over time, this KPI is another that should be maximized. Speed is a function of Project Procurement Management, namely outsourcing strategies and parallel supply chains. Scope is treated as an output and time as an input, so the more utility provided per unit of time the faster is the delivery process." Project scope as defined by the PMI (2013) "is the work performed to deliver a product, service or result with the logical relationships among the project schedule activities."

In project, project speed can change within a certain period. Like acceleration and deceleration in physics, project pace can speed up or slow done. Figure 7.1-2 is an example illustrating the changes of speed; such changes will also cause changes of pace – pace is the value of an average speed in an interval of time. Figure 7.1-3 represents the cash-flow report and progress report; the target accumulative progress can be achieved in a shorter period if the speed of progress is higher.

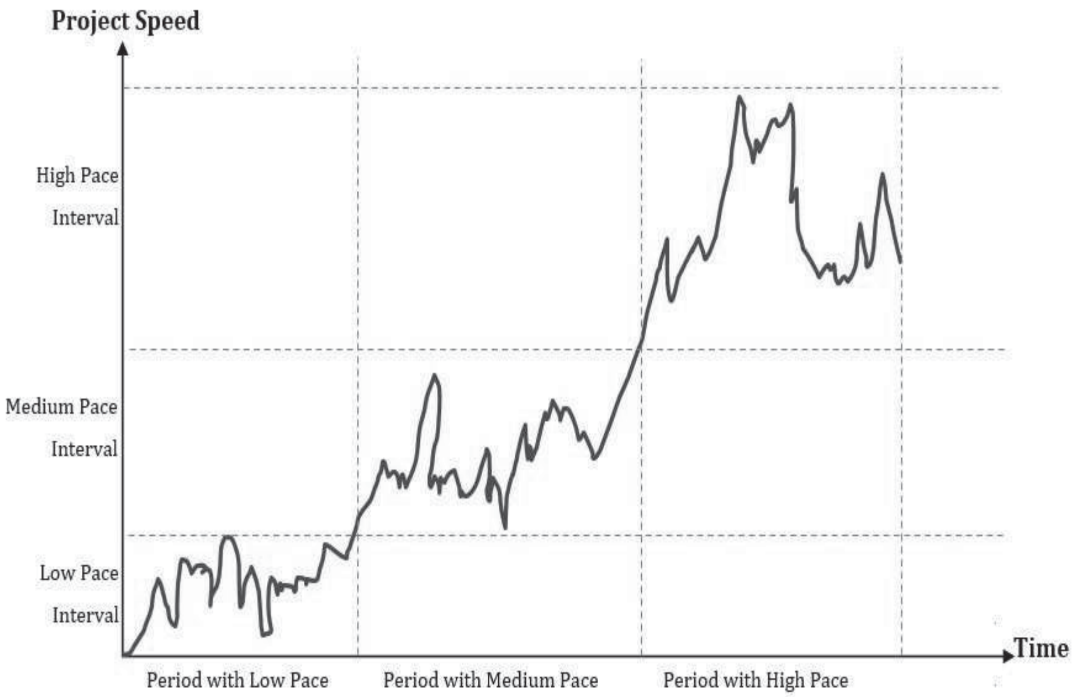

Figure 7.1-2: Project speed and project pace.

b. Project Intensity

Langston (2013) uses the term "efficiency" for the relationship between cost and time; this will confuse and interfere with the definition of project efficiency in this dissertation, thus the word "intensity" is used instead to reflect the relationship between cost and time (see Figure 7.1-1). However, the same definition is used but switching the term "efficiency" with the term "intensity," so project intensity is "the ratio of cost over time, this KPI is also one that should be maximized. Intensity [instead of efficiency] is a function of Project Human Resource Management, namely team performance and leadership. Cost in this case is treated as an output [value of work completed] and time as an input, so the more money spent per unit of time the more intense [instead of efficient] is the delivery process." Figure 7.1-3 shows the cash-flow report, where the red curve (cumulative cost) represents what was meant by the project intensity, and the blue curve the delivered scope. Both are to some extent directly proportional, however project value should be considered to confirm that, and this is defined next.

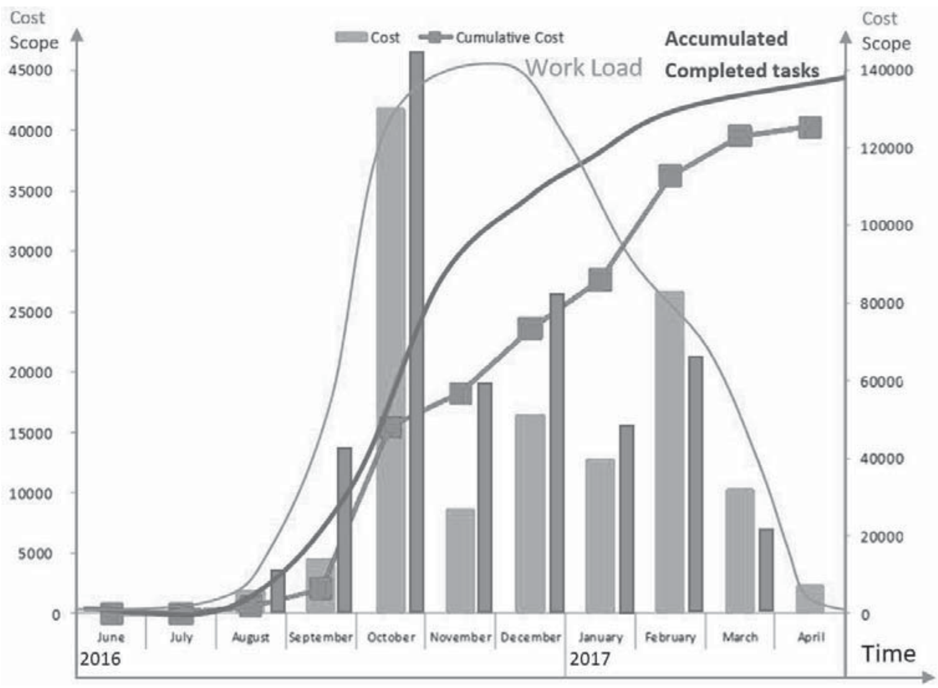

Figure 7.1-3: Cash flow (red and green) – scope progress (blue).

c. Project Value

Project value is defined as "the ratio of scope over cost, this KPI is one that should be maximized. Value is a function of Project Stakeholder Management, namely meeting expectations and fostering engagement. Scope is treated as an output and cost is treated as an input, so the more utility per unit of cost the greater is the value for money" (Langston 2013). This relationship between scope and cost is more related to minimizing waste on the one hand, and better use of "money" on the other, by making the best deals when purchasing the needs for the project. The term "value" is used in multiple contexts, which is why it should be defined in this Ph.D. work context.

7.2 Project Flexibility, Uncertainty & Complexity

This section is based entirely on a literature review. Before discussing the relationships between project speed, as discussed in the previous section, and project flexibility, uncertainty and complexity, a brief literature review is conducted regarding these concepts. There are numerous schools and scholars discussing these concepts; however, in this section, the conducted literature review is concise and oriented toward definitions meeting the research objectives.

a. Project Flexibility

According to Merriam-Webster (1984), being flexible is "characterized by a ready capability to adapt to new, different, or changing requirements." In other disciplines, such as in strategic management, flexibility is an established enabler for managing uncertainty (Olsson, 2006). Bahrami and Evans (2005) list 11 concepts related to flexibility: adaptability, agility, elasticity, hedging, liquidity, malleability, mobility, modularity, robustness, resilience and versatility. From a planning perspective, Sager (1994) points out that flexibility refers to future choices among satisfactory alternatives, and that flexibility implies adjustments in accordance with principles and criteria. Bahrami and Evans (2005) used the term "super flexibility" to describe the most flexible companies, where they consider flexibility to be a key success factor in competitive organizations. However, projects need stability to be controlled and executed efficiently, typically measured in terms of their efficiency (i.e., time, cost and scope); from this perspective, flexibility should be minimized (Olsson, 2006). One project flexibility approach to address this dilemma is to postpone irreversible decisions until more information is available (Olsson, 2006).

The engineering tradition of project management, referred to by Söderlund (2004) and Crawford and Pollack (2004), focuses on stability for projects, particularly in their later phases. The social science tradition has a greater understanding of the benefits of project flexibility. Kreiner (1995) points out that the traditional focus on stability becomes challenging under conditions of uncertainty, which creates what he calls "drifting environments." The drifting environments of a project are not always caused by actual changes but may also result when the project's stakeholders gain a better understanding of, and ability to express, their actual needs. Flexible projects are generally not desirable when the unit of analysis is limited to the project itself, but can be rational when a wider context is included in the analysis (Olsson, 2006). Real options represent one approach to project flexibility (e.g., Brennan and Trigeorgis, 2000). Real options illustrate the significance of flexibility based on theory related to financial options. Flexibility is compared to owning the right option, but not the obligation to take an action in the future (Amram and Kulatlaka, 1999). The real-options paradigm recognizes that decisions are made sequentially over phases. Uncertainty can increase for the project as long as flexibility is well maintained and resources are not irreversibly committed. The worth of flexibility can be quantified in monetary terms. Uncertainty about the future profitability of an investment project often makes it optimal to postpone commitment to a project (Brennan and Trigeorgis, 2000; Olsson, 2006).

b. Project Uncertainty

The uncertainty of a decision in a project is “the gap between the amount of information needed to perform a task and the amount of information already possessed by the organization” (Galbraith, 1973, p.5). Jensen *et al.* (2006) divide contextual uncertainty into two categories, (1) institutional uncertainty and (2) interactional uncertainty. Christensen and Kreiner (1991) make a distinction between operational uncertainty and contextual uncertainty. They relate operational uncertainty to uncertainty within the defined scope of the project, and contextual uncertainty to the project context. Karlsen (1998) discusses contextual uncertainty, which represents uncertainty generated by factors outside the project’s system boundaries, and task uncertainty, which relates to factors within project boundaries. With all these distinctions between the types of uncertainties, the purpose is to identify interactional uncertainty as representing environmental explanations necessary for understanding the circumstances of a project without including everything outside the project (Olsson, 2006).

c. Project Complexity

In project literature, there are at least 31 definitions of complexity (Gul and Khan, 2011). In systems theory, the term “complex” refers to a system that is composed of interrelated subsystems, each being, in turn, hierarchic in structure (Hussein *et al.*, 2014). Common synonyms for the term “complex” are “difficult,” “complicated,” “intricate,” “involved,” “tangled” and “knotty” (Whitty and Maylor, 2009). The term “complex” is perhaps used because of the lack of a more appropriate expression describing the interrelated features that affect a project’s life cycle, subsequently complicating decision-making (Hussein *et al.*, 2014). The term “complexity” is in common usage and practitioners have a diverse understanding of this term. Syed *et al.* (2010) attribute this diversity to the lack of clear distinction between the terms “complex” and “complicated.”

In the current project management literature, complexity can be grouped into three classes. The first class attempts to examine complex dynamic systems in terms of adaptability, nonlinearity, emergence, feedback, self-organization and dependency, and to determine how these characteristics can be used to understand single or multiple project environments (Aritua *et al.*, 2009). The second class of studies examines single elements, factors, sources or patterns that contribute to project or managerial complexity (Hussein *et al.*, 2014). The third class of studies involves efforts to propose or examine methods, processes or conceptual models that deal with one or several complexity factors. Whitty and Maylor (2009) argue that just because a project is called “complex” does not mean that complex managerial tools and techniques are required to control it. Hussein (2012) conducted an empirical investigation to document the perception of complexity among project practitioners. Its main purpose was to examine the degree to which practitioners differentiate between sources of complexity and the complicated situations that arise because of these singular elements in the course of the project. The complicated situations have therefore to do with the managerial complexities of the efforts conducted to attain the project’s goals and objectives in the presence of complex elements (Whitty and Maylor, 2009).

7.3 Project Speed vs Flexibility, Uncertainty & Complexity

This dissertation does not aim to cover the issue of uncertainty from a broad perspective. However, the distinction between the two types of uncertainty that Karlsen (1998) and Christensen and Kreiner (1991), among others, discuss has implications for the analysis of project speed. The author uses the terms "contextual uncertainty" and "internal uncertainty." Internal uncertainty is linked to operational uncertainty (Christensen and Kreiner, 1991) or task uncertainty (Karlsen, 2011).

With such a wide definition, project flexibility includes preparations to manage both internal and contextual uncertainty, such as scope change management, iterative decision process and adjustments related to uncertain funding in general (Olsson, 2006).

This part is based on evaluations of telecoms infrastructure projects in Algeria; however, the project cases are not presented in detail anywhere in this dissertation, and the data collected are based only on in-depth interviews with project managers. The interviewees, while being questioned, did have access to the documentation and evaluation reports related to the cases to provide them with information about the cases.

As discussed in the methodology chapter, unstructured interviews, or in-depth interviews, are informal and are used to explore in depth the general area in which the researcher is interested (Fontana and Frey, 2005). In this kind of interview, the interviewee is given the opportunity to talk freely about the topic, with the interaction being nondirected, and this is labeled an "informant interview." On the other hand, the other type of unstructured interview is the focused interview, where the interviewer exercises direction on the interview and guides the interviewees during the interview (Robson, 2011).

Interviewees reviewed independent project evaluation reports; the interviewees were project managers of the related project case, and all of them were from the contractor side. Their personal experience from projects was also utilized.

When it came to the nature of the research, the interviews conducted fit better qualitative research with an exploratory nature and inductive approach. The interviews were one to one, interviewer to interviewee. The interviews were telephone interviews or sometimes Internet-mediated interviews. The list of topics was refined and added to throughout the course of the interviews. The number of interviewees was five; each interviewee was in charge of three to five projects. However, the number of interviews was a multiple of three to four times (number of rounds), and there was no maximum to the number of interviews that could be conducted. The first rounds of the interviews lasted for half an hour to an hour, depending on the interviewee feedback and discussion; the time was reduced in the last rounds of the interviews.

To analyze the information related to the projects, codified data were entered into a database. This included information on the general characteristics of the project. Based on the descriptive information, an assessment was made of approaches to project speed, flexibility and complexity. This was based on subjective assessments made by the researcher. The initial number of selected projects was 29; the number was reduced to 19 due to a lack of key information for the other ten projects removed from the list. A summary of the information sources can be seen in Table 7.3-1 below.

Table 7.3-1: The information sources upon which the chapter is based

Project Type	Content	Number	Modularity	Paper	Type of data	Data source
Equipment indoor (hardware and software)	Public and private sector depending on the owner of the telecom network. Years 2007–2015	10	Low	Paper 17	Qualitative	Interviews with PMs, documents
Equipment indoor/outdoor (hardware and software) and construction (equipment rooms, shelters, towers)	Public and private sector depending on the owner of the telecom network. Years 2007–2015	9	High	Paper 17	Qualitative	Interviews with PMs, documents

Because of the design of the study presented in this chapter, the opportunities to assert the validity or test the reliability of the findings are limited. It cannot be statistically proved that the findings are generally applicable. In this study, reliability cannot be ensured through large, representative samples of research material. The methods used to extract and codify information may be affected by judgmental subjectivity. To compensate for this, several rounds of interviews were conducted.

Validity, as defined in the methodology chapter, concerns how well a measure does in fact measure what it is intended to measure. To address validity in the study of this chapter, some indicators are used. Validity and reliability associated with the data used are not sufficient, taken separately, to provide solid answers. More valid and reliable results can only be established through a series of replications. This study has to a certain extent indicated some nuances to common understanding of project speed and its relationship with project flexibility, uncertainty and complexity. Further researches are needed to clarify the extent to which these indications are of a general nature or project-specific.

The main research question in this study, as discussed in Section 2.3 in the methodology chapter, is: What are the relationships between project speed and project flexibility, uncertainty and complexity? Answering the research question 3 is base based on the definition of project speed in Section 7.1. Moreover, on the definition of flexibility, uncertainty and complexity as defined in the literature from previous existing studies. The results from answering the *RQ3*, is the understanding on the implications of the aspects of flexibility, uncertainty and complexity on project speed positively or negatively, and vice versa. Unfortunately, it was impossible for the researcher to collect the information regarding the cash flow versus scope in these projects due to the confidentiality regulations related to the interviewees' organizations on the one hand, and the limited time for the researcher on the other. Thus, the investigations were limited to the speed of the project versus the three concepts.

In line with the scale of the projects, where the budgets vary from approx. 2 to 42 US$ million, the analysis is based on the strategies of the projects and major events. Table 7.3-2 shows the project attributes that were used in the study.

Table 7.3-2: The parameters used in the study

Measurement	Scale, alternatives
Type of project/industry	Telecommunications infrastructure projects (buildings, shelters, towers, equipment)
Project size	Completed project with budgets vary between 2 and 42 US$ M
Type of complexity	Organizational, technological, structural, uncertainty in goals, uncertainty in methods, pace, people uncertainty, environmental uncertainty
Complexity level	High, medium, low
Complexity in project phase	Front-end, planning, execution
Type of flexibility	Change, extension, contingency planning, late locking, continuous locking, none
Flexibility in the product	High, medium, low
Flexibility in the process	High, medium, low
Degree of modularity	High, medium, low
Pace of the project in the front-end phase	High, medium, low
Pace of the project in the planning phase	High, medium, low
Pace of the project in the execution	High, medium, low
TTD	Ahead of schedule, on schedule, behind schedule
Cost overrun	Under budget, on budget, over budget
Meeting project goals	Yes, no

The types of complexity listed in the table came from the literature review as mentioned previously. Organizational complexity is the degree of operational interdependencies between organizational units (Baccarini, 1996).

Structural complexity is the number of elements and their interdependence in the project, the reciprocal interdependence adding the most complexity (Baccarini, 1996; Williams, 1999). Williams (1999) added to the complexity uncertainty – i.e., in methods and goals. However, Gul and Khan (2011) extended that to environmental and people uncertainty.

Bosch-Rekveldt *et al.* (2011) mentioned that there is also technical complexity, which comes from the content of the project; in this study, the interviewees referred to it as technological complexity, due to the complexity of the project coming from the technology used. The last type of complexity is pace, with Geraldi *et al.* (2011) mentioning that high pace might cause an increase in complexity.

The two types of flexibility stated in Table 7.3-2 are flexibility in the product and flexibility in the process. Flexibility in the decision process is based on an approach where decisions and commitments in the projects are made sequentially over episodes: (1) a "late locking" of project concepts, specifications and organizations can be used (Miller and Lessard, 2000); (2) A "continuous systematic locking" of the project by a successive commitment to projects (Eskerod and Östergren, 2000); (3) The "contingency planning," where a set of base plans is defined, but also a set of alternative plans that can be activated if needed. According to Chapman and Ward (1997), contingency plans reflect anticipated potential departures from the defined plans for a project. Contingency plans are alternative plans that can be used if the baseline plans cannot be executed. As described by Brand (1994), flexibility in the product is achieved when the final product of the project is prepared for alternative use.

Table 7.3-3 summarizes the analysis of the project cases based on interviews. Since the interviews were conducted only with contractors' PMs, the analysis is based on that perception.

Table 7.3-3: The studied projects and related PMs from contractor perspective

PMs	Project #	Complexity type	Complexity phase	Complexity source	Flexibility type – level	Flexibility phase	Flexibility level	Pace front-end	Pace planning	Pace execution	Efficiency level	Effectiveness level
1	1	Technological	All phases	New technology	Contingency planning	Front-end	High	Medium	High	High	High	High
	2	Technological	All phases	New technology and existing equipment	Contingency planning	Front-end	High	Medium	High	High	High	High
	13	Technological	Front-end, HO	Owner – users	Change	All phases	High	Medium	High	High	Medium	High
	15	Pace	Front-end	Owner – users	Change	All phases	High	Low	High	High	Low	High
	16	Structural, organizational	Front-end	Modularity, number of organizations	Change	All phases	High	Medium	Medium	Low	Low	Medium
	18	Uncertainty in Methods	Front-end, execution	Modularity, number of organizations	Change	Plan, execution	High	Low	Low	Low	Low	High
	19	Uncertainty in Methods	All phases	New technology – PM	Change	Plan, execution	High	Low	Low	Medium	Low	High
2	3	Technological	All phases	New technology and existing equipment	Change	Front-end, planning	Low	Medium	Medium	Medium	Medium	Medium
	8	Pace	Execution	Owner – Users	Extension	All phases	High	Medium	Medium	Medium	Medium	High
	17	Uncertainty in goals	Execution	Owner – users	Change	Planning, execution	High	Low	Low	Low	Low	High
3	7	Uncertainty in goals	Front-end	Owner	Contingency planning	All phases	Low	Medium	Low	Low	Low	Medium
	10	Technological	Front-end, execution, HO	New technology and existing equipment	Contingency planning	Front-end, planning	Low	Medium	High	High	Medium	Medium
	11	Structural	All phases	Modularity, number of organizations	Extension	Execution	High	Low	Low	Low	Low	Medium
	14	Technological	All phases	New technology and existing equipment	Contingency planning	Front-end, planning	Low	Low	Low	Low	Low	Medium
4	6	Technological, uncertainty in goals	All phases	Owner interferences and mistakes – subcontractors unqualified	Change	Execution	Low	Low	Low	Low	Low	Medium
	12	Uncertainty in goals	Planning, execution	Owner interferences and mistakes	Change	Execution	High	High	High	Medium	Very low	Abandoned
5	4	Technological	Front-end, execution, HO	New technology and existing equipment	Change	Planning, execution	Low	Low	Medium	Medium	Medium	Medium
	5	Technological	Front-end, execution, HO	New technology and existing equipment	Contingency planning	Front-end, planning	Low	Low	Low	Low	Low	Medium
	9	Technological	Front-end, execution, HO	New technology and existing equipment	Contingency planning	Front-end, planning	Low	Low	Low	Low	Low	Medium

a. Project Speed vs Project Flexibility

All the coming discussions are based on the collected data from the project managers on the contractor side only (see Tables 7.3-1, 7.3-3), and they do not reflect exactly all the stakeholders' perceptions involved in the set of selected projects.

Flexibility was used in a different level in all phases of five projects, seven projects with high flexibility in the front-end phase, eight in the planning and seven in the execution. The most common types of flexibility used are change and contingency planning, with change in ten projects and contingency planning in seven.

Owners and users are more likely to be interested in flexibility than the project management and contractors (Olsson, 2006). Across the 19 projects, this study supports this assumption. In the studied projects, users were generally positive toward flexibility, but also very concerned about the time to delivery of the product, especially when it comes to new products to the market or extending the existing product capacity – e.g., Projects 11, 16, 17, 18 and 19. However, this positive attitude toward flexibility does not fit with implementing the project, which leads to delaying it. When it comes to the other types of projects, where the users do not know the goals of the projects, the users have less interest in the projects and their purposes.

Owners/clients are positive toward flexibility for all types of projects – i.e., new products, extending the existing products or renewal of the existing products. This flexibility from the owner/client affects negatively the speed of the project if it comes during the planning and especially the execution. Before the project, the owner/client spends a lot of time making decisions, and the process is always slow in selecting the desired solutions. This is due to many reasons, including missing trust between the client and their contractors, the different choices in the available technical solutions and the high competition among the contractors.

Stakeholders whose incentives are related to delivering the project on time and within budget saw flexibility as a threat (Olsson, 2006). That is the case for contractors' project managers. The use of flexibility in the execution leads to rework because of changes, modifying agreed plans and waiting time to take new decisions. All the project managers agreed that flexibility in execution is against the project pace and it is not advised at this stage of the project. However, Project Manager 1 mentioned that the use of flexibility in the process in the front-end phase was very beneficial for the whole project, with Projects 1 and 2 being successful in terms of both efficiency and effectiveness, and they were fast projects. The secret was involving the contractor team in the very early phases; when the top management of the client decided on those projects, this early involvement made the contractor's team more informed and able to share more knowledge about the projects.

There were nine projects with high modularity – i.e., modularity is the possibility of dividing the project into clusters and executing them in parallel. This type of flexibility in the product can allow fast execution if the contractor has enough resources. This was not the case in most of the nine projects in the studied set of projects. This modularity is seen only in the access part of the telecoms projects (see Figure 2.4-8).

b. Project Speed vs Project Complexity

The complexity of the project was seen in this study based on the perception of the interviewees. Ten projects were seen to have technological complexity; this complexity is noticed in core network projects (see Figure 2.4-8). The reason is that core network projects use high technology and the worst part is the adaptation of the new technology to the existing technologies when it comes to extension projects. In addition, the core network projects have no, or very limited, modularity; this limitation of modularity will restrict being able to divide the project into clusters and completing them in parallel, so the core network projects are complex because of the technology and because of the nonmodularity in their scope. The effect of this complexity on project speed is seen in the front-end and planning phases; once the project team has all the technical answers, the progress and project pace will keep increasing continuously until the end of the project.

There is one project, number 15, where the complexity of the project came from the pace and pressure to speed up the project from the owner/client. This pressure in speeding the project is dictated from the market need, where there were more demands from users to provide new lines. However, the project is mostly an access network project, which allowed flexibility in dividing it into clusters. The project manager divided the project into six similar-size projects, and assigned a project manager to each cluster; this allowed the project pace to be increased, especially in the execution phase. The project was delivered behind schedule, because of the long wasted time in the front-end phase. Projects with complexity such as “uncertainty in goals” do not have good reputations. The problem with these projects is that the owner/client has no clear idea about the real goal of the project. Project number 12 had been abandoned because of this kind of complexity, where the owner interfered during the project execution and made a decision to agree plans and scope that led to a chaotic situation: The project was over budget, behind schedule and never succeeded in meeting the desired outcome, which eventually led to it being abandoned. Even the pace of delivery was high; the deliverables did not meet the desired purpose of the project, and this meant that the project speed was high but in a negative sense, or in the opposite direction to the right one.

Structural and organizational complexity, as well as complexity coming from uncertainty in methods, are due to the project manager’s experience within the contractor’s organization and getting used to the process, methods of management and administration rules. As Project Manager 1 stated: *“When I started my career in this company, I did not know that there were many IT systems that I should use continuously for everything related to my work; for me that was more complicated than my work as project manager.”*

In terms of the complexity level, in general it appears in early phases, especially in the front end, or at the end of the front-end phase, since that is the usual time when the project manager from the contractor is involved. Then the level of complexity starts to be reduced in the planning. However, the level may increase dramatically in the execution and handover (HO) phases, due to the unidentified uncertainties and missing information once the team starts the execution of the project. This demonstrates again that uncertainty is a part of complexity.

Conclusions—Factors Related to Project Speed and Implication for Project Management Practice

The research described in this chapter was started by setting the frame and selecting the appropriate concepts (i.e., project speed, project intensity, project value, flexibility, complexity, and uncertainty). The data source is raw data collected from three different sources, mainly interviews and documents. The method is qualitative and the research is an explanatory in nature. Specific findings from this chapter are briefly described and the results of all the analyses are combined in this summary below. The research question (RQ3) answered in this chapter is:

RQ3: What are the relationships between project speed and project flexibility, uncertainty, and complexity?

The answer to this question is based on the following definition of project speed: “the ratio of scope over time […]. Speed is a function of Project Procurement Management [...]. Scope is treated as an output and time as an input, so the more utility provided per unit of time the faster is the delivery process.”

The main findings are:

1. The study indicates that flexibility in the process is advised only in the front-end phase. However, it will make the sponsor/client spend a long time in the phase before deciding to start the project, especially if the contractors are not fully involved in it. Projects take a long time before the client decides to start implementing them. However, once the decision is made, the client wants the project to be finished as soon as possible.

2. Flexibility after the front-end phase will affect the speed and pace of the project if the project is a core network project in which there is no modularity in the execution of the project. However, the access network type has the advantage of modularity, which allows the execution of the project in blocks and in parallel. This will increase the speed of the project (scope/time) if there are enough resources for a parallel execution.

3. For the contractor’s project managers, flexibility in the process can be tolerated in the front-end phase and to some extent in the planning phase before starting the execution phase. However, the contractor prefers to have no process flexibility once the project moves into the execution phase. The only tolerance can be for projects with high modularity, such as access network projects.

4. Since core network projects have almost no modularity, the preference of the contractor is to have no flexibility in the process or the product, and the best way to avoid flexibility in the execution phase is to extend the planning phase if the contractor was not sufficiently involved in the front-end phase. This extension will need time, but will save time in the execution phase by avoiding mistakes and uncertainties due to rushing.

5. The complexity of the project affects the speed of the project negatively: the more complex the project is experienced by the project manager and his/her team, the more time is needed to make decisions and progress. Base on my research, I find that the project complexity comes from two main sources: (1) the level of the new technology used in the project, the ability of the project manager to understand it, and the degree to which the technical team can simplify this complexity for the management; and (2) the degree to which project manager is aware of his/her organization process, systems, and administration rules.

The project managers suggested the following ways to deal with complexity sources, which have implications for project management practice.

1. The provision of training in the administrative rules, the use of the company's IT systems, and the organization structure and processes before someone is appointed as project manager will reduce any ambiguity from their side.

2. The appointment of the project manager as a deputy project manager to run projects for a certain period before appointing him/her as an independent project manager (i.e., only in the case of newly hired, experienced project managers).

3. Project managers with a background in telecommunications (telecoms engineers) have more chance of avoiding any ambiguity in the understanding of the project scope and dealing with the complexity coming from the technology. Project managers should be appointed from the same field in projects with high technical complexity.

In the next chapter, I examine the "Why" behind both faster project delivery and the benefits of speeding up project delivery, if any.

CHAPTER 8

Faster! Always Better?

"I live my life a quarter mile at a time."
— *Dom Toretto*

''There are two kinds of firms—the quick and the dead.''
— *Andy Grove*

The purpose of this chapter is to investigate "Why delivering slowly and/or behind schedule is a problem, and should we always go faster?" – Of course, without neglecting to explain the negative effects of the delay factors identified in Research Question 2. In other words, "Why should delay factors be dealt with?" This will be discussed in the first section. The second section is a comparison between NPD projects and construction projects; the comparison is related to the value of TTM versus the project cost in the two types of these projects. There is a high probability that fast project delivery or ahead-of-schedule delivery is not wanted by all stakeholders; even being on schedule is not a motivation for all parties involved in the project. Thus, it is necessary to answer the question related to which types of projects need to be delivered faster and/or whether there is a need for projects to be categorized based on the project pace and urgency. This chapter, like the last three previous chapters, is based on empirical studies. The first section is based on the literature review already used in Chapter 6, and on a case study, "Case 1", as detailed in the methodology chapter. The second section is based on a conceptual and qualitative interpretation of the concept of TTM in NPD projects, then in construction projects. The data used are recycled from a study conducted by a group of researchers in Finland. Another case study, "Case 2", is used to illustrate the motivation behind speeding up the delivery of that project. The chapter ends with a categorization of projects.

8.1 Effects of delays – Literature & Case 1

Projects behind schedule are an indicator of poor productivity and bad project performance (Ramanathan *et al.*, 2012). Any delay in a project can lead to cost and time overruns, and these two are connected (Sambasivan and Soon, 2007). When projects are delayed, they are either extended or accelerated, and therefore incur additional cost. It's common practice to keep a percentage of the estimated project cost as a contingency allowance in the contract price (Ramanathan *et al.*, 2012). Delays can also cause increased costs, and loss of competitive advantage and market share. Additional costs may be incurred through disputes and claims among involved parties (Odeh and Battaineh, 2002). For the project owner, delays may lead to loss of revenue through a lack of production facilities, rentable space or shortcomings with the present facilities. For the contractor, delay may result in cost overrun due to a longer work period or penalties, and higher material and labor costs (Assaf and Al-Hejji, 2006; Khoshgoftar *et al.*, 2010).

According to Al-Khalil and Al-Ghafly (1999), delays can undesirably affect project stakeholders; this is also confirmed by Zidane *et al.* (2016c) based on their study conducted on the road construction project in Algeria. To the client, delay means loss of revenue due to a lack of rentable space or lack of production facilities. On the other hand, to the contractor, delay can be mean higher overhead costs, and higher material and labor costs, because the project takes longer than was planned. The possibility of delivering projects on time can be marked as an indicator of efficiency, but construction involves many unpredictable factors and variables that arise from various sources (Assaf and Al-Hejji, 2006). These sources may include environmental circumstances, availability of resources, stakeholders' performance and contractual relations. Nevertheless, Trauner *et al.* (2009) state that construction projects hardly ever finish within the planned time. According to Kikwasi (2012), a prolonged period of disruptions affects construction programs negatively. He emphasized that disruptions and delays are among the critical challenges faced in the course of executing construction projects and are sources of potential risks. According to Aibinu and Jagboro (2002), who investigated the effects of project delays in the Nigerian construction industry, the six main effects of construction delays are: time overrun, cost overrun, dispute, arbitration, litigation and total abandonment.

In a study carried out by Kaliba *et al.* (2009) in Zambia about the schedule delays in road construction projects, they stated that the major effects of schedule delays in these projects were identified as being poor quality of end product, project extension, litigation and cost overruns. Amoatey *et al.* (2015) performed a study on Ghanaian state housing construction projects; they identified in their study ten effects of delays, with the most important being cost overrun, followed by time overrun. Cost overrun was one of the most important effects of delay in construction projects based on the studies of Kaliba *et al.* (2009), Sambasivan and Soon (2007), and Faridi and El-Sayegh (2006). While conducting the case study (Case 1) described in the methodology chapter and in Chapter 6, some of the notable effects of delays were also collected. However, in this study, the effects are not classified and ranked. Table 8.1-1 summarizes them, along with those from the literature.

Table 8.1-1: Effects of delays in the megaproject compared to literature

Effects of delays	In Case 1	From literature review (existing studies)
Cost overrun	Project cost overrun: > US$ 4.2 billion.	Oshungade and Kruger (2017); Amoatey *et al.* (2015); Akinsiku and Akinsulire (2012); Kikwasi (2012); Pourrostam and Ismail (2012); Pourrostam and Ismail (2011); Haseeb *et al.* (2011a); Haseeb *et al.* (2011b); Sambasivan and Soon (2007); Aibinu and Jagboro (2002).
Time overrun	Project delivery behind schedule: > 5 years.	Oshungade and Kruger (2017); Amoatey *et al.* (2015); Akinsiku and Akinsulire (2012); Kikwasi (2012); Pourrostam and Ismail (2012); Pourrostam and Ismail (2011); Haseeb *et al.* (2011a); Haseeb *et al.* (2011b); Sambasivan and Soon (2007); Aibinu and Jagboro (2002).
Litigation	With one of the main contractors (east side contractor).	Oshungade and Kruger (2017); Amoatey *et al.* (2015); Akinsiku and Akinsulire (2012); Pourrostam and Ismail (2012); Pourrostam and Ismail (2011); Haseeb *et al.* (2011a); Sambasivan and Soon (2007).
disputes	With one of the main contractors (east side contractor).	Oshungade and Kruger (2017); Akinsiku and Akinsulire (2012); Kikwasi (2012); Pourrostam and Ismail (2012); Pourrostam and Ismail (2011); Haseeb *et al.* (2011a); Haseeb *et al.* (2011b); Sambasivan and Soon (2007); Aibinu and Jagboro (2002).
Lack of continuity by client	-	Amoatey *et al.* (2015).
Negotiations	In all levels, even without delays.	Haseeb *et al.* (2011a).
Arbitration	With one of the main contractors (east side contractor).	Oshungade and Kruger (2017); Amoatey *et al.* (2015); Akinsiku and Akinsulire (2012); Kikwasi (2012); Pourrostam and Ismail (2012); Pourrostam and Ismail (2011); Haseeb *et al.* (2011a); Haseeb *et al.* (2011b); Sambasivan and Soon (2007); Aibinu and Jagboro (2002).
Termination of contract	With one of the main contractors (east side contractor).	Amoatey *et al.* (2015).
Increased portfolio of "nonperforming" projects	Rework projects because of the very bad quality.	Amoatey *et al.* (2015).
Contractor in financial crisis	Delay inspections cause delay in contractors' payments, which lead to crisis on contractors' side.	Oshungade and Kruger (2017); Amoatey *et al.* (2015); Akinsiku and Akinsulire (2012).
Difficulties with payment	Delay inspections cause delay in contractors' payments, which lead to crisis on contractors' side.	Oshungade and Kruger (2017); Amoatey *et al.* (2015); Akinsiku and Akinsulire (2012); Kikwasi (2012).
Total abandonment of project	With one of the main contractors (east side contractor).	Oshungade and Kruger (2017); Amoatey *et al.* (2015); Akinsiku and Akinsulire (2012); Pourrostam and Ismail (2012); Haseeb *et al.* (2011a); Pourrostam and Ismail (2011); Sambasivan and Soon (2007); Aibinu and Jagboro (2002).
Wastage and underutilization of manpower, idling resources	At all levels (contractors, subcontractors, etc.).	Oshungade and Kruger (2017); Akinsiku and Akinsulire (2012); Kikwasi (2012); Sambasivan and Soon (2007); Aibinu and Jagboro (2002).
Contractor's reputation	With one of the main contractors (east side contractor).	Akinsiku and Akinsulire (2012).
Extra taxes	The highway will have no incomes since its use will be free until 2017, thus apply more taxes on citizens.	Akinsiku and Akinsulire (2012).
Negative social impacts	Society was not satisfied with the project efficiency.	Oshungade and Kruger (2017); Kikwasi (2012).
Bad quality of outputs and work due to rush	Rush due to delays led to bad quality of the highway.	Oshungade and Kruger (2017); Kikwasi (2012).
Creating stress on contractors	Pressure from MTP and virtual enterprise created useless pressure.	Oshungade and Kruger (2017); Kikwasi (2012).
Fatal accidents	Accidents caused because of rush to catch up on the delays.	
Delay from getting profit on client side	There is no direct profit from this project since it is free use.	Oshungade and Kruger (2017); Kikwasi (2012).

Cost overrun is the excess of planned budget or cost for a project and is considered one of the most important effects of project delays; in the megaproject case, there was a cost overrun of more than US$ 4.2 billion compared to the initial estimate. The cost overrun was accepted for a start-up period of a few months, which was not enough. The cost estimations were done based on the wrong assumptions: for example, by supposing that the land was flat and that the project would need minor modifications. This was not the case for this project, since most of the land is on mountains and hills (billions of tons of soil needed to be moved from or to the highway). This also caused delays and extra costs. Other common reasons for project cost overruns include inaccuracy of cost estimates, unrealistic project design, poor planning relating to assigned duration to project tasks and scope changes.

Time overrun is also one of the most important effects. The project was completed more than five years behind schedule. The initial plan was to finish the project within three years, but because of the complexity of the project and many technical obstacles (including thousands of internal stakeholders), it was impossible to meet the target completion date. Factors such as "interference by sponsor (then owner/client)," "optimistic (unrealistic) estimation of project duration and cost," "external stakeholders (media, landowners, users, etc.)", "site handover/site change," "poor contract management/bidding process" and "delay in the payments for the work completed" directly affected the completion of the project and caused time overrun.

Litigation is also considered an important effect of delay. Sometimes parties involved in projects use litigation as a last alternative to settle disputes (Sambasivan and Soon, 2007; Amoatey *et al.*, 2015). Litigation was caused by the increased demand from the client to meet the delivery date, which was completely impossible.

Arbitration involves using a third party to resolve project disputes amicably without going to the courts (Sambasivan and Soon, 2007; Amoatey *et al.*, 2015). Arbitration is mostly necessitated by factors such as a lack of clear understanding of contract documents by all stakeholders and contract flaws.

The contract was terminated at the main contractor level, whereby one of the two contractors litigated against the client. This led to termination of their contract, followed automatically by the termination of hundreds of contracts with that contractor and their subcontractors, suppliers and consultants.

Some causes of delays left contractors and subcontractors in financial crises, delays in contractors' payments being one of the main factors. The reason for these delays was related to other delay factors: the delay in carrying out inspection of the completed work, and a shortage of the resources required to complete the inspection. All this led to delays in paying first the contractors, then the subcontractors and suppliers.

Fatal accidents were caused by one of the contractors using explosives to speed up the digging of tunnels. This use of explosives led to loss of life and destroyed some houses due to a landslide caused by the explosions. This also had an effect on the reputation of the contractor.

8.2 Time-Cost Trade-offs in NPD vs Construction Projects

The purpose behind balancing time and cost is to avoid wasting resources. If the direct and indirect costs can be accurately discovered, then a region of feasible budgets can be found, bounded by early-start and late-start activities. Time-cost trade-off relationships are created by searching for the lowest possible total costs (i.e., direct and indirect) that likewise satisfy the region of feasible budgets. These methods, like the critical path method (CPM), use the concept of slack time and the maximum amount of time that a job may be delayed for beyond its early start without delaying the project completion time. The critical path determines the optimum project duration, and this will determine the minimum total costs of the project (Kerzner, 2009).

This Section 8.2 is particularly concerned with the time-cost trade-offs in large-scale engineering projects. The time-cost trade-off curve is explained in general, followed by a qualitative analysis of the same curve and its transformation in "successful" NPD projects and of how the changes happened in less than three decades to achieve the high efficiency and effectiveness that we now know within this type of project. The curve will be used in looking back on the actual situation within the construction industry. Four successful (in terms of efficiency and effectiveness) construction projects from other countries are presented to show that the construction industry can learn from the industry's notable innovative projects.

In order to attain the research objective presented in this section, a literature review has been carried out on the concept of time-cost trade-offs in new product development projects and construction projects. Although many authors have written about time-cost trade-offs based on quantitative methods, nothing, to the best of my knowledge, has been said about the time-cost trade-off curve and its interpretation by relating it to the efficiency and effectiveness of the project. To achieve this purpose, the results used mainly come from the work conducted by some researchers on NPD projects and construction projects and are not limited to Schmelzer (1992), Hutchinson (2007), Ben Mahmoud-Jouini *et al.* (2004), Karlsson *et al.* (2008), Demartini and Mella (2011), and Kim *et al.* (2012), Construction project cases studied by the School of Civil Engineering at the University of Leeds were used to look at their time and cost overrun to try to allocating on them on the time-cost trade-off curve in construction projects. The same is done for the four cases used by Karlsson *et al.* (2008) to come up with a new assumption about the time-cost trade-off curve. For NPD projects, the time-cost trade-off curve is a qualitative conceptual interpretation coming from the changes taking place in industries that are based on innovative projects from a few decades ago until the present. This is based on the interpretation of Schmelzer (1992), Stalk and Hout (1990, 2003), and Hutchinson (2007).

8.2.1 Time-Cost Trade-offs in NPD Projects

The evolution of time-based competition follows a continually evolving global manufacturing environment, where the order winners quickly become order qualifiers (Hutchinson, 2007). The manufacturing industries, which are based on innovation and NPD, have struggled to keep up with the global competition in the new millennium, as the basis of competition has shifted from cost to quality, to variety and now to speed, where time to market has been becoming more important than the amount of money invested and accounting (Hayes *et al.*, 2005; Hutchinson, 2007).

Most innovative companies in this new era of globalization are more concerned with time reduction as their first/major priority than cost reduction (Ansoff, 1965; Rich and Hines, 1997; Porter, 2008; Demartini and Mella, 2011). Hutchinson (2007) and based on an adaptation from Blackburn (1991), as illustrated in Figure 8.2-2, concerning the long-term trends in manufacturing. He plotted the graphs with the 1950s, 60s, 70s, 80s, 90s, 2000s and beyond on the x-axis have been made, and he plotted lines indicate roughly how industry norms have changed from decade to decade. Changes in the periods present a revealing picture of the evolution towards time-based competition that is almost universal across all industries.

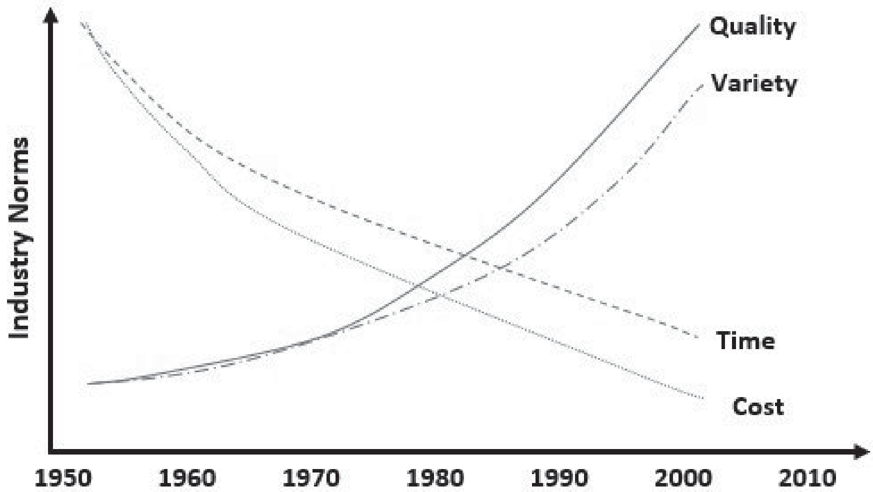

Figure 8.2-1: The trend of manufacturing: towards time-based competition.
(Adopted from: Hutchinson, 2007, p.34)

The aim here is to understand the NPD projects and to reflect and learn how the same behavior can be relevant to construction projects (this will be discussed further in Chapter 9). By going through the literature about NPD projects, attempt to interpret the information in a conceptual, qualitative way to develop the time-cost trade-offs curve, as illustrated in Figure 8.2-3.

It can be seen that NPD projects went through two paths crossing three major states ("0," "1" and "2"). State "0" depicts many companies that are cost-reduction oriented; this is because the markets are closed and fewer newcomers enter the local market. One example that illustrates this is that fewer Japanese cars were sold in Europe a few decades ago than is the case nowadays. When globalization appeared, the survivors were the companies that changed direction from cost-reduction orientation to time-reduction orientation.

The value of time (time to market) increased, and this increment led companies to crash their NPD projects to be first in the market, thereby ensuring their survival (moving gradually from state "0.1," "0.2," etc., as the competition increases, up to state "1"). Based on some case studies, Schmelzer (1992) explains that when comparing an increase in the total project costs of 50 percent (crashing the project, state "0.1" and up) versus trying to fit the optimum path duration (state "0"), the latter will be more harmful.

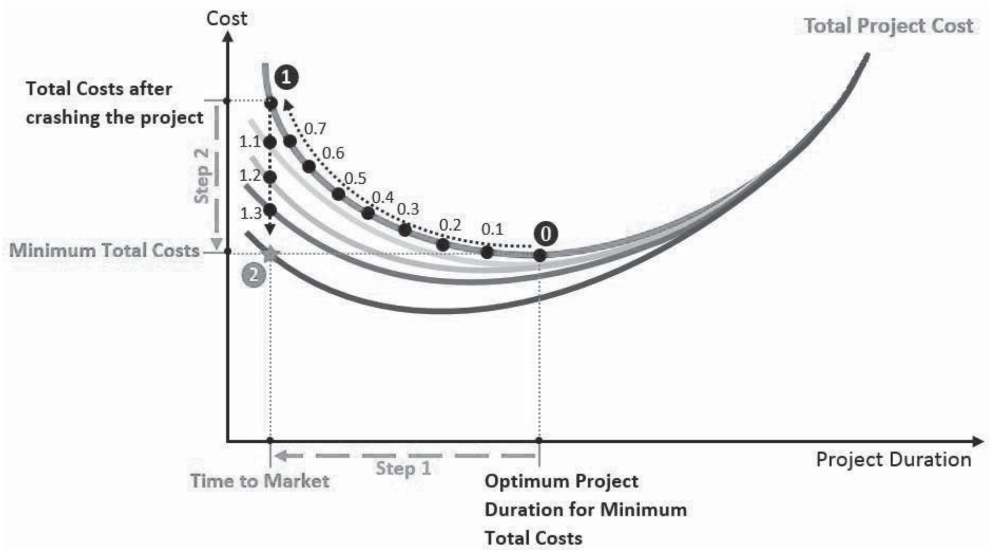

Figure 8.2-2: Time-cost trade-offs in NPD projects.

Being effective to maximum will ensure the company's competitive advantage in the market. On the other hand, companies want maximum profits from their NPD projects, and they increase efficiency to its maximum while they have maximum effectiveness. Figure 8.2-4 is based on Schmelzer (1992) after combining it with Figure 8.2-3.

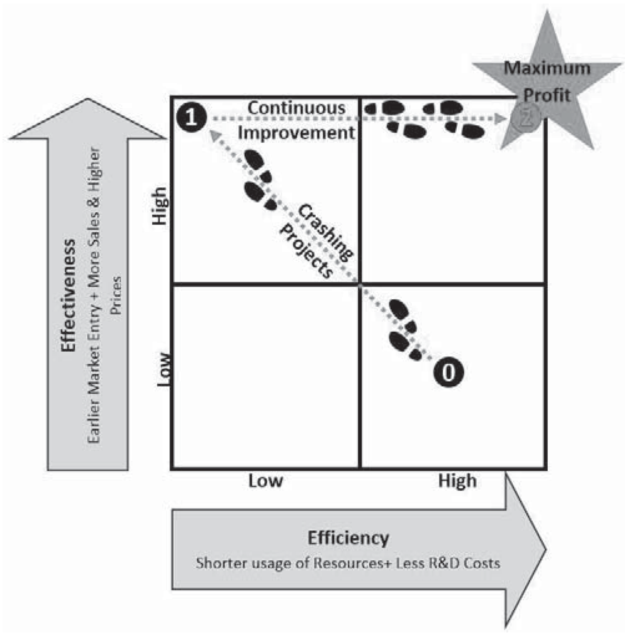

Figure 8.2-3: Efficiency vs effectiveness matrix for time-based management.

The leading companies are those that ended in state "2," where they are (1) highly effective by being the first into the market with high sales and prices and (2), as a secondary objective, increasingly efficient by improving their NPD projects' delivery management and methods through continuous improvement.

8.2.2 Time-Cost Trade-offs in Construction Projects

The construction industry is notoriously fragmented: A typical project will involve up to six or more different professional disciplines/suppliers. This has led to numerous problems including, *inter alia*, an adversarial culture, fragmentation of the design and construction data and a lack of true life cycle analysis of projects (Anumba *et al.*, 1997; Zidane *et al.*, 2015e). The number of organizations involved within a single construction project will increase with the increment in the project size and complexity (Zidane *et al.*, 2013, 2015b, 2015d). Therefore, when comparing NPD projects, one of the main reasons behind the bad performance of construction projects in general is the projects' attributes – including their environment. The motivation behind NPD projects to finish fast is driven more by globalization. However, construction projects cannot be generalized in that way; each project is singular to the point where the motivation behind being fast depends on the definition of project success given/interpreted by its key stakeholders.

Figure 8.2-4 represents time-cost trade-off curves in construction projects. The red zone to the right represents the majority of construction projects. Here, I refer to the study performed by the University of Leeds on many construction megaprojects in Europe (University of Leeds 2015); all the projects came in over budget and behind schedule (represented by red dots in the red zone in Figure 8.2-4). In the same figure, the left gray zone depicts construction projects that ended ahead of schedule but were over budget due to compression or crashing of the projects. There are a few rare exceptions, but in general, these kinds of projects are motivated to speed up because of their sense of emergency, their immediate needs to materialize their outcome and purpose. Going through many construction project cases, it was found that some cases have been completed ahead of schedule and under budget. Table 8.2-1 (Karlsson *et al.*, 2008, p.297) summarizes a few of them. These cases are represented by the green dot on the green curve in Figure 8.2-4.

Table 8.2-1: Four cases of construction projects (Karlsson *et al.*, 2008)

Project type	Country	Planned duration	Estimated cost	Ahead of schedule	Cost saving US$
Mixed-use office building	Finland	3 years	US$ 25 million	29 working days	17300
School	Sweden	10 months	US$ 7.5 million	4 calendar months	81000
Commercial retail store	UK	1 year	US$ 25 million	20 working days	19000
Educational training center	USA	10 months	US$ 5.2 million	46 working days	27000

The cases can provide another interpretation of the curve in construction projects, knowing that these four projects used a different methodology, which was based on concurrent engineering philosophy. That means there are opportunities for construction projects to position themselves on the left side of the green curve by first looking for the value of time to delivery, then introducing competitive management methods and keeping on making continuous improvements to their practices.

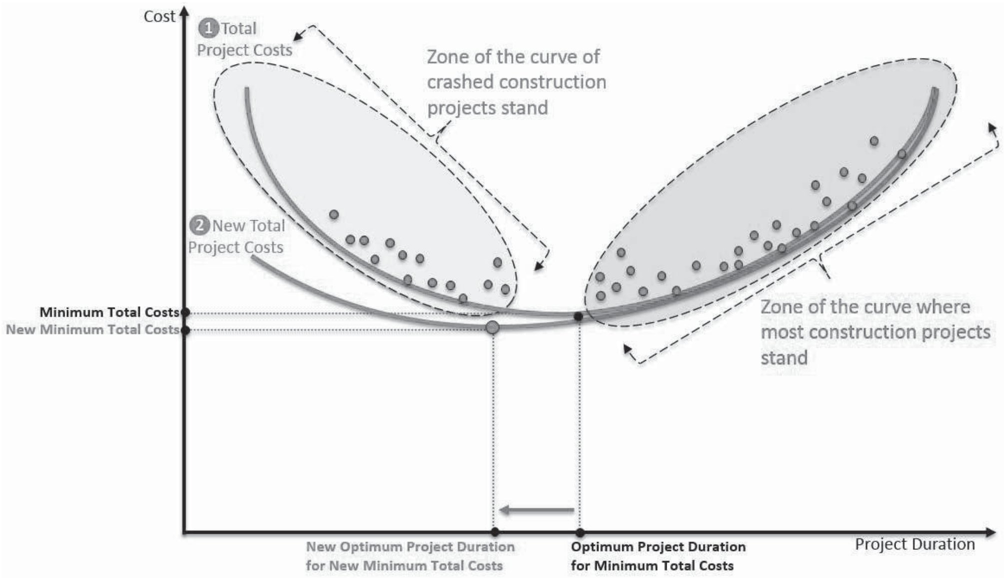

Figure 8.2-4: Time-cost trade-offs in construction projects.

Time to market in NPD projects does not have the same emphasis and value as time to delivery in construction projects. Due to the different attributes, stimuli and environments of each type of project, we cannot apply everything learned from NPD projects directly to construction projects. Nevertheless, knowing that NPD projects exhibited the same behaviors before globalization, and that they transformed gradually to effective and efficient projects after the emergence of globalization, one can assume that the same may happen to construction projects. A contractor or contractors deliver construction projects in general, depending on the size of the project, by involving subcontractors and suppliers and many other stakeholders. This is in contrast to NPD projects, since they are delivered by a single organization and the main players are the organization and the consumers. This difference plays a significant role in each key stakeholder's perception on the effect of time to delivery in construction projects.

8.3 Impetus behind High Project Speed – Case 2

In field research work conducted by Dutch practitioners, it was found that reducing the time to delivery by half in construction projects and speeding up the plan and execution phases would result not only in early project delivery, but also in lowering the amount of transportation, thereby reducing both CO_2 emissions and project costs (Ruijtenbeek *et al.*, 2013). This shows how shortening delivery time can positively affect efficiency as a whole (as defined by Zidane *et al.* (2016c) in terms of scope, cost and time) and can positively affect at least one of the outcomes, by reducing CO_2 emissions. Several companies have employed time-based strategies, such as in the telecommunication and ICT industry. Speeding up the delivery of new products in these markets reduces costs, increases profits and creates value (Schmelzer, 1992).

For many years, the telecommunications industry around the world was highly regulated. This changed dramatically during the last decades of the twentieth century with the commercial introduction of mobile data, the deregulation of the telecommunications industry, the emergence of new global competitors and the development of the IT industry (Bergman *et al.*, 2013). Many telecommunications projects are international projects involving collaboration between participants from multiple countries. They face unique challenges that do not appear in intra-national projects, these being challenges related to differences in work practices, legal regulations and cultural values (Mahalingam and Levitt, 2007; Aarseth *et al.*, 2013, Zidane *et al., 2018*). The telecommunications industry relies on time to market and fast delivery to gain competitive advantages and increase profit margins; thus, the need for speed is a major priority. Rapid and short-lived technology advances, deregulation and greater competition have transformed the telecommunications industry by bringing new products into the market faster; nevertheless, the literature covers little about this hypercompetitive industry in the present day (Kosaroglu and Hunt, 2009).

With the aim of furthering the understanding of project speed, and why there is a need to increase it, the purpose of this section is to investigate and understand the reasons behind the urgency, as well as why the project management team wants to succeed in delivering within such a tight time window. To answer this research question about "why" it is necessary to speed up the project delivery, a research design based on a case study strategy is used. This was an empirical study, which used as techniques of data collection both archival material and semi-structured interviews. A typical case study focuses on matters that exemplify a stable, cross-case relationship (Seawright and Gerring, 2013). To put the observations in the first case project into perspective, a similar case project has been chosen with a comparable scope. Case 2 is also introduced briefly in the methodology chapter in Subsection 2.4.6 (schedules in Figure 8.3-1 and Figure 8.3-2). The primary purpose of this comparison was to examine the assumption that the project (the case) qualifies as "superfast." The primary case project does not represent a typical case; it is a very special case. It is understood that this unique case has a lot to offer as an illustration of the effects investigated in this section. In line with Flyvbjerg (2006), thorough investigation of a single case is very useful for learning purposes. Although the findings cannot be generalized, a single-case study does contribute to scientific development.

In this case study, ten semi-structured and in-depth interviews were organized to investigate the reason for the urgency of the project, along with two other issues: 1) the fast execution; and 2) the post-project evaluation. These last two questions are discussed in further detail in Chapter 9. The data collected were publicly available material from the Ministry of ICT and information obtained through telephone interviews with two persons from the top management of the client (heads of departments in Operator B). The two interviews specifically addressed the urgency of the project. In addition, key individuals from the contractor side were interviewed: the product line manager, the accounts manager, the core network technical expert and the project director. The interviews were virtual, using digital means of communication, and the duration of the interviews varied from half an hour to an hour and half. From Operator B, I interviewed the project director and deputy project director in the form of open discussions by digital means. The total discussion time was an hour and a half to two hours. To collect data for issue three, in addition to those interviewed listed above, I also interviewed the after-sales manager in charge of the maintenance of the network and the new project director.

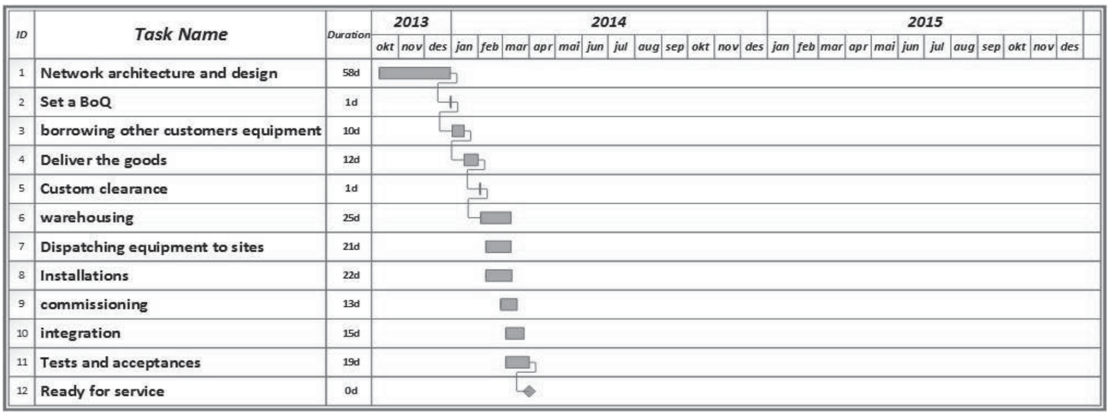

Figure 8.3-1: Schedule of the case.

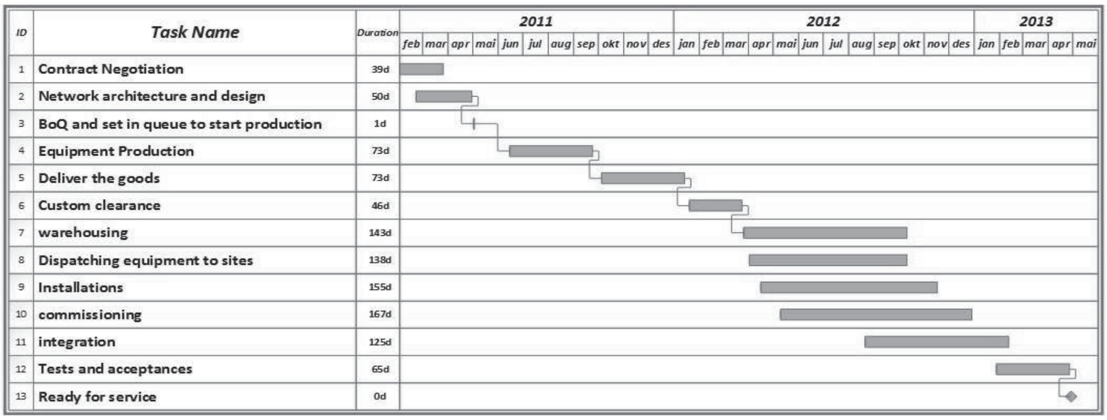

Figure 8.3-2: Schedule of similar case.

Access to archives was limited due to confidentiality and privacy matters. The archives used were the case project director's notes, a similar case project director's notes from the same contractor, archival documents from Operator B's website, archival documents from the Ministry of ICT's website and archival documents from the local telecommunications regulation agency (ARPT).

The data obtained from archives and interviews were analyzed using qualitative data analysis (Miles and Huberman, 1994, pp.8–9). The qualitative data analysis consisted of three approaches: data reduction, data display, and conclusion drawing and verification (Miles and Huberman, 1994). Data reduction refers to the process of selecting, focusing, simplifying, abstracting and transforming the data that appear in written-up field notes or transcriptions. Data reduction is a form of analysis that sharpens, sorts, focuses, discards and organizes data in such a way that conclusions can be drawn (Miles and Huberman, 1994). Tesch (1990) calls this process data condensation. Data display is an organized, compressed assembly of information that permits conclusion drawing and action (Miles and Huberman, 1994).

This case study of a large-scale telecommunications project involves a number of actors in both the private and the public sector (as described in the methodology chapter, Case 2). The case project – to expand an existing telecommunications network in Algeria (I call the network “Operator B”) – was a megaproject financed through the state budget and estimated to cost approximately USD 100 million for the first phase and with a total budget estimated at approximately USD 1.2 billion. The project’s legitimacy, and urgency, lay largely in the return on investment (ROI) for the upgraded and implemented network, where ROI (Muller *et al.*, 2005; Rong Chang *et al.*, 2014) related to two factors, savings and investment, and is equal to savings over investment. In this dissertation, ROI is simply the cost-to-benefit ratio. The existing 2G network was to be upgraded to 3G/4G before the Algerian state, currently the sole owner, sold a 49 percent share of Operator B at an expected four times return on the investment.

The project was a complex endeavor in terms of organization and technology: It involved several influential public bodies and authorities, with the lead being taken by the Ministry of ICT and external suppliers (the main contractor was chosen after swift bidding for the project). Moreover, the project was global through the involvement of suppliers from other countries, requiring virtual cooperation between the organizations involved. This posed challenges in terms of time difference combined with cultural differences, exacerbated by the strict timeline.

Figure 8.3-1 and Figure 8.3-2 depict simplified project schedules for the two project cases, the primary case in Figure 8.3-1 and the comparison case in Figure 8.3-2, based on calendar time. It can be seen from the schedule of the comparison case that most of the time was spent before starting implementation – i.e., from contract negotiation to equipment delivery. The fast case spent half of the project period on preparations, but, compared to the comparison case, this was done in three months instead of 14 months, thereby saving almost a year. Implementation took 13 months in the comparison case and three months in the fast project. For both case projects, the split between preparations and delivery was about 50–50. In the fast case, there was no waiting time for equipment production to start; instead, equipment was redirected from suitable supplies already produced for other clients. These units would have to be replaced in the other projects, which meant there would be delays in those projects.

The comparison case in Figure 8.3-2 was executed under normal circumstances: There was no extreme urgency for project delivery, so all the activities followed a routine sequence. This project was delivered with all its scope, respecting the requirements and testing them, within budget and a few weeks behind schedule. The compressed case project was delivered a week ahead of schedule, within budget (at the customer acceptance moment, and including forecasted costs for the remaining activities) and adhering to the technical specifications by testing the main ones. However, the full scope was not delivered as the main contractor delivered the parts that would strongly contribute to the project efficacy – i.e., enabling 3G/4G services, including their billing. The scope of delivery was 95 percent of the core network, including the billing system, and 50 percent of the radio access network, which gives an overall scope delivery of about 70 percent. In this kind of project, the scope of the project lies in a workload of 40 percent core network and 60 percent radio access network. However, the technological complexity always lies in the core network, which requires more expertise and extremely highly qualified engineers to deliver a working system.

This project (the superfast case) was awarded to the main contractor at rather short notice – i.e., three months from the issue of the invitation for bidding to signing of the contract – so there was an urgent need to establish subcontractors for the dispatching and logistics, equipment hardware installations and some materials. The core network was divided into seven main sites requiring seven hardware installation teams with at least nine team members experienced in this kind of hardware installation.

The radio access network gets its complexity from the number and the location of sites: 1,320 Node-Bs located in different sites and widely dispersed geographically. The most difficult task regarding the access network sites is dispatching the equipment and the logistics, especially when it comes to urban areas (due to traffic, regulations regarding truck traffic, etc.). Another difficulty is related to replacing the existing antennae, which support only the 2G frequency, with new antennae that support 2G, 3G and 4G frequencies. The replacement should be done late at night and very quickly to avoid long interruptions to the service. The subcontractors' selection was done without any bidding, but rather based on inviting suppliers (for services and materials) and trying to negotiate acceptable terms.

The case project would normally take two years to be delivered, but was compressed into three months. Similar case project, owned by Operator A but using the same contractor and in the same country, is used for comparison. This reveals big differences in schedule, taking these schedule differences as a starting point.

There were many organizations involved in this project, each organization having its own motivation for compressing the project schedule. The project's main driver, however, was the government, which had delegated the project to the Ministry of ICT. Since the government already owned Operator A, which provides a full range of services to users, including 3G/4G, there was no need to rush getting a second operator in place to provide the same services. However, since the project's legitimacy and urgency lay in the financial profitability of the upgraded existing network, it was important to upgrade as soon as possible the existing 2G network to 3G/4G before selling 49 percent of the stocks.

One of the interviewees in the top management of Operator B explained the urgency in upgrading the network. The sooner the network was upgraded, the higher the value of the stocks, as shown in Figure 8.3-3 by the solid dark blue curve 1, representing the superfast project with selling of the stocks.

Furthermore, based on interviewee information, the Δ\$ of NPV in Figure 8.3-3 represents a decrease in the monetary value of the network after a certain time, believed to be caused by the rapid and short-lived technology advances, deregulation and greater competition (Kosaroglu and Hunt, 2009). The authors question this assumption and rather believe the monetary value of the network would increase during the two years following completion. There are two reasons for this. Firstly, the number of subscribers (users) in the network will increase, and secondly, the next generation (5G) is expected to be introduced in the market only in 2020. For these two reasons, someone may think that the Δ$ of NPV would be a positive value. However, in terms of the return on investment (ROI), the sooner the service is introduced to the market, the sooner it will generate incomes.

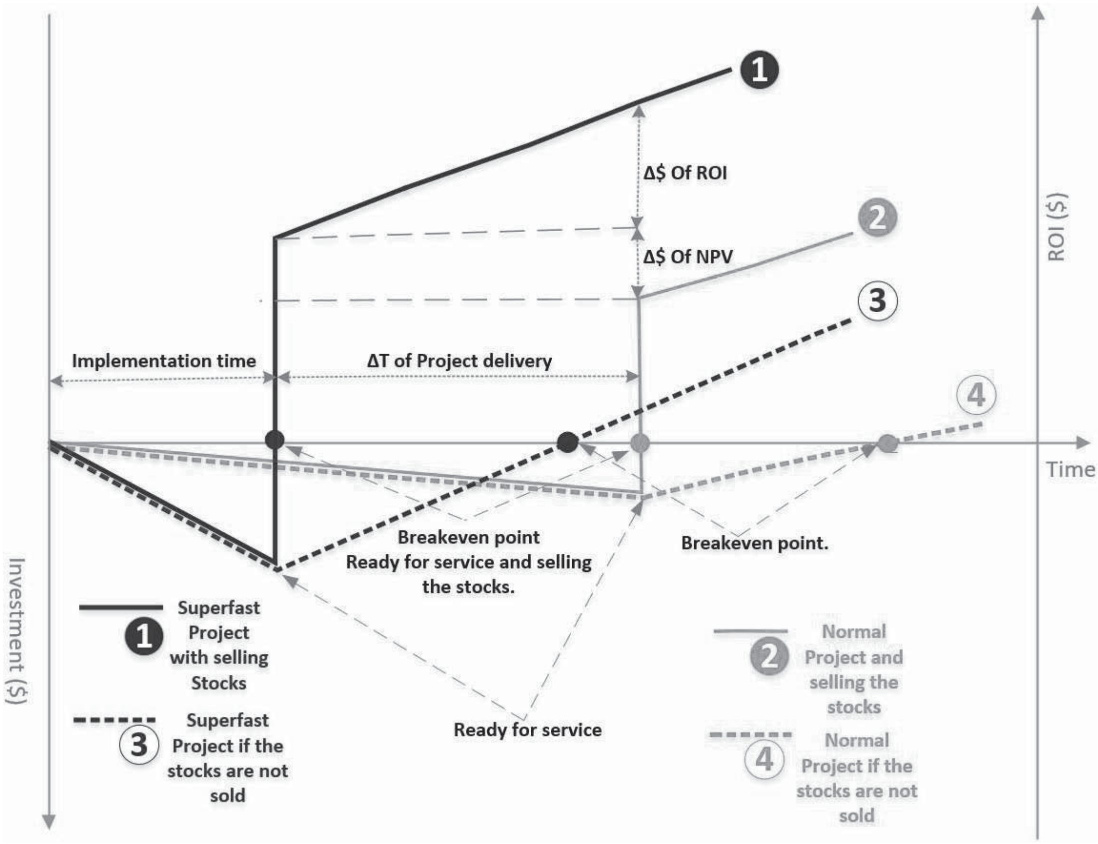

Figure 8.3-3: The cash-flow curves for the superfast project and normal project.

The four assumptions of the government regarding the project (curves 1, 2, 3 and 4 in Figure 8.3-3) show in all cases that the sooner the project is delivered, the earlier ROI is realized. As ROI was defined as the cost-to-benefit ratio, the ROI in Figure 8.3-3 starts to appear and accumulate from the break-even point.

The motivation for the main contractor to accept the tight time window and commit to the delivery date was being awarded the whole contract value, which is USD 1.2 billion, with an expected net profit of approximately 13 percent, which means approximately USD 156 million. The main contractor was also motivated by establishing a strong position within the local and international market, gaining a reputation and improving the partnership with the project owner.

For the subcontractors the motivation is more to gain the respect of the contractor since the relationship is not only a limited contract but also long-term cooperation. The same can be applied to suppliers, who are looking for stable long-term clients to supply them with the necessary materials, tools and machinery.

8.4 Project Categorization – What & Who Decide the TTD?

Archibald (2004) emphasizes differentiating between project categorization and project classification. According to this author, the term "categorization" is used to identify "a set of items with similar characteristics or properties. An item may be placed in more than one category; in other words, categories are not mutually exclusive. A class is often used more rigorously to denote a set of items that can only be placed within a given class; classes are therefore mutually exclusive, when used in this sense." Among the purposes and uses of project categorization listed by Archibald (2004) are: (1) definition of strategic project portfolios and their alignment with growth strategies; (2) selection and development of the best project life cycle (or life span) models; (3) identification and application of best practices for project selection and prioritization; planning, executing and controlling methods and templates; risk management methods; governance policies and procedures; and development of specialized software applications; (4) building of specialized bodies of knowledge; and (5) selection and training of project managers and project management specialists.

As defined in Chapter 1, Section 1.4, time to delivery (TTD) in LSEPs is the time window needed to design and/or produce/fabricate/build/construct the desired product once the LSEP project reaches its end (building, a turnkey factory, a power plant, a weapons system, etc.), and is a function of the system complexity and requirements (Cova and Hoskins, 1997). In here, TTD is mostly used to express the final milestone date of completing the project.

The importance of TTD, which decides the level of project speed and pace, depends on the project type and the industry. Thus, the categorization of projects is related to the need for speed. Someone may ask themselves why new product development projects move at extremely high speed? Month after month, we hear of a new mobile phone set from *Brand A* (market leader) coming into the market, with a new design, new features, etc. Then, a few days, or a maximum maybe of a few weeks, later *Brands B*, *C* and *D* do the same; these are called "followers" in strategic management discipline. Market followers are firms that replicate what a particular business does (market leader). They do not take any risks, rather they wait and observe others' (market leaders') strategies and implement only the successful ones (Cambridge, 2013).

This is because there is one very strong incentive behind NPD and innovation projects. That incentive is to "survive" in the global market known as the "Red Ocean" – Red Ocean refers to an ocean of blood caused by competition, as globalization has increased the competition level in innovation industries to become a global war and thus an ocean of blood (Kim and Mauborgne, 2005). Innovation industries rely on technologies; the issue with technologies is that they are continuously becoming outdated, and thus companies must innovate continuously as well, but their NPD projects should be delivered faster than ever if they are competing in the Red Ocean, and not in a Blue Ocean – a new market with a new product and new customers (Kim and Mauborgne, 2005).

Shenhar and Dvir (2007) presented a model, which they named the NTCP model as shown in Figure 8.4-1, where the letters represent four dimensions, which are novelty, technology, complexity and pace. Moreover, each dimension is divided into three to four levels. Novelty is the degree of product novelty in the market, which is divided into derivative, platform and breakthrough. Technology is the level of uncertainty coming from technology, or as they call it "technological uncertainty"; they divide it into four levels: super-high-tech, high-tech, medium-tech and low-tech. Complexity is related to system scope (i.e., hierarchical framework of systems and subsystems), and it has three levels: assembly, system and array. Last but not least is pace; this last dimension is related to the project's needed time to deliver (TTD). According to Shenhar and Dvir (2007), this fourth dimension that they call "pace" affects the autonomy of project teams, the bureaucracy, the speed of decision-making and the intensity of top management involvement. The NTCP model is introduced in this section because of its fourth dimension, "Pace." This dimension is divided into four levels: (1) regular projects, where time is not critical to immediate organizational success; (2) fast/competitive projects, which are the most common projects carried out by industrial and profit-driven organizations; (3) time-critical projects, which must be completed by a specific date; and (4) blitz projects, which are the most urgent and most time-critical.

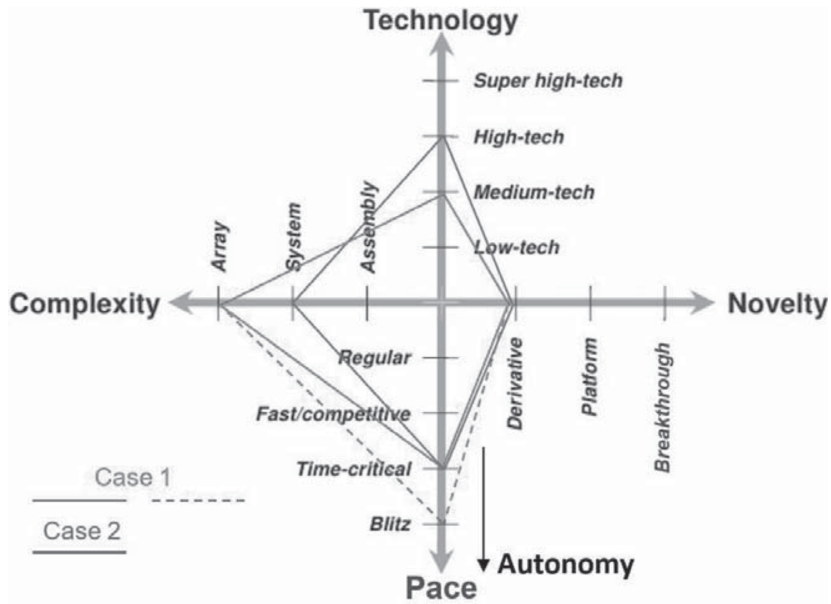

Figure 8.4-1: The NTCP diamond.
(Adopted from: Shenhar and Dvir, 2007, p.47)

Plotting the two case studies on the NTCP model, as shown in Figure 8.4-1, both cases were urgent, but for different reasons. *Case 1*'s urgency came from social, economic and political drivers; *Case 2*'s urgency was only driven by financial and economic reasons, which are discussed in a later section. The reason behind the creation of the NTCP model by Shenhar and Dvir (2007) was to help the project management team to choose their management style – e.g., between outsourcing, selective outsourcing and not outsourcing any activity from the project. When it came to the "Pace", both projects were judged as "Blitz". According to Shenhar and Dvir (2007), the time constraint comes from the accelerating pace of technological development, the market needs, competitive pressures, management strategies and environmental, natural or enemy threats that prompt immediate action. They add that the available time window to complete a project has a considerable effect on how the project is managed – e.g., different project structures, processes and management attention.

Back to the model and based on the authors' arguments, for the pace dimension and for the first level, which is regular, the best example is Sydney Opera House, where the project duration was scheduled to be six years, but eventually 16 years were required. They justify the reason for this extended project duration by the external, competitive or enforced pressure. As fast/competitive is more closely related to competitive advantage'. The interesting thing in the "Pace" dimension is that it resembles the last two levels, which are time-critical and blitz; the difference between them is that in the time-critical projects the TTD is well-known in advance, which in here is *Case 2*. In contrast, blitz projects emerge from crisis, when unexpected events promote the need for immediate action. The example is *Case 1*, where at first deadlines were known but suddenly the project became blitz project because of external factors (pressure from the minister and government to finish the project as soon as possible).

According to the authors, time-critical projects can turn to blitz projects when the projects run out of time and that is the case here with *Case 2*. The discontinuous red line in Figure 8.4-1 shows the change from the previous time-critical level to a blitz management style of case project. However, the authors mention that for Blitz projects, (1) the project management team needs autonomy to make and carry out decisions, (2) the team members are taken from other assignments and released from any commitment, (3) there are no bureaucracy or procedures to follow, (4) top management are involved. These characteristics were identified explicitly in Case 2; Case 1 was not studied from this viewpoint due to the complexity of the project (scale) and the huge number of shareholders involved in it. The same conclusion can be drawn about that case.

Section 8.2 from this chapter discusses a comparison between the importance of TTD in NPD and innovation projects, compared to construction projects. The importance of TTD in NPD is crucial; organizations are competing in a global market, where the success of their NPD projects is measured in terms of TTM. Where "Timing" (kairos) is the decisive for their success, this is explained by the change of the success measure criteria – i.e., efficiency and effectiveness, where time is a shared constraint of these two criteria for meeting project success. These changes, as stated many times previously in this dissertation, are due to globalization; this means an increase in the number of stakeholders from a national market to the international one, and all that follows from media, competitors, etc. Figure 8-4.2 shows the increase in the degree of pressure in the NPD and innovative projects due to external stakeholders, which will increase the pressure on the organizations to shorten their project delivery and put their projects on the "Blitz" level depending on the market needs and competition.

In LSEPs – e.g., construction, oil and gas, and infrastructure development – projects also have an impetus. However, in the construction industry, for example, the impetus cannot be compared with that of the innovation industry. The same can be said for all other types of industry. Each industry has its own driver behind the speed of running projects. That impetus can be decided by many parameters, such as the "needs of the project" and "the urgency of the needs from the project", the benefits (all types – e.g., financial, reputational, etc.), the purpose of the project, the country context, etc. Going back to Chapter 5, Figure 5.2-3 and Figure 5.2-5 show that the cost and the scale of the projects do not decide the TTD of the projects. Thus, there are other impetuses behind the TTD. On the other hand, comparing again to NPD projects, and based on Figure 8.4-2, the number of stakeholders is limited to the local stakeholders, or at most to the national stakeholders at the TTD, since the short- to medium-term impacts are felt only by those stakeholders. This is not the case with the long-term impacts, e.g., in the cases of Sydney Opera House and the Eiffel Tower.

Figure 8.4-2: NPD and innovative projects in international context.

Stakeholders in LSEPs are generally limited to a list of clients/sponsors/owners, contractors, subcontractors, consultants, and suppliers as internal stakeholders to the project, or in other words, as the parties involved directly in the projects. The external stakeholders are the local community, users, politicians and in some cases the nation; *Case 1* is an example of this. However, the cases in Table 8.2-1 are projects that ended ahead of their schedules and under their estimated budgets (compared to the projects' front-end budgets and schedule estimations). The projects are on the level of "Fast/competitive" in the NTCP model, and the reason from the findings for completing the projects ahead of schedule, as discussed in Subsection 8.2-2, was the chosen philosophy to manage the whole project life cycle, which was based on the CE philosophy. The decision regarding the TTD depends on many parameters in LSEPs, depending on the drivers behind them.

Classification of projects is based on those parameters by type, for example: residential construction – e.g., a single-family residence or a residential facility with (usually) many units; commercial construction – e.g., restaurants, grocery stores, skyscrapers, shopping centers, sports facilities, hospitals, private schools and universities, etc.; industrial construction – e.g., power plants, manufacturing plants, solar wind farms, refineries, etc.; and infrastructure projects, like road construction, telecommunications network constructions, etc. These classifications will help in better portfolio and program management if the initiators are at the strategic level; these scenarios mostly come from public projects.

Conclusions—Faster! Always Better?

The research described in this chapter is based mainly on raw data collected from three different sources, based on case study, "Case 1", as detailed in the methodology chapter. The second section in the chapter is based on a conceptual and qualitative interpretation of the concept of TTM in NPD projects and construction projects. The data are recycled from a study conducted by a group of researchers in Finland. Another case study, "Case 2", is used to illustrate the motivation to speed up the delivery of that project. The research question (RQ4) answered in this chapter is:

RQ4: Is faster project delivery better? If so, why?

The answer to this question is related to four findings:

1. Delays are considered wasteful and cause projects to be executed slower than otherwise, which means slow project speed. Moreover, delays have several negative effects. The negative effects identified in this dissertation and most frequently cited in the literature are cost overruns, time overruns, litigation, disputes, negotiations, arbitration, total abandonment of projects, wastage, underutilization of manpower, and idling resources. Hence, it is necessary to deal with them and their causes.

2. Projects can be delivered faster, ahead of schedule, and under budget if the appropriate philosophy is used for the purpose, which in the studied case is the use of concurrent engineering. Studies of NPD have shown that the reasons behind high project speed in NPD is driven by the market demands, which is done (1) by being highly effective—by being the first into the market with high sales and prices, and (2), as a secondary objective, by becoming increasingly efficient by improving NPD projects' delivery management and methods through continuous improvement. For LSEPs, TTD is not as important as TTM, and therefore the use of relevant philosophy to improve the practices.

3. Fixing a delivery date (TTD), and being asked to deliver a project within a tight time window, from the day of asking for the project to be implemented to the date of delivery, may lead the contractor and all subcontractors to squeeze the plans to meet that target date. This would lead to the project being run at a superfast speed. The project owner's concern with high project speed depends on the needs and the time of using the deliverables from the project.

4. A project may have superfast speed when the TTD is fixed earlier than it should be and the time window is tight (i.e., has a more compressed schedule than usual). Setting the TTD depends on many parameters in LSEPs, depending on the drivers behind these parameters. In contrast to TTM, when competition at the level the own is a necessity, TTD is less concerned with competition, in most cases.

In the next chapter, in which fifth and final research is addresses, I discuss how projects can deliver faster.

CHAPTER 9

How to? – Fast Project Delivery!

"I feel the need, the need for speed!"
— Peter 'Maverick' Mitchell

"Need for Speed" – this does not only mean that the management want to go fast and quickly regarding the implementations of the project (in all its phases). Nevertheless, there are real desires to go fast and deliver the project as quickly as possible. This chapter is divided into four sections. The first is a discussion about the cures and remedies for "how" to deal with delays based on *Survey 1* and on some conducted interviews. Few have been carried out regarding the cures and remedies for delays, thus there was little said in the literature regarding the issue. The second section of this chapter is a discussion about superfast projects, using *Case 2*, which is presented in the methodology chapter and used in Chapter 8. The schedule of the case was dramatically compressed, and a discussion of how that happened is contained within the section. Moreover, there is a discussion about the negative side of fast tracking. Last and in the same section, the barriers to using CE in Norwegian construction based on a Norwegian case company are discussed. The third part of the chapter is about "how" to boost project speed in construction projects. A speedometer was developed using performance measurements and identifying KPIs to develop the framework for this speedometer. The use of a road construction project as a case based on interviews helped in identifying the KPIs. The second part of boosting project speed was based on *Case 1*, as well as in many individual papers, where the case has been evaluated, and from the evaluation it has been established how lessons learned can help to avoid making similar mistakes and how opportunities can be generated to deliver the project within or ahead of schedule. The last, but not least, section is about how to reflect the Yin and Yang philosophy on time and timing, and on project efficiency and project effectiveness.

9.1 Dealing with Delays in LSEPs – Survey 1 & Interviews

In the last four decades, significant attention has been given to identifying possible causes of delays in large-scale engineering projects (Yang *et al.*, 2013). Delays are costly, and with even a small increase in delay, recovery may have a substantial impact on the financial returns of parties involved in the project (Faridi and El-Sayegh, 2006; Khoshgoftar *et al.*, 2010); thus, it is very important to address cures for delays. The first step in minimizing delays is to identify causes that may lead to delay (Pourrostam and Ismail, 2011; Yang *et al.*, 2013).

While studies on the causes and effects of construction delays are plenteous, there is a shortage of findings on mitigation measures to address these delay causes and effects (Amoatey *et al.*, 2015). Sambasivan and Soon (2007) recommended delaying mitigation prescriptions for contractors, consultants and clients. Mahamid (2011) investigated factors affecting time delays in road construction projects and recommended training programs to improve the managerial skills of project parties.

Gidado and Niazai (2012) conducted a study on the causes of project delays in the construction industry in Afghanistan; they gave six general recommendations for dealing with the major delay factors and in addition included tailored recommendations to the parties (i.e., clients, contractors and consultants). Amoatey *et al.* (2015), based on their study of Ghanaian state housing construction projects, identified 13 causes of delays and ten effects of delays, and recommended solutions for the top six delay causes.

In this section, the second part of *Survey 1* (Identification of Delay Factors and their Remedies in Major Norwegian Projects) is presented and findings are compared to literature and some conducted interviews. *Survey 1* is introduced initially in Chapter 2 of the methodology in Subsection 2.4.6 (Research strategies), and in more detail in Subsection 6.2.1 (Causes of delays in major Norwegian LSEPs). As explained in Subsection 6.2.1, an open questionnaire shown in Figure 6.2-1 was designed and sent to 300 practitioners from Norwegian companies. A total of 202 out of 300 participants responded. It is important to mention that the participants comprised clients, owners, sponsors, contractors, subcontractors and suppliers. Column 2 in Table 9.1-1 summarizes the major delay factors from the survey and the remedies from the same survey (*Survey 1*).

The findings "from the interviews," in the third column in Table 9.1-1, came from interviews conducted in 2016. The interviewer is a member of the "SpeedUp" research project (the project is discussed in more detail in the introductory chapter, Section 1.3). The interviewees are six senior project managers who belong to a client of the biggest construction organization in Norway. Employees from this organization also took part in *Survey 1* along with the interviewees.

From the conducted literature review presented in Chapter 6 (in more detail), some recommendations are extracted when they fit the same delay factors. Most of the literature and studies on delays in LSEPs focus more on the causes, factors and effects of delays, and less on the remedies and cures for these delay factors and how to deal with them.

Table 9.1-1: Cures for delay causes in Norwegian construction

Delay factors (from Survey 1)	Cure/Remedy/Reduction/Mitigation		
	From Survey 1	**From the interviews**	**From the literature**
1 – Poor planning and scheduling	- Combination of project management training and more efficient procedures - Improve the front-end planning - Improve the start-up process - Competent project managers - Better prioritization - Improve front-end planning - Improve planning engineering - Improve the plan	- Structure the planning phase - Facilitate better compliance schedule - Proactively transition between planning and the construction phase - Improve experience and knowledge sharing within the organization	- Virtual modeling (Toor and Ogunlana, 2008). - Unrealistic contract duration and requirements (Sambasivan and Soon, 2007) - Accurate estimation (Mansfield *et al.*, 1994) - Provide training and self-study on proper planning (Lim and Mohamed, 1999)
2 – Slow/poor decision-making process	- Owner/client decision-making process - Business strategy training	- Anchor major decisions in advance of engineering	- Decision-makers should be clearly identified (Chan and Kumaraswamy, 1997)
3 – Internal administrative procedures and bureaucracy within project organizations	- Improve administrative system (access system, filing system)	- Simplification of procedures	- Make quick decisions (Sambasivan and Soon, 2007)
4 – Resource shortage (human resources, machinery, equipment)	- Improve resource allocation - Executive support & involvement - More personnel - More power to the project managers - Better prioritization	- Performing prequalification - Establish an upper rent limit - Retaining parts of the project organization between projects - Provide knowledge transfer to new project members	- Use of industrialized building system IBS (Alaghbari *et al.*, 2007) - Training for labours (Khoshgoftar *et al.*, 2010; Hwang *et al.*, 2013) -Long-term procurement contracts (Kaming *et al.*, 1997; Hwang *et al.*, 2013).
5 – Poor communication and coordination between parties	- Improve interdisciplinary coordination - Improve communication - Structured meetings - Improve the collaboration - Committed and organized subcontractors	-Involve contractor earlier in planning process - Prepare project phase transition to construction phase - Facilitate internal informal learning through seminars and start-up meetings - Utilizing software coordinator between different parties	- Virtual modeling (Toor and Ogunlana, 2008). - Efficient methods of information processing (Chan and Kumaraswamy, 1997).
6 – Slow quality inspection process of the completed work	- Improve quality engineering - Simplified monitoring and control system - Simplify external QA	- Setting incentives on major milestones - Use systematic methods for monitoring progress	
7 – Design changes during construction/changed orders	- Fewer changes - More control of the engineering process - Better configuration management	- Clarify the user's real needs - Utilizing software coordinator between different parties	- Virtual modeling (Toor and Ogunlana, 2008).
8 – Sponsor/owner/client lack of commitment and/or clear demands (goals and objectives)	- Clear goals and demands - Better owner/client representatives (marketing, accounts and sale managers)	- Introducing a fast and frequent meeting frequency during the planning phase	- Interfere less frequently during the execution (Sambasivan and Soon, 2007)
9 – Office issues	- Improve the office design - More IT engineers in office - Easy software tools for use		
10 – Late/Slow or incomplete or improper design	- Better-structured process	- Create a schedule for the submission of documents - Clarify expectations for content	- Virtual modeling (Toor and Ogunlana, 2008). - prepare and approve drawings on time (Sambasivan and Soon, 2007)

Delay factors (from Survey 1)	Cure/Remedy/Reduction/Mitigation		
	From Survey 1	From the interviews	From the literature
		- Perform an internal quality assurance document and preparing the receiver - Execute project's turnkey contracts with proposition or interaction	
11 – User issues	- Intensive involvement of users in the types of projects where users are key stakeholders (e.g. doctors as users for hospital project)		

Back to the theoretical perspectives: Odeyinka and Yusif (1997), in their study on Nigerian housing construction projects, suggested that the best solution for dealing with the causes of delay was through the joint efforts of all parties involved (i.e., clients, contractors, government, etc.). Within the same country and in a similar study carried out by Aibinu and Jagboro (2002), the authors gave two possibilities for minimizing their negative effects. The first was the acceleration of the subsequent activities, which was successful in Germany as a solution based on the study of Mobbs (1982). The second was a contingency allowance.

Pourrostam and Ismail (2012, 2011) gave recommendations to each of the involved parties based on their ownership in relation to the major causes of delay. Haseeb *et al.* (2011a) and Haseeb *et al.* (2011b) did the same for causes of delay in Pakistan. Kikwasi (2012) gave general recommendations for the top six causes of delay in Tanzanian construction projects, saying, "adequate construction budget, timely issuing of information, finalization of design and project management skills should be the focus of the parties in the project procurement process".

Some authors gave tailored solutions to tailored causes of delay in a specific subject (e.g., procurement, leadership, contracting, etc.). These included Manavazhi and Adhikari (2002) on the causes of delay in procurement in Nepal, Odeh and Battaineh (2002) on contracting and Arditi *et al.* (2017) on the effect of organizational culture on delay. However, unfortunately few of the studies based their recommendations on empirical data, but rather on their own perceptions and knowledge.

This section is about the cures and remedies for delays in large-scale engineering projects in general and construction projects specifically. The recommendations came from the 202 respondents of *Survey 1*, where more than half of the respondents were project managers (54%). In addition to the survey, the six in-depth interviews conducted regarding remedies for delays also produced some interesting recommendations.

When it comes to the major delay factors in Norway, it is noticeable that the recommendations from the survey and interviews complement each other when they do not overlap. If I take the first major delay causes, it is very clear that based on the survey, the interviews and the literature, all suggested training and knowledge sharing as solutions for this factor. As I can see, there is also no universal root cause of delay and no universal solution for a specific cause of delay. However, as recommended by most authors, each of the parties involved in the project can handle their own causes, and all the parties can come together to face the factors emerging from shared responsibilities or from the project context.

9.2 FT & CE as Technique &/or Philosophy

Pinto (2013) mentioned seven planning errors in NPD projects that lead to cost and time overrun: (1) optimism bias, (2) massaging the plan, (3) creating project death marches, (4) ending date-driven schedules, (5) lack of relevant project management training, (6) poor change control, and (7) superficial risk management. Moreover, he suggested four ways to deal with planning errors.

The concerns are more about LSEPs, more precisely construction projects in general. According to Kerzner (2009), there are many reasons leading to problems in managing time and bad quality of scheduling, which include:

- Unrealistic estimates;
- Inability to handle employee workload imbalances;
- Having to share critical resources over several projects;
- Overcommitted resources;
- Continuous readjustments to the WBS and scope changes;
- Unforeseen delay factors.

Kerzner (2009) listed five common techniques for reducing project duration, and he added that each technique has significant limitations that may make this technique more a myth than a reality. This is shown in Table 9.2-1.

Table 9.2-1: Myths and reality of schedule compression
(Adopted from: Kerzner, 2009, p.529)

Compression Technique	Myth	Reality
Use of overtime	Work will progress at the same rate on overtime.	The rate of progress is less on overtime; more mistakes may occur; and prolonged overtime may lead to burnout.
Adding more resources (i.e., crashing)	The performance rate will increase due to the added resources.	It takes time to finish the resources; it takes time to get them up to speed; the resources used for the training must come from the existing resources.
Reducing scope (i.e., needed. Reducing functionality)	The customer always requests more work than actually needed.	The customer needs all the tasks agreed to in the statement of work.
Outsourcing	Numerous qualified suppliers exist.	The quality of the suppliers' work can damage your reputation; the supplier may go out of business; and the supplier may have limited concern for your scheduled dates.
Doing series work in parallel	An activity can start before the previous activity has finished.	The risks increase and rework becomes expensive because it may involve multiple activities.

The next two subsections present the use of the fast-tracking technique as an ad hoc solution for reducing project duration and compressing dramatically the schedule. The last subsection describes partial failure of implementing the CE philosophy within a Norwegian construction company; there were barriers blocking the organization from doing so.

9.2.1 Superfast! – Case 2

This subsection is an extension of the discussion in Section 8. The discussion in that section was about investigating the reasons for the urgency of a project. In this and the following subsections the questions to answer, based on the same case study, and on the same described techniques for data collection and procedures for data analysis, are about: 1) fast execution; and 2) post-project evaluation. The case study in the last two questions mainly investigates "How" the project management team (mainly from the contractor side) identified opportunities and "How" these were implemented to fit the project duration within that time window details about Case 2 are described in Subsection 2.4-6 and used in Section 8.3).

The overall objective of this subsection is to contribute to an understanding of the management of fast projects in a setting of urgency. This was approached by creating a chronological narrative story of the case project and subjecting the underlying project data to various analyses. What emerges is a novel understanding of the role and practice of project management in fast-paced projects and a theory of project management that acknowledges the importance of taking a holistic view – i.e., balancing short- and long-term considerations – of urgent projects. The case project offers a view into how the idea of embracing uncertainty can be linked with project speed management and time-to-market assessments, and allows us to understand how these concepts are implemented at the project level. *How was the schedule of two years' workload dramatically compressed into three months?* The project scope and the workload would in a normal project need at least two years to be delivered. The comparison case project, with a similar main contractor, within the same country, was delivered in 27 months (see Table 2.4-9, Figure 8.3-1 and Figure 8.3-2). The only difference is that the project was with another client, Operator A (Chapter 2, Section 2.4.6, Case 2 description).

Figure 9.2-1 and Table 9.2-2 show the timeline and the events that happened along the project's trajectory. This kind of telecommunications infrastructure project is not about introducing new product development to the market: 3G/4G technologies are already available in the same market with competitors (Operators A and Operator C). However, there is still a need to develop some customized solutions for different specific issues – e.g., software applications, integration solutions, licenses, etc. The main contractor is part of a global company with many projects, both similar and different to this project case, all over the world, meaning it is practically impossible for the central headquarters to directly support the projects. Because of this, the company has developed a categorization system where projects are classified from A to F. The categorization reflects the priority of each project: A project with high-level strategic objectives or high financial benefits will be highly ranked (A or B). When a project is classified as level A, it will be subject to a high level of attention from the central organization and be monitored daily from headquarters. Undoubtedly, a high ranking may have negative effects on the project manager because of high pressure, more time spent on detailed reporting, intensive and long meetings with senior management, and interference with the tactical and operational decisions of the project manager. On the other hand, classifying a project as "level A" means giving full authority to the project manager regarding the management of the project. Thus, it is the full responsibility of the project manager to cope with the pressure and the interferences regarding tactical and operational decisions and plans.

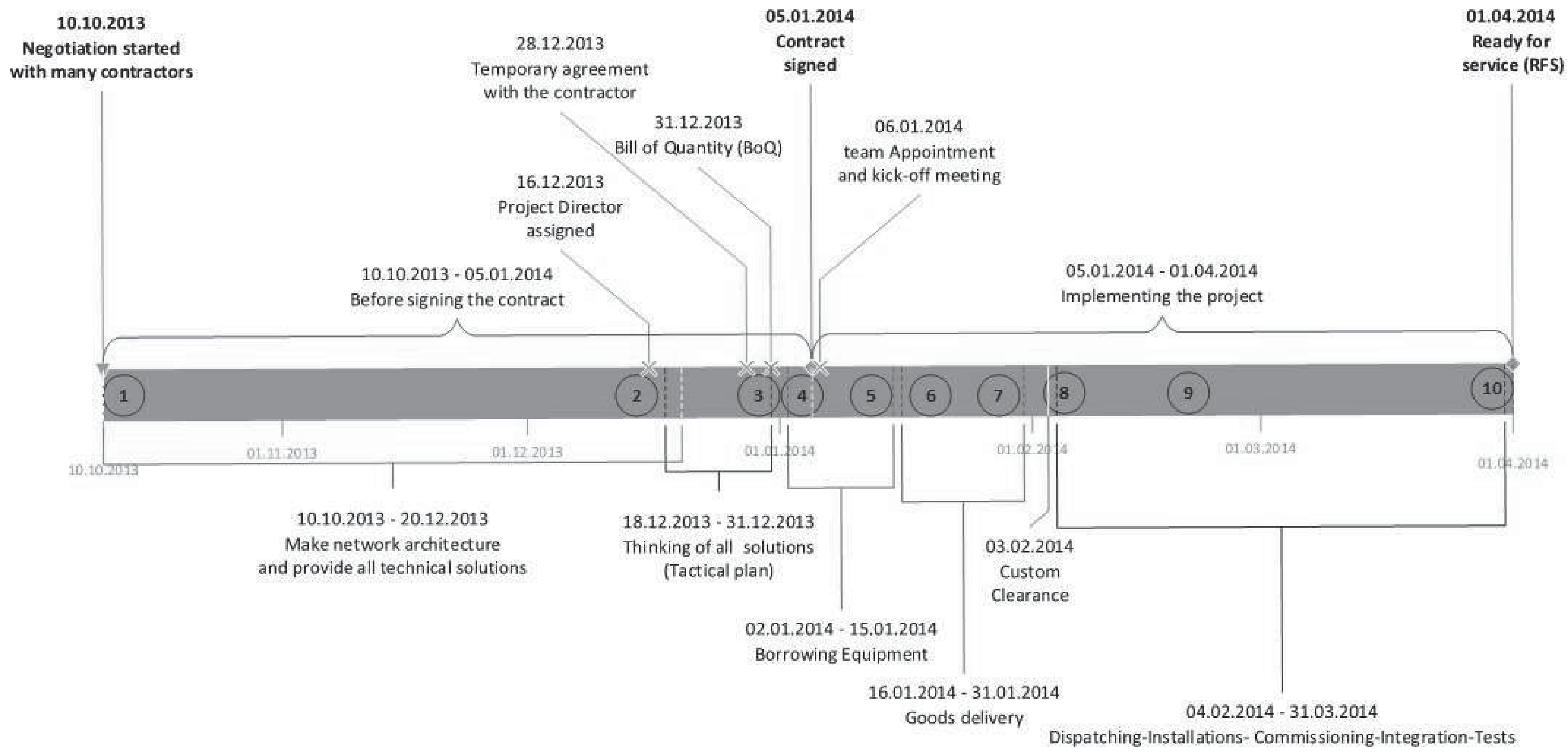

Figure 9.2-1: The timeline and events.

Table 9.2-2: Summary of the events and actions during the project

Occur -rence	Event	Description
1	Invitation for bidding	Operator B initiated suppliers' marketing to start the bidding process and subsequent negotiations about the contract.
1 to 2	New network architecture	Product line managers from the marketing department were proactive (contractor side): They started collecting information about the existing network and trying to find solutions for better integration of future equipment. This resulted in significant time saving and being ready before the potential contract was signed.
Few days before 2	Competition	Most, if not all, of the competitors of the main contractor backed out, the reason being the clause related to the highly compressed delivery date.
2	Project director appointment	Main contractor was confident of being awarded the contract since all the clauses were accepted, so the top management made it a priority to assign the project director for the project.
2 to 3	Tactical plan	Project team from the main contractor, which was composed of the project director and technical experts, started to think of all the possible scenarios to meet the target.
3	Temporary agreement	Operator B and the main contractor reached an informal agreement; the main contractor issued the bill of quantity (BoQ) to start the acquisition of the equipment.
3 to 4	Request for equipment	The BoQ was send to the headquarters of the main contractor for headquarters to provide the equipment; meanwhile headquarters were considering how to provide the equipment as soon as possible.
4	Contract	Contract signed between Operator B and the main contractor, with subsequent team appointment and kick-off meeting.
4 to 5	Borrowing equipment	Headquarters of main contractor contacted other local offices in other countries where there were similar projects with the aim of negotiating with those customers to accept delays in delivery of their equipment and extend their project duration.
5	Equipment	Headquarters of main contractor had determined a combination of already produced equipment for other projects to be able to provide the necessary equipment to the project based on the BoQ.
6	Transportation	The equipment was shipped using aircraft.
6 to 7	Goods delivery	The goods were delivered by air; due to the number of packages to be delivered, this took two weeks.
7	Goods received	The goods were received at the airport and proceeded to customs for checking and inspection.
7 to 8	Customs clearance	Ministry of ICT made an intervention to the Ministry of Commerce to skip customs clearance and release the goods in one day.
8	Warehousing	All goods were shipped to a warehouse.
8 to 9	Reconfiguration of the equipment	The borrowed equipment had been designed for other clients; thus the physical quantities matched the needs, but the configuration for each site had to be redone.
9	Core network	Core network hardware installations almost completed, ready to start commissioning.
9 to 10	Concurrency	During this period, all activities were executed in parallel: installation of Node-B, commissioning, integration of the core network, and Node-B tests and acceptances.
10	RFS	Ready for service (mainly core network and parts of the access network).

To fully understand “How” the main contractor was able to compress the project duration to the extreme extent seen in this case project, I need to review the many tactical decisions made both at the front end and at the operational level of the project. In chronological order, they were as follows:

(1) When Operator B initiated discussions with the supplier market to obtain a contractor willing to take on such an accelerated project, almost all of the contractors were concerned about the delivery time target. Instead of trying to understand the operator requirements and analyze their needs, the potential contractors were tried extend the project delivery date. The chosen contractor was the only exception, and intensively mobilized its product line managers from marketing and sales to understand the technical requirements and specifications, understand the existing network, design a potential network architecture and determine the required equipment. This early involvement made the product line managers more knowledgeable about the existing network and its architecture, and thus about saving time when it comes to designing new architecture or updating the existing one if needed.

(2) This was a risky decision on the part of the chosen main contractor. In reality, all available local marketing resources were assigned to a high-risk project before having signed any agreement. In addition, appointing a project director before signing any contract was risky, but this early assignment allowed the project director to oversee the work done by the marketing department and translate early on the technical requirements into actions that later formed much of the project plan. However, in a routine case, the project director/manager is assigned at the signing of the contract, and the first meeting is the kickoff meeting.

(3) The choice of project director was also important: He was a senior project manager with long experience in managing telecommunications infrastructure projects, with good knowledge of the company and its internal regulations, and with strong administrative skills. These skills helped him to forecast possible scenarios and make plans that would allow the client to be satisfied. A project manager with strong administrative skills will have more chance of facing and dealing with the internal company’s bureaucracy when it is necessary.

(4) At a certain point in time, when all the competitors pulled out, the operator made an unofficial agreement with the chosen contractor, even though a formal contract had still not been awarded. In a normal project, the BoQ would not have been issued this early and, when issued, it would have been sent to headquarters to initiate production of the equipment. This would have taken at least six months, followed by shipping of the goods by sea, meaning at least another two months. Nevertheless, being a “level A” project, the radical decision was made to assemble the equipment from batches already produced for other projects, as well as to undertake the shipping by air. This saved more than eight months in the project schedule.

(5) Another significant time saving was made at customs clearance, which normally would take at least two months. Managing to have the Ministry of ICT, as project sponsor, intervene saved another two months by avoiding inspection and checking. The process of customs clearance in general takes at least three months, and it can last for more than six months, depending on the quantities of the imported goods and the queueing at that moment.

(6) The equipment sourced from other projects had to be physically reconfigured, and this was done by utilizing all available resources in the local office, prioritizing this project over other tasks. The physical reconfiguration of the equipment was done in the warehouse by moving the electronic boards from the cabinets with extra boards to those with fewer boards. This physical reconfiguration occurred and was necessary because the original equipment, as previously mentioned, was designated to other clients in other countries. Any mistake in carrying out this operation will lead to rework, thus expert engineers were asked to recheck the equipment once reconfigured before sending it to the concerned site, especially for the core network-related equipment.

(7) For transportation and hardware installation of the equipment, a large number of suppliers and subcontractors were engaged to speed up the process. Generally, there should be a bidding before engaging any suppliers or subcontractors; however, because of the situation they were all engaged directly in the project. In telecommunication infrastructure projects, the characteristics of the projects allow the commencement of all sites in parallel since they are physically independent. This modularity in these types of projects is an advantage in terms of saving time by doing multiple sites at once. However, the main condition is to have very qualified subcontractors on hand to avoid rework due to quality defects.

(8) Despite employing a large number of subcontractors, the project team understood that delivering the whole scope within the deadline would be impossible. The solution was to split the project into two subprojects: the project director managed the core network project and a subproject manager took charge of the access network project (see a diagram of the simplified network architecture in Figure 2.4-8, Subsection 2.4-6). The core network is the brain and the heart of the whole network: Without the core network in place (having been commissioned, integrated and tested), no service would be available, even if the complete access network was installed. Thus, the project director negotiated with the client to set a new target of delivering the full core network within the deadline. The access network would be delivered prioritized based on population density and with priority given to the capital of the country. Under this agreement, completion of the access network after the original deadline would not be considered a delay and the client would not apply penalty clauses towards the main contractor.

(9) There are seven core networks within the whole network: Among the seven, three are principals, the other four auxiliaries. The three principal and three of the auxiliary core networks were completed a week ahead of schedule; the last auxiliary was delivered a week behind schedule. The radio access networks in place at the deadline were mostly located in the capital and in four other big cities with a high population density. Service testing and acceptances were done a week ahead of schedule, and the announcement of the 3G/4G network was pronounced officially by the Ministry of ICT on the fixed date, at the end of the first quarter of 2014.

This case study reflects how it is possible to complete a project that was supposed to last two years in just a few months. This schedule compressing was possible because of the many reasons discussed here. However, fast tracking and schedule compressing may have some negative effects, and in some cases they are irreversible.

9.2.2 From Fast tracking to Backtracking – Case 2

As introduced previously in Chapter 4, Sections 4.1 and 4.2, FT (fast tracking) is a technique that sets its basis in concurrency principles to achieve the simultaneous performance of product design and construction. The procedure of overlapping the design and construction can substantially reduce the total time required to reach project completion (De la Garza and Hidrobo, 2006).

FT is the compression of the design and construction schedule through overlapping activities or reducing activity duration. Fast tracking involves starting construction on a work package before its design is completed. These exceptional strategies invariably introduce additional risks, which is why they are not more commonly practiced. These risks need to be actively managed to limit their impact on other aspects of the projects, such as safety, cost or quality (Eastham, 2002). The fast-track technique mostly has the reputation of a technique that is applied as an ad hoc solution for those projects and programs characterized by urgency. However, Alhomadi *et al.* (2011) argue, based on the manual guide of Eastham (2002), that fast-tracked projects should be predictable, and there should be indices to measure the predictability of each project before taking the decision to fast-track it.

The PMI (2013) defines fast tracking in the PMBOK Guide as a schedule compression technique where phases that would normally be done in sequence are performed in parallel. However, the guide also warns that fast tracking can result in reworks and increased risks. While fast tracking trades cost for time, it can actually increase the risks of achieving a shortened schedule.

According to Tighe (1991), FT is seen as a remedial step rather than a desirable alternative, where a proper planning and analysis FT would be unnecessary and undesirable except in unusual circumstances. He adds that if the forecasted market conditions are reasonably accurate and there is proper planning, there is no need for a fast-tracked project. However, this is not always the case, and not a view shared by other scholars (e.g., Eastham, 2002; De la Garza and Hidrobo,2006; CII, 2015). Who provided clear guides that include the key elements leading to the success of using the FT method based on similar authors.

Eastham (2002) and De la Garza and Hidrobo (2006) are more related to inter-phase integration; however, the CII's (2015) flash tracking is related to intra-phase integration. The FT suggested by authors can be implemented and sustained in stable inter-organization environment projects. This means that there should be stability in the inter-organizational network at the level of the client/customer, along with its contractors, to achieve complete success in applying it.

Furthermore, more communication is required to manage fast-tracked projects. This often results in more collaborative sessions, e-mails, phone calls and a higher level of management supervision and crisis intervention. Fast-tracked projects are to some extent compared to the NTCP model and can be classified on the level of "Blitz" in the "Pace" dimension; Shenhar and Dvir (2007) share this opinion regarding the top management support and increasing communication with the elimination of bureaucracy. However, this is contradicted in real life, as top management will always ask for more reporting in this kind of project and close follow-up, which will lead to more time being wasted on reporting.

The urgency behind Case 2 has already been discussed in Section 2.3 and the previous Subsection 9.2.1 along with how it was delivered in superfast speed and ahead of fixed TTD.

Before listing the consequences and impacts of the superfast speed of this fast-tracked project, it is necessary to examine the extent to which it was a success or failure from the perspectives of different stakeholders. Project efficiency is a question of "doing things right" and producing project outputs in terms of the agreed scope, cost, time and quality. Effectiveness is "doing the right things" – i.e., setting the right targets to achieve an overall goal. Samset (2010) defines effectiveness as a measure of the extent to which the objectives have been achieved – that is, the first-order effect of the project for the users, in the market, in terms of production, etc. Therefore, the measure of effectiveness is more related to the project stakeholders.

The project was considered highly successful from the owner and client perspectives. The owner reached the target by selling the planned 49 percent stocks of the operator company at the desired price and the operator established operation of 3G/4G services. The operator had zero 3G/4G subscribers (3G/4G users) at the end of the first quarter of 2014, while in January 2015, the registered number of 3G/4G subscribers was approximately 4.1 million out of a total market of 16 million, a market share of 25.39 percent (ARPT, 2015).

This illustrates how the project started to show its effectiveness and that the objectives had been achieved. Efficiency is more the concern of the main contractor and subcontractors. The project met the expectations of the client, even if the efficiency was not as good. The scope was not fully delivered by the deadline: The reality was that some months were still needed to complete the scope (the radio access network part) and, although the cost at the deadline was under budget, there was the remaining work to deliver.

From the human resources perspective, there were several issues. Firstly, the team members involved in the project were exhausted: Working 18 hours a day, seven days a week during the three-month period was devastating for the people. Kerzner (2009) confirms this, and argues that the prolonged overtime may lead to burnout.

Secondly, there were safety issues that might be traced back to cost cutting and a lack of incentives. The local technical director, under whom the project director was organizationally positioned, was only concerned about costs and cancelled all rewards for the project team and subcontractors. This caused dissatisfaction and a lack of trust and, combined with cost cutting, led to the resignation of many employees and subcontractors. Consequently, there was a lack of resources for the second phase, which was expanding the coverage area of the radio access network. In addition, the technical director cut costs related to safety – e.g., safety equipment like helmets and climbing belts for subcontractors involved in hardware installations and truck backup drivers for long distances. These cost-cutting measures resulted in two main incidents:

1) a subcontractor tower climber fell from a tower because of using a bad-quality climbing belt; and 2) a traffic accident occurred when one driver had to travel a distance of more than 800 km to deliver equipment. I should emphasize that these incidents were not mainly due to the high project speed, but mostly to the cost-cutting measures.

It should also be noted that decisions made in this project to source equipment from other projects led to dissatisfaction among clients in other countries because of the delays in delivering their equipment as planned. One of the clients applied a penalty clause, which meant the mother company lost approximately USD 2 million. The project manager on the main contractor side did succeed in delivering most of the project scope within that tight time window. The main means of achieving this are discussed in the following.

At the heart of this project, including both its birth and execution, lies a willingness to embrace uncertainty. This meant not shying away from the obvious risk posed in the front-end phase of the project when being faced with the request from the client to compress the project dramatically and fast-track it, but rather investing the resources required to undertake appropriate investigations to determine whether the request could be met. When this tough request caused all other competitors to pull out of the competition, this paid off in the form of a large contract that, if successfully delivered, could help the company build a reputation that could contribute to its winning future contracts for similar projects.

The main contractor in this case project was proactive before even signing the contract by being fully involved in the bidding and mobilizing their resources to identify potential business opportunities. This intensive early involvement, embracing uncertainty, saved the contractor an enormous amount of time before even signing any agreement with the client.

By applying project portfolio management principles and having a system for classifying projects based on their importance and urgency, the main contractor was able to rightly categorize the case project as level A. This meant giving it top priority in terms of resources and personnel, and freedom to operate under less stringent administrative procedures that could otherwise slow down progress by imposing reporting and consultation burdens.

Assigning key personnel, including the project director, to the project before even knowing whether the efforts in the front-end phase would translate into an awarded contract was another important decision. The technical skills and insight into this type of project held by the project director enabled him to understand which part of the project scope must be given priority in order to deliver the project faster – i.e., the core network.

The single decision that saved most time was redirecting equipment that had already been produced for other projects to eliminate the long manufacturing time that would otherwise have prolonged the project by eight months. This approach might be questioned: Partly one could claim that a fair amount of luck allowed this, due to other projects having been scheduled such that suitable equipment had been produced, and partly this decision had detrimental effects on the projects that had to surrender their equipment, causing client dissatisfaction that nullify some or all of the positive effects on market reputation achieved by delivering the case project in such a short time. Nevertheless, the principle of saving time by removing manufacturing of equipment from the critical path of the project could not be achieved by other means and still produce the same effect of massive time saving. If the company could be fairly sure that there would be a series of projects using the same or similar equipment, the equipment could be produced as stock rather than to order. If the equipment must be tailored to each project (which was the case in this project, as the equipment had to be reworked), it might still be possible to produce parts, subsystems and intermediate assemblies that allow fast final assembly of the equipment when specific project requirements are known.

Having secured the necessary equipment, the company deviated from normal practices of sea transport of large volumes of bulky and heavy equipment and instead accepted the much higher cost of air freight. This saved an additional two months and was necessary to deliver on time. Had a too strong cost focus been allowed to prevail, the decision might have been to stick to sea freight, thereby almost certainly incurring penalty payments. Furthermore, the company decided to allocate massive manpower resources to repurpose the equipment, transport it to the various locations and install the hardware. This was another decision made that carried high additional cost compared with the planned approach, but which saved much time and thus helped the project meet its deadline. As I see, many of the decisions made throughout this project are of this nature – being proactive in accepting a higher cost to cut the duration of project tasks, and thus being willing to invest in order to be able to deliver on time and thereby meet project objectives.

Case 2, which is the first phase of a megaproject, was successfully fast-tracked and compressed (client perspective); that was due to the nimble and skillful project management team available at the contractor level. However, the project was a complete failure in the midterm for the contractor. The safety issues, caused by cost cutting and a lack of incentives as discussed above, which led to the resignation of many employees and subcontractors, left the contractor out of resources for continuing the next phases of the megaproject. I should emphasize that these incidents were not mainly due to the high project speed, but mostly to the cost-cutting measures. Fast-tracked projects with high risks for the safety of people, staff burnout, product defects, etc. should not have any cost cutting, but rather they should have contingency budgets as well as incentives. The contractor succeeded in fast-tracking the project at the operational level but failed completely at the tactical level, which led to backtracking and trying to repair the mistakes instead of progressing with other phases of the megaproject.

There are times when market conditions will change radically and quickly in a manner that no one would have been capable of predicting. Such uncommon changes require unfamiliar actions. Fast tracking may be one of these unfamiliar actions. Fast tracking may be the cleverest decision if facilities have to be provided swiftly to realize a large increase in revenues made possible by a change in market conditions. Long-term planning will preserve the option of not fast tracking any project. This, combined with an examination that accurately measures the advantages and disadvantages of fast tracking, will result in far fewer fast-tracked projects. To minimize backtracking, project managers must be aware of the risks of fast tracking. Armed with that evidence, project managers can accomplish their usual project magic.

9.2.3 Barriers to Using CE in PLC Phases

In the past few decades, organizations have increasingly focused on how to structure their project delivery (Morton *et al.*, 2006). Many methods are used to reduce project delivery time; this is met by abandoning the classic serial planning methods, which are simpler, in favor of new methods like fast tracking or parallel planning. However, these last two are unstructured, less trustworthy and difficult, and generate errors, changes and more risks (Morton *et al.*, 2006). Hence the idea to investigate a new approach, which is a concurrent engineering method. It is now recognized that the adoption of new business processes based on concurrent engineering principles will provide a means of overcoming these problems, and improving the competitiveness of the industry (Anumba *et al.*, 2000).

As introduced in Chapter 4, CE was proposed as a means to minimize product development time (Prasad, 1996). The interest in modeling construction as a manufacturing process is primarily based on the similarities between the two industries, and the assumption that aligning the business processes of the construction industry with those of the manufacturing industry will significantly improve its competitiveness (Egan, 1998). Both the manufacturing and construction industries: 1) produce engineered products that provide a service to the user; 2) are involved in the processing of raw materials and the assembly of many diverse pre-manufactured components in the final products; 3) utilize repeated processes in the design and production of their products; and 4) experience similar problems, such as the high cost of correcting design errors due to late changes, poor resource utilization and inadequate information management (Anumba *et al.*, 2007). Another justification for the adoption of CE in construction is based on the fact that the goals and strategies (principles) of CE directly address the problems in the construction industry. Anumba *et al.* (2007) discussed how the needs in construction can be addressed by CE. This pairing of needs versus capabilities in support of CE in construction is further buttressed by the fact that existing practices in the construction industry, which are similar to CE, can facilitate its successful implementation in construction. It is therefore evident that CE has considerable potential in construction. Its capacity to provide an effective framework for integrating and improving the construction process is now also widely acknowledged in the industry (Egan, 1998). From both the context in which it evolved (manufacturing) and its inherent features, CE can be matched to the construction process. Its implementation, however, needs to suit the particular needs of the construction industry (Anumba *et al.*, 2007).

This subsection addresses the barriers and challenges behind uncompleted achievement to employing concurrent engineering within the whole project life cycle in the Norwegian construction industry; compared to the oil and gas industry, concurrent engineering methodology has been used for decades. The specific research questions addressed in this subsection are: (1) What are the criteria behind the success of using concurrent engineering methods in the Norwegian oil and gas industry? (2) To what extent has a concurrent engineering methodology been implemented in the Norwegian construction industry? (3) What can we learn from the oil and gas industry and how can we apply the lessons learned to the construction industry? To achieve this research objective, a case company is used. The firm is a leading Norwegian oil and gas, civil engineering and construction company "Contractor" founded in

1946, with an annual turnover of 4 billion Norwegian krone and more than 2,700 employees. It delivers all aspects of a project – from design to engineering, procurement, construction and fabrication services. The company started implementing the concurrent engineering methodology in the oil and gas sector in 2005. They have been reticent to do the same in the civil engineering and construction sectors because of a number of barriers and challenges to be faced in introducing the concurrent engineering method into this sector.

Exploratory research, as suggested by Tjora (2012) and Neville (2007), was used to design and validate the research work. It was a multi-method qualitative study, with secondary (internal and external) and primary (interviews) data. To achieve good reliability and validity and high triangulation quality, several sources were used to collect the data through interviewing project participants (i.e., project managers, project members, functional managers, consultants, suppliers, project owners and subcontractors), with the most interesting participants in terms of contractors being the persons in charge of implementing the CE method in all the company's projects (mainly contractors). I should also mention that some data are collected from companies' internal documentation, archives and process model booklets.

The study covered two sectors: the oil and gas sector and the construction sector. Exploratory, unstructured and in-depth interviews were conducted as part of the sector-based case studies. During the interviews, there were no fixed questions, but rather the interviewer had a general list of topics that were used to guide the interview (Oppenheim, 2000). The initial list of topics was derived from the research questions and the background literature review. The list of topics was refined and added to throughout the course of the interviews. There were eight interviewees (four from the oil and gas industry and four from the construction industry), but the number of interviews ranged from three to four times (number of rounds), and there was no maximum to the number of interviews that could be conducted. The first rounds of the interviews lasted for two to four hours, depending on the interviewees' feedback and discussion; the time was reduced in the last rounds of the interviews. The data were analyzed for each resource to identify the dominant challenges experienced in each project group (oil and gas vs construction). The collected and categorized data were analyzed using the cause and effect relationship to identify the relations between challenges and root causes, which eventually led to identifying most of the enablers and barriers.

a. CE in Norwegian Oil and Gas Industry

Several oil companies on the Norwegian continental shelf have implemented Integrated Operations (IOs), which is a concurrent engineering method, as a strategic method to achieve safe, reliable and efficient operations (Reinertsen and Smith, 1991). There are a variety of concepts describing IOs (CE in oil and gas industry), also called "e-Operations" and "Smart Operations." IOs (I call them "CE" in this dissertation) allow for a tighter integration of offshore and onshore personnel, operator companies and service companies, by working with real-time data from offshore installations. The aim of that is to achieve improved decisions, remote control of processes and equipment, and to relocate functions and personnel to a remote installation or an onshore facility. CE is both a technological and an organizational issue, focusing on the use of new and advanced technology as well as new work practices (Reinertsen and Smith, 1991). The integration of people, work processes and even vendors is a high priority and a key success factor for major oil operators as well as operating service companies that is required to succeed in using CE principles (Rosendahl *et al.*, 2013). In the oil and gas industry, most of the time projects are on a large scale, and present high complexity and uncertainty (Zidane *et al.*, 2012, 2013). In order to solve complex problems and cope with uncertainty, organizations in the oil and gas industry typically require the integration of knowledge from such different specialists as geologists, system engineers, civil engineers, economists, managers, drilling personnel, etc. (Kirkman *et al.*, 2004). That integration is done in the early-phase field development.

The CE method is implemented in oil and gas organizations based on the interconnection between the members of the team, the CE process and the use of relevant tools early on in the process (Flin, 1997; Øxnevad, 2000). These three main elements are illustrated in Figure 9.2-2. Bringing in all the relevant disciplines from all participant organizations in very early phases of the project ensures that all the functional areas are covered (Rosendahl *et al.*, 2013). From our study, one of the findings is that oil and gas clients/sponsors/owners/operators involve consultants, contractors, subcontractors and suppliers in the early phases of the project (on the tactical and strategic level), which is possible by using suitable types of agreements (joint venture, frame contract, partnership, etc.).

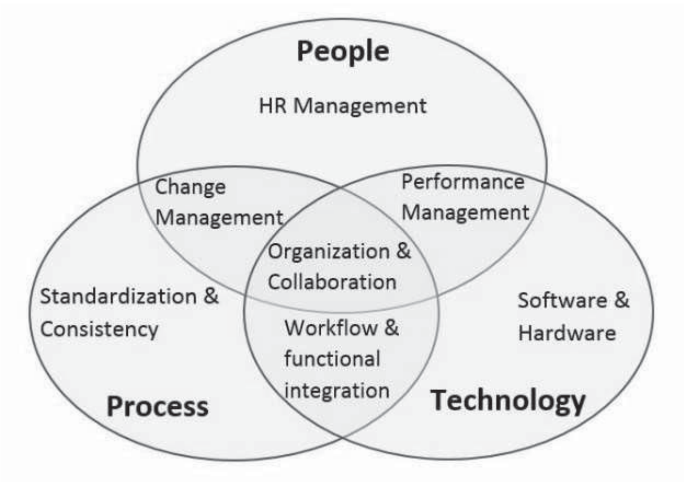

Figure 9.2-2: The integration of the three important elements in an organization.
(Adopted from: Rosendahl *et al*., 2013)

In the oil and gas industry, the team members from all participant organizations are brought together in the same room to work in concurrent sessions from the early phases of the project (i.e., on tactical and strategic levels of the project). This ensures that the disciplines have quick access to the relevant knowledge and have the opportunity to deal with the problems and the challenges in real time, faster than before. With quick and sufficient access to the relevant knowledge (i.e., needed information), it gives the disciplines the opportunity to challenge the parameters and the data early on and to work with the solutions in real time (Hepsø, 2009; Skarholt *et al.*, 2009). This will, in the end, save time and consequently money for organizations that are able to structure their work in this more efficient way (Øxnevad, 2000).

b. CE in Norwegian Construction Industry

In contrast to the oil and gas industry, the construction industry is organized around projects that are paid for by clients/owners/sponsors who are technically not part of the industry; they step back just after deciding from bids which contractor will be in charge of implementing the project. The same can be said about subcontractors and suppliers. As stated in the theory part, CE stands for two key principles: integration and concurrency. Integration is very hard to achieve in construction projects because of the timing required to involve the different stakeholders within the early phases and throughout the project life cycle (Zidane *et al.*, 2015c). Figure 9.2-3 reflects the timing of involving the different firms and stakeholders throughout the project life cycle and shows the existing gaps in achieving the desired integration in construction projects (Morris and Pinto, 2004). The absence of the operator/users in all project phases, except the handover and operating phase, leads to missing knowledge and information about what should be delivered, thereby affecting the effectiveness and the project outcome (i.e., tactical and strategic levels), and therefore the necessity to involve them in early project phases, at least from the needs identification phase up to the front-end planning phase.

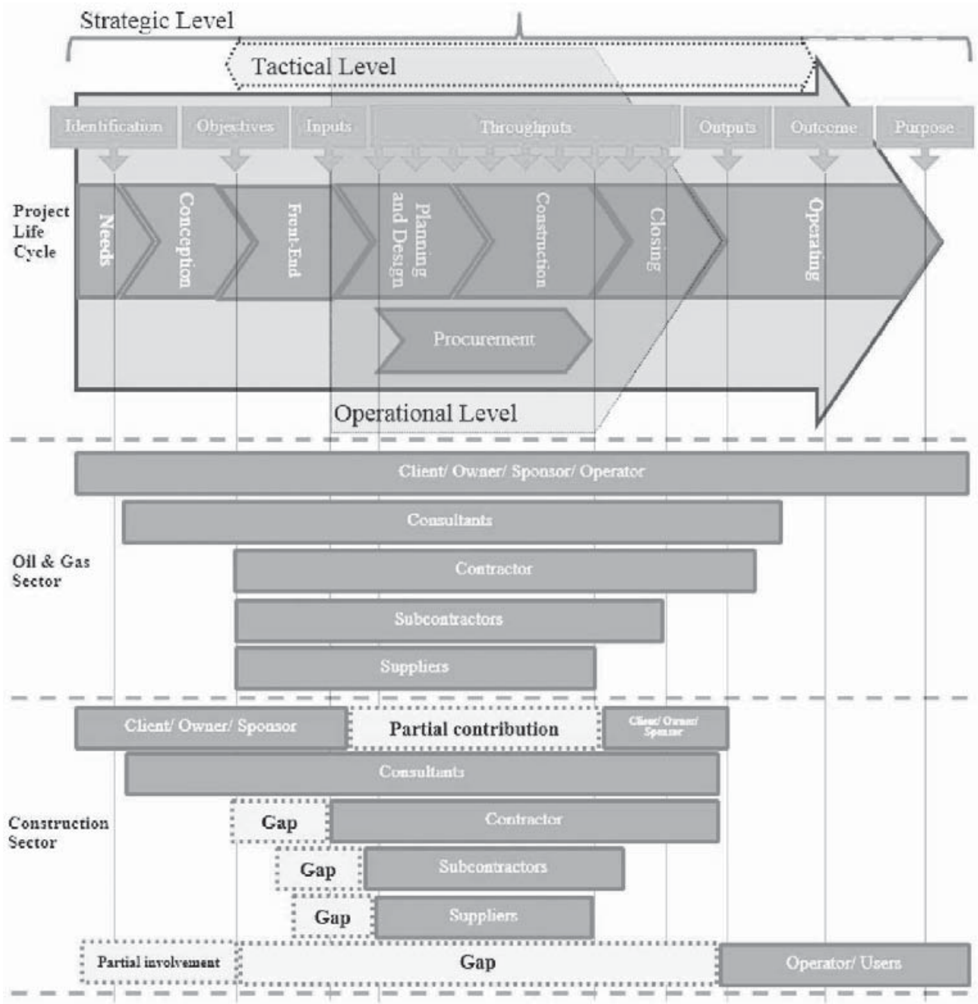

Figure 9.2-3: Timing of involvement of project participants in project phases.

Integration is not the only key principle that is hard to attain in the construction industry; the second key principle is concurrency and it is determined by the way tasks are scheduled and the interactions between different actors (people and tools). It is also challenging. Some studies have been conducted about the readiness of companies to implement the CE method (Khalfan *et al.*, 2001); the results showed that those most ready to implement the CE method are subcontractors, followed by contractors, while clients and consultants are less ready.

In Norwegian firms, those who are most ready are contractors, followed by subcontractors and suppliers, while clients and consultants are almost completely not ready. Accomplishing "accurate concurrency" in construction projects requires the extension of the role of the client/owner/sponsor to the operational level. It requires the early involvement of contractors, subcontractors, suppliers and operator/users in the early phases of the project (tactical level); this will allow a high level of integration. The next, easier step is to implement the right standardized process and technology by considering the changes on individual and organizational levels (see Figure 9.2-2).

c. *Enablers or Barriers to using CE Method in both Industries*

Most of the findings regarding the enablers and barriers to using the CE method are summarized in Table 9.2-3.

Norwegian oil and gas firms understood the high importance of the CE philosophy, which is conducive to true life cycle analysis. It brings together, from the inception of the project, multiple individuals to address all angles of the project and enables the accumulation of average shared knowledge and information among all the participants – i.e., in Figure 9.2-4; the two graphs are an interpretation of the analyzed data from the research work; so as to reduce downstream risks and anticipate constructability, operability and maintainability expectations (De la Garza *et al.*, 1994). To reach a high level of concurrency throughout the project life cycle, the client/owner/sponsor, who are the operator/users in our case, took the initiative to implement the CE method, and thus automatically all the following organizations (contractors, suppliers, consultants, subcontractors, etc.) were able to adopt it in a systematic manner. The early involvement of all participant firms in the early project phases permitted a high level of integration and proper use of the CE method.

On the other hand, the construction industry is fragmented to a high degree (client, consultants, contractors, subcontractors, suppliers, users, etc.) (Anumba *et al.*, 1997). Clients/owners/sponsors in most cases are technically not part of the industry; they create construction documents with the support of consultants, then use those documents to invite bids from qualified contractors. The contract will be offered to the lowest bidder. The type of contract and agreement makes the contractors come late to the project (operation level), leading to discontinuity in the processes and less integration among the organizations (Muspratt, 1988). The same can be said about the subcontractors and suppliers: The contractor in general executes part of the work, and subcontracts the remaining part to subcontractors. Consequently, there is less average accumulated information and knowledge sharing among the participants (see Figure 9.2-4).

The average accumulated shared required knowledge and information decreases each time new firms are involved (contractors, subcontractors, etc.). There is timid use of CE within the planning and design phase but that is not enough to get all the benefit from it; if it used throughout the life cycle the benefits will be enormous.

Table 9.2-3: Enablers/barriers to CE use in oil and gas vs construction industries

Elements	Oil & Gas Industry	Construction Industry
Client/owner/sponsor	The clients/owners/sponsors are the major enablers of using concurrent engineering within their projects. Thus, involving all other project participants in using the method is a systematic outcome.	The clients/owners/ sponsors are the major disablers of using concurrent engineering within their projects. There have even been some attempts from other project participants (e.g., contractors, subcontractors, etc.) but still the method used is far from being a widespread CE method.
Operator/users	Operator/users play an important role in enabling the use of concurrent engineering. The reason is because they belong to the same organization as the client, owner or sponsor. Thus an increase in the flow of information is needed in the early phases of the project, thereby avoiding many modifications at the end of the project.	Operator/users are almost completely absent from needs identification until the close-up phase. This causes missing information in the start-up of the project, and therefore extends the project duration because of changes, modifications and redoing some parts of the deliverables.
Contractors	The contractor is involved in the early phases before starting the implementation of the project; this gives more chance of using the CE method properly.	The contractor is involved only in the implementation of the project, after bidding.
Subcontractors and suppliers	Involved in the early stages, considered as partners.	Come late at the start of the planning and design phase.
Type of contract/agreement	Most cases joint venture, partnership, frame contract.	Bidding in most cases.
Time to delivery	It is extremely important that the project should be delivered within or ahead of schedule.	Less important than in the oil and gas industry, or even new product development.
HSE	Priority and key success factor.	Important, not critical.
Process	Aligned and standardized in all firms.	Well defined within the contractor level.
Technology	Available in all firms.	Complete tools within the contractor level.
Concurrent sessions	More integrated, start in early project phases, they are more collaborative sessions than traditional unproductive meetings.	Scattered, unstructured, start at the implementation of the project, they have more characteristics of hierarchical meetings than collaborative sessions.
Readiness	All participant firms are completely ready to implement the CE method (e.g., sponsor, clients, operator, consultants, suppliers, etc.).	Except for the contractors and subcontractors, no other type of firm is ready to implement the CE method (client, consultants, suppliers, etc.).

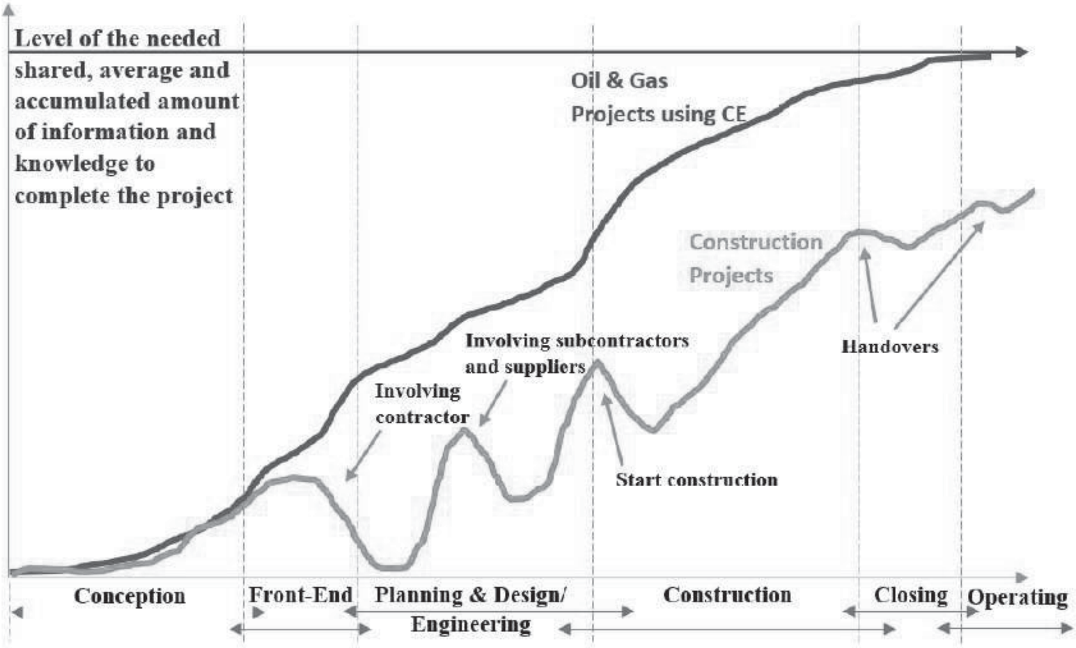

Figure 9.2-4: Level of knowledge sharing within oil and gas vs construction industries.

CE as a philosophy requires preparation and dedication to planning and implementation, along with adequate resources. It requires numerous changes in the organization's and in the employees' mindsets. The oil and gas industry succeeded in implementing the CE method, which is not the case for the construction industry. However, one should not forget that there is a huge difference between construction projects, which range from small to large scale, and oil and gas projects, which range from large to megaprojects with high complexity and uncertainty.

Therefore, the clients are more aware of the challenges, make themselves involved throughout the life cycle of the project and behave as the leading party for their projects. Clients using the CE method makes all other firms follow them, since most firms are customer oriented. In the construction industry, the role of the client is limited to the conception, and rarely involves front-end planning; this does not help in implementing CE philosophy properly throughout the project life cycle.

There is a chance to apply CE philosophy in LSEPs (construction in general, infrastructure, etc.) for public investment projects. The possibility comes from creating enterprises for each industry type (road construction, telecommunications, hospital and university construction, etc.). These enterprises, of course, will be under the delegation of the ministries concerned. This strategy will allow the ministries to focus on the strategic decisions and portfolio management, and leave the tactical and operational decisions to these enterprises. The other question to answer is: "What stopped these enterprises from using the CE philosophy in their management?" – knowing that for example in Norway, there are interface independent organizations between the government and the projects selected for implementation.

9.3 Boosting Project Speed

"Boosting" or, in other words, improving, enhancing, advancing, increasing and furthering. This section is divided into two subsections.

The first is about measuring project speed: Once something can be measured, it will be possible to monitor and control. However, this measurement is done on the operational level and specifically on construction work.

The second subsection is about evaluation and learning in a project. Five types of evaluations are introduced and linked to each other.

9.3.1 Performance Measurement – Project Speedometer

Performance measurement has been subject to a considerable amount of research and attention in recent decades. The introduction of nonfinancial measures has triggered much of this research; with the increase of the competitive environment, measuring performance has become crucial to business success (Bassioni *et al.*, 2004; Hajikazemi *et al.*, 2016)

The aim of this subsection is to develop a framework for measuring and monitoring construction project speed at the operational level of the execution phase and demonstrate how it can be employed to assess the performance in terms of speed of a road construction project. This includes a review of recent literature, the derivation of generic KPIs and a practical example of how this framework operates. It is imperative to note that this subsection concentrates on performance measurement for the purpose of internal management of the contractor in charge of the execution of the project and not for evaluation by other stakeholders. Furthermore, a performance measurement framework is a general theoretical framework developed in research that can act as the basis for a company's performance measurement system, while a performance measurement system refers to the measurement system implemented by a company (Bassioni *et al.*, 2004). Likewise, this subsection will consider both a performance measurement framework and a performance measurement system in road construction projects. In the construction industry, there is a tendency to measure performance in terms of time, cost and meeting code (Forbes *et al.*, 2002). Egan (1998) motivated organizations to move toward best practice in response to his report (Sarhan and Fox, 2013). As a result, the UK working groups on KPIs identified a set of nonfinancial parameters for benchmarking projects (Takim and Akintoye ,2002; Dawood *et al.*, 2006; Sarhan and Fox, 2013). Regardless of the KPI agenda, there are some problems identified in the KPIs. For instance, none of the measures mentioned could identify the performance of suppliers in a project environment (Takim and Akintoye, 2002; Sarhan and Fox, 2013; Gao and Low, 2014).

Time can be managed as well as delay and speed, which has been shown in a lot of the research conducted on concurrent engineering (Midler, 1993; Ben Mahmoud-Jouini *et al.*, 2004). Thus, it is necessary to develop a framework based on generic KPIs to measure and monitor the project speed performance with a view to being on schedule or even ahead of it. Chan and Chan (2004) state that the purpose of KPIs is to enable measurement of project performance. Collin (2002, cited in: Langston, 2013; Chan and Chan, 2004) agrees that the following attributes should be kept in mind: (1) KPIs are general indicators of performance that focus on critical aspects of outputs or outcomes; (2) Only a limited, manageable number of KPIs is maintainable for regular use (too many or too complex KPIs can be time- and resource-consuming); (3) The systematic use of KPIs is essential as their value is almost completely derived from their consistent use across projects; (4) Data collection must be made as simple as possible; (5) KPIs should be generic and able to be used on every project; (6) For performance measurement to be effective, the KPIs must be widely accepted, understood and owned. Cox *et al.* (2003) defined key performance indicators in construction as compilations of data measures used to assess the performance of a construction operation. They divided them into qualitative and quantitative performance indicators, with the former being the most commonly accepted performance indicators since they can be physically measured in dollars, units or man-hours. Sikka *et al.* (2006), cited in Sarhan and Fox (2013), classified KPIs into three conceptual phases of a construction project, pre-construction, construction and post-construction, because project success criteria change over time in each phase. Our concern in this paper is more about developing KPIs for measuring, monitoring and controlling project speed in the construction phase. This may be subjective to some extent, as most of the basic data for performance measurement are qualitative and difficult to convert into numbers for calculating the values of our KPIs. According to Langston (2013), speed is one of the six success KPIs for a construction project. Within the case discussed in this subsection, speed should be considered separately and techniques for dealing with it identified, ensuring the success of construction projects with regard to their time management.

In order to determine a set of perceived key performance indicators for project speed, a tangible example is described next. The model in Figure 9.3-1 helps to superpose the scenario onto a construction project and attempts to understand and apply the concept of speed to it. Once the KPIs are identified, a review of a real case of a road construction project is carried out. A literature review has been conducted on performance measurement in construction projects and on the concept of project speed and the time vs scope relationship in construction projects. Although many authors have written about velocity in software development projects, nothing, to the best of my knowledge, has been said speed as a measurable concept and how this can be measured in construction projects. A road construction project case has been used to illustrate the potential use of the concept. The described concept has not yet been tested or verified in the field.

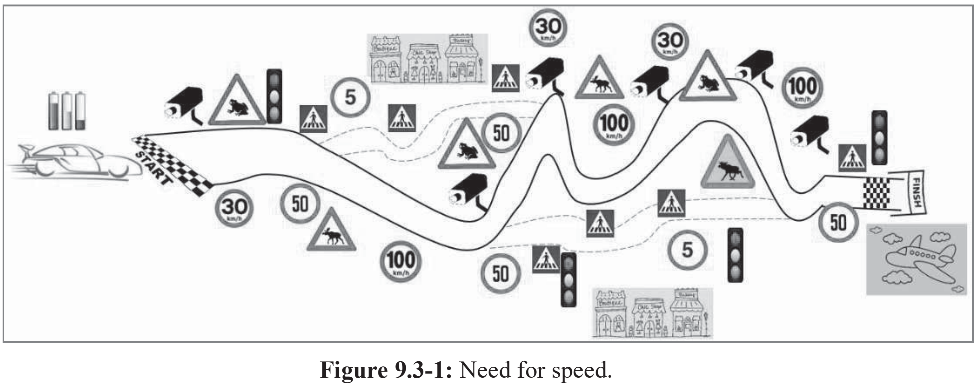

Figure 9.3-1: Need for speed.

The case is a road construction project; the road project is a highway that is under construction and located in the south of Norway. In this case, the described concept does not consider the construction of bridges and tunnels.

To be more practical, the example provided in this subsection describes a trip to the airport, which must end safely in 30 minutes and without the driver being fined. The distance to the airport is 50 km; the time frequently required for reaching the airport from our location is at least 60 minutes. So how is it possible to reach the airport in half the time? The required average speed for reaching the target (arriving in 30 minutes) is 100 km/h.

The car's maximum speed is 200 km/h. That is not the most important issue; the most important aspect is the acceleration of the car. It can accelerate from 0 km/h to 110 km/h in just one and a half seconds, and the speed can be reduced from 110 km/h to 0 km/h in just three seconds. The road is full of obstacles, which is the external environment (e.g., speed cameras, pedestrian crossings, traffic lights, speed limitation signs, etc.). However, the car is equipped with a very sophisticated GPS system that can calculate every second the remaining time before reaching the target based on the actual speed of the car. The driver is experienced, healthy and reflective, and he knows the route to the airport very well, including the pitfalls (i.e., where the speed cameras are located, when traffic jams may occur in the shortcuts, etc.), as well as the potential opportunities for reducing the time of the trip. All these parameters and indicators will enable the driver to reach the target safely and without being fined in half the time of what is usually required, based on using the GPS system. Using only the GPS system to control the speed in reaching the target can never be the case; it is just a tool that supports the whole (i.e., the experienced driver, his knowledge of the trajectory and his car, the car's quality and performance, etc.).

The same can be said about projects and project management: The framework suggested in this subsection is a tool for measuring and monitoring the speed of the delivery but not the single key success factor if all the other preconditions are not available (Zidane *et al.*, 2016a).

Langston (2013) identified six KPIs that articulate successful project delivery: complexity, impact, innovation, value, efficiency and speed. In this subsection, as previously mentioned, the concern is more about the speed (Figure 7.1-1 and Figure 7.1-2), which is the relationship between scope and time, which Langston (2013) defined as "the ratio of scope over time; this KPI is another that should be maximized. Speed is a function of Project Procurement Management, namely outsourcing strategies and parallel supply chains. Scope is treated as an output and time as an input, so the more utility provided per unit of time the faster is the delivery process"; and this is discussed further in Section 7.1. Therefore, here it is more about the identification of the most vital key performance indicators for project speed. The average speed is the minimum production speed required for completing the tasks as planned. Referring again to the trip example, if I have to travel 50 km, and I need to complete the trip in 30 minutes, the average speed should be a minimum of 100 km/h. If I are required to build a 50 km road (two lanes) in 300 working days, our production speed should be at least 0.17 km/day. From the previous definition (Langston, 2013) of project speed, the first KPI identified is inputs, in other words all the necessary materials, designs, documents, decisions, utilities, instruments, resources and human resources needed to accomplish a certain amount of progress within a unit of time in the appointed time within the execution phase. The inputs can be categorized as soft inputs, such as decisions, designs, etc., or hard inputs, such as materials, instruments, etc. The level of inputs is directly proportional to project speed (see curve number 2 in Figure 9.3-2). The more the inputs are increased per unit of time, the more possible it is to increase the project speed. The level of inputs is determined by the minimum level of all inputs (see Figure 9.3-3 as an example; the level of inputs is equal to the level of input I_7).

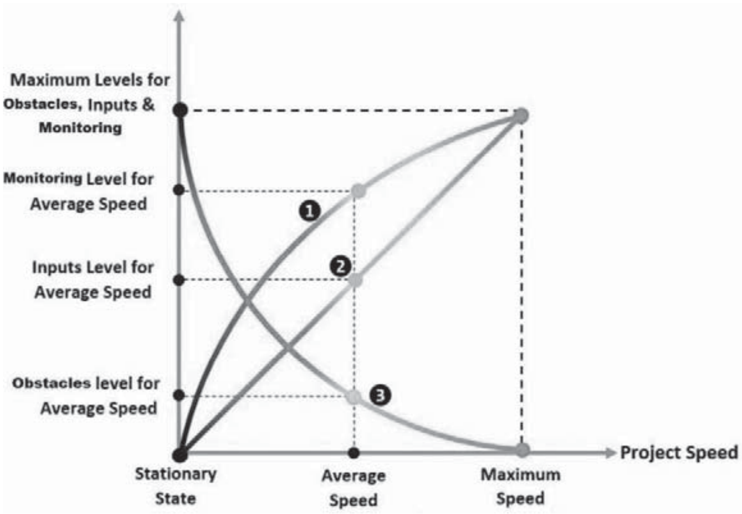

Figure 9.3-2: Framework of project speed vs monitoring, inputs and obstacles.

In other words, whatever the highest level of all inputs is, if one of them is low, then the total level of inputs will depend on the lowest level of all inputs independently. This means that the input level KPI is equal to the lowest input level of all inputs.

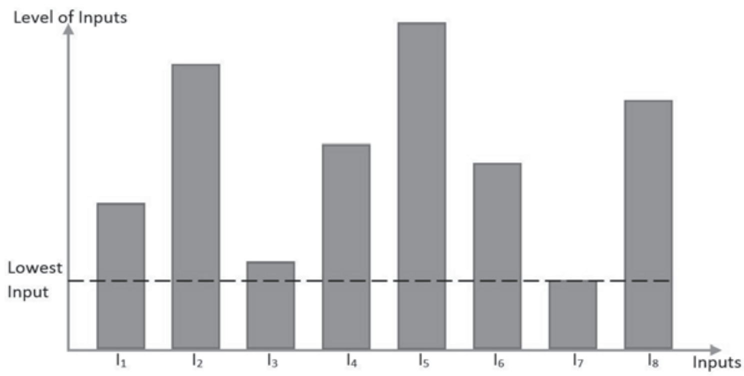

Figure 9.3-3: Example of level of all needed inputs for a block activity in a given time.

The second KPI is monitoring, as in driving the car. I cannot keep the speed at more than 80 km/h on sharp bends or on a curvy road, or drive slower than 50 km/h on a highway where the minimum speed is 80 km/h. There are road signs one must observe and the environment surrounding the car to consider, e.g., the state of the driver (tired, sleepy, etc.), other cars, animals, pedestrians, rain, snow, etc.

The same can be said about the monitoring KPI: If the project has no qualified human resources with enough knowledge and skills to do their tasks, they will keep making mistakes, and that will lead to rework, accidents and changes. In this case, the project management team will lose some of the project speed control. However, if I have experienced and skilled team members, a good HSE plan to follow, enough information for completing each task and integrated teams, the project management team will have good monitoring and control of the project progress, and thus be able to sustain a good speed. The monitoring KPI is also directly proportional to project speed (see curve number 1 in Figure 9.3-2).

The more I achieve good monitoring, the more I control, and consequently I will be able to increase the project speed more. The last KPI is obstacles. These are risks, barriers, ambiguities, difficulties, *forces majeures*, bottlenecks and time thieves that can hinder progress (Hillson, 1997, 1998; Zidane *et al.*, 2015b). Opportunities are considered to be the most positive side of obstacles. In other words, when I have no obstacles in a given time, then that should be considered an opportunity to increase the project speed.

Table 9.3-1 summarizes the parameters that stimulate the three KPIs relating to project speed. Of course, most of them are subjective since they are hard to measure, except when it comes to speed inputs, where most are measurable. I should also draw attention to these parameters and mention that they are interrelated to a great extent. For example, delays in making decisions in the inputs KPI may be due to a lack of information and experience; that parameter belongs to the monitoring KPI, and so on.

Table 9.3-1: Project speed KPIs and parameters needed to calculate them

KPIs	Parameters	Type and Effect
Speed monitoring	Changes Rework Errors and mistakes	Quantitative. Negative effect on project speed, causes delay and extra costs.
	Accidents	Quantitative. Negative effect, causes delay and extra costs and even may harm employees.
	HSE	Qualitative. Positive effect decreases accidents, thus saves time and costs.
	Skills and knowledge Experiences Information Integration	Qualitative. Positive effect saves time and costs.
Speed Inputs	Materials Utilities Human resources Design decisions	Quantitative. Positive effect in case of high input level, the more procurement is done in advance, resources prepared, decisions made, the higher the project speed will be.
	Interdependencies	Qualitative, depends on the degree of integration among the project teams; the more integration, the easier to manage interdependencies.
Obstacles	Risks Difficulties and pitfalls Ambiguities Bottlenecks Time thieves *Forces majeures*	Qualitative. Negative effect, the more intense, the more delays and costs.
	Opportunities	Qualitative. Positive effect, occurs when all above pitfalls are absent.

To give more credibility to the framework, as introduced at the beginning of this subsection, a case of a road construction project is considered (excluding bridges and tunnels) to illustrate the performance measurement system. There are typically six layers in Norwegian roads (Figure 9.3-4). Each layer is considered to be a block activity. Let us consider the bottom layer, the subgrade. In order to realize the subgrade layer, one must do block "activity 1" (Figure 9.3-5), which is called a "cut and fill" in road construction projects. The production is measured in cubic meters.

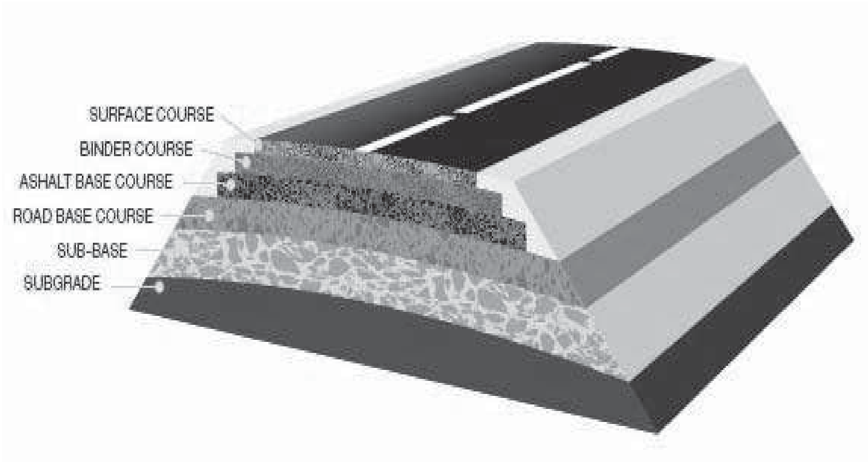

Figure 9.3-4: Different road layers.

For instance, in block "activity 6," which is the upper layer, production is measured in terms of meters; the same can be said about block "activity 7," painting separation lines on the road. Thus, in order to measure the total speed of the project I need to measure the speed of each block activity separately. The unit of speed used in the performance measurement system is cubic meter/day, square meter/day or meter/day, depending on the block activity. The block activities in road construction projects are in sequence: For example, if I achieved sufficient progress in the "cut and fill" activity, the teams can start putting down the subbase, etc. A delay in one block activity will cause a delay in all the others. The same applies if time is saved and one is ahead of schedule.

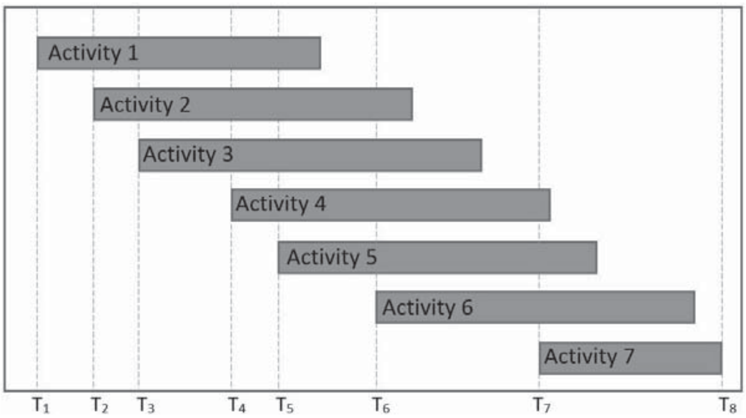

Figure 9.3-5: Simple Gantt chart for construction phase.

Using the framework discussed previous in this subsection, the road construction case, the guidance of the book *Performance Measurement Explained: Designing and Implementing your State-of-the-Art System* by Andersen and Fagerhaug (2001). In addition, using the guide titled *Building a Performance Measurement System: A How-to Guide* by Wolk *et al.* (2009), the author came up with the performance measurement system interface shown in Figure 9-3.6.

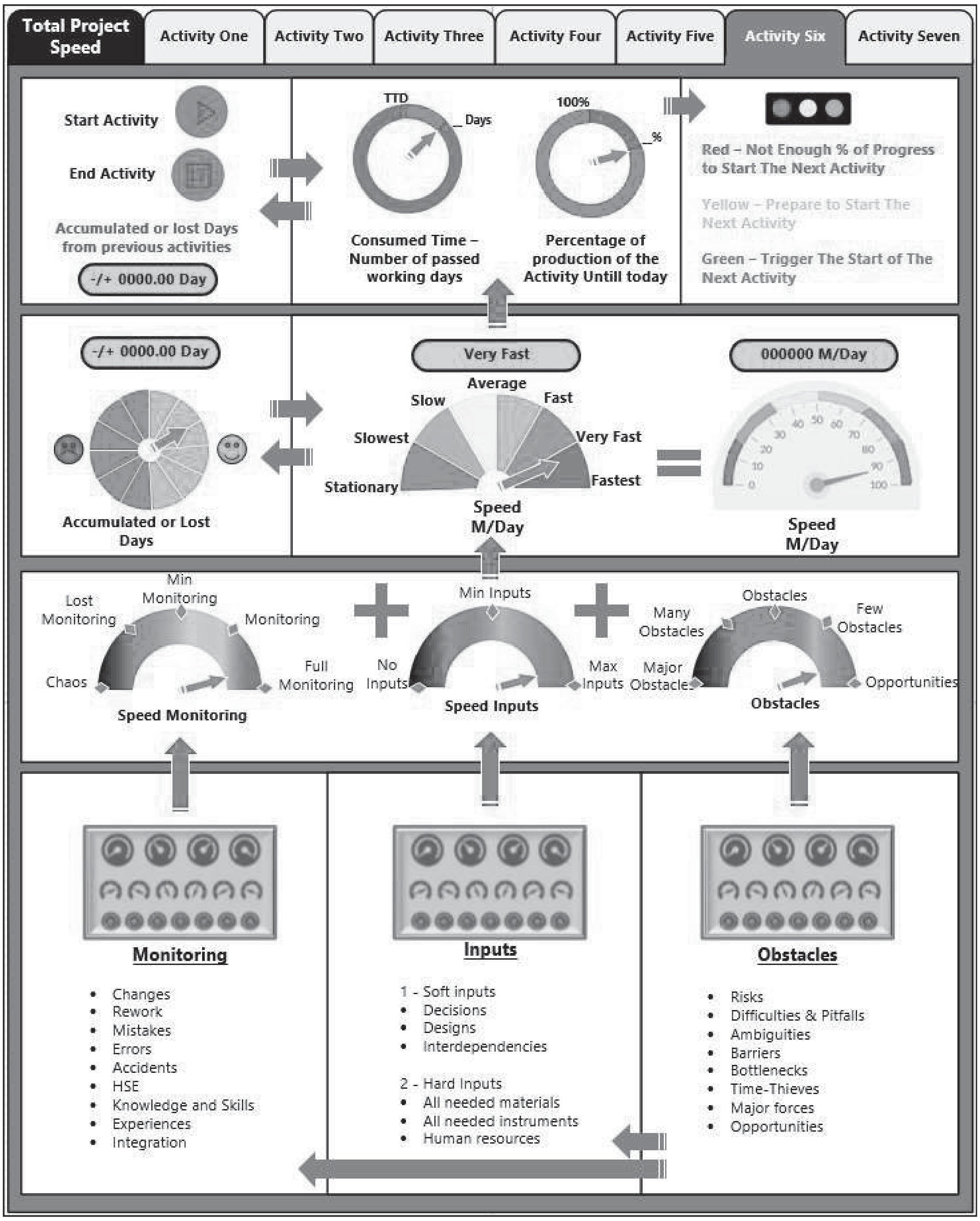

Figure 9.3-6: Example of possible "Project Speed Performance Measurement System."

For the tab showing block "activity six," this block activity will be triggered when there is enough accumulated progress from all previous block activities. The same principle applies to all the block activities from the second until the seventh tab. "Activity 1" is triggered by the decision to start construction of the road. There is a tab for each block activity, as the speed of each block activity is measured separately.

The lowest fourth level is the basic data for performing calculations for the monitoring, inputs and obstacles KPIs. Once completed, these three KPIs will in turn constitute the input for determining the value of the construction speed. To meet time to delivery (TTD) or, in other words, the planned time to complete the block activity, I need the speed to be at least average. To keep the speed average based on the three KPIs, the speed monitoring KPI should be on the indicator in the state "Control" or higher, the speed inputs KPI should be on the indicator in the state "Min Inputs" or higher, and the last KPI, pitfalls, should be on the indicator in the state "Few obstacles" or higher.

The performance measurement system in Figure 9.3-6 is based on daily measuring. This enables us to know the real speed of the production and the accumulated or lost days within the block activity (Figure 5, level 2, the indicator on the left-hand side) and also within the whole construction phase (Figure 9.3-6, level 1, the indicator on the left-hand side).

The indicators in the middle of level 1 in Figure 9.3-6 show the percentage of the completed production, and the number of days taken to produce that percentage. The tab in Figure 9.3-6 is the same for all "Total Project Speed" tabs; it is a summary of the total progress, the accumulated or lost days, where there is a need for improvement, the cause of delay (e.g., one of the inputs) and any indicators that allow the project team to take immediate action for improvement to increase the construction speed in order to hit the target.

Finally, it should be mentioned that all the departments within the project should feed this performance measurement system as they are all involved, e.g., the procurement department, the quality and risk management department, functional departments, etc. This feeding can be done using a systematic approach by collecting "big data", and by using sensor information and production data from several existing systems (e.g., GPS, internal administrative IT systems, etc.). Thus, the performance measurement system is not required to rely on information from all the departments (which tend to neglect reporting or submit the data very late). A systematic "big data" collection will make it possible to design a live performance system for speed in construction projects.

As stated at the beginning of this subsection, the framework suggested here is only a tool for measuring and monitoring the speed of the delivery but not the single key success factor if all the other preconditions are not available. The project speed framework for the construction phase has been developed based on a set of KPIs. Although two of the KPIs are subjective, as they are difficult to measure, the framework can trigger real consideration for measuring construction speed. Being able to manage the speed of project productivity in real time and on a daily basis will enable the project management team to meet the targets regarding the project's time to delivery.

9.3.2 Enhancing Project Speed through Evaluation and Learning

According to Suchman (1967), all social institutions are required to provide "proof" of their legitimacy and effectiveness in order to justify society's continued support. In this contest for public projects, evaluation is a major "weapon" (Weisbrod, 1960; Suchman, 1967; Weiss, 1972; Zidane *et al.*, 2016c). Scriven (1991) stated that evaluation is "the process of determining the merit, worth or value of something". Patton (1997) defines program and project evaluation as "the systematic collection of information about the activities, characteristics, and outcomes of programs for use by specific people to reduce uncertainties, improve effectiveness, and make decisions with regard to what those programs are doing and affecting". Patton's (1997) definition is concerned more about *ex ante* monitoring and midterm evaluations. However, our concerns are more about the *ex post* evaluation. There are five types of evaluations, which are are *ex ante* (e.g., Samset 2003) monitoring (previous Section 9.3.1), midterm (e.g., JICA, 2004), terminal (e.g., JICA, 2004) and *ex post* evaluations (e.g., UNIDO, 1972; USAID, 1979; UWA, 1996; NORAD, 1999; OECD, 2002; JICA, 2004; Samset 2003; Zidane *et al.*, 2016c). Evaluation of major governmental projects and programs has existed for more than six decades.

The OECD (2002) has defined evaluation as "A systematic and objective assessment of an ongoing or completed project, program or policy, its design, implementation and results." *Ex post* evaluation can be described as an evaluation of an intervention after the intervention has been completed (Samset, 2003). In addition, *ex post* evaluation is conducted after a certain period following the completion of a target project, with emphasis on the effectiveness and sustainability of the project. Such evaluations aim to derive lessons and recommendations for the improvement of future projects and programs (OECD, 2002; Samset, 2003; Zidane *et al.*, 2016c). Worsley (2015) mentions that *ex post* evaluation can serve multiple purposes, of which the two primary ones are learning and/or improvement and accountability and/or control.

Zidane *et al.* (2016c) developed an *ex post* evaluation model, which they named the PESTOL model (Project Evaluation on Strategic, Tactical and Operational Levels). Their model is based on an existing model (e.g., UNIDO, 1972; USAID, 1979; UWA, 1996; NORAD, 1999; OECD, 2002; Samset, 2003; JICA, 2004). The PESTOL model, presented in Figure 9.3-7, considers all project levels, i.e., the strategic, tactical and operational levels. And for measuring success it uses the concepts "efficiency," "effectiveness," "relevance," "impact" and "sustainability." "Efficiency" reflects a short-term perspective; in this regard, discussions are notably associated with delays and expenditures coming in over budget. These aspects can easily be measured. The relevance of the project and its effects – whether it attains its goals and objectives measured in terms of effectiveness, including impact and sustainability – can only be verified at a later stage, after the project has delivered its results. These are much broader aspects and are therefore difficult to measure.

Zidane and Olsson (2017) define project "efficiency" as a question of doing things right and producing project outputs in terms of the agreed scope, cost, time and quality (discussed in Section 7.1 in this dissertation). They added that quality is not a constraint per se, but often a by-product of the other three factors (scope, time and cost), and one that generally suffers when the others are not properly managed. "Effectiveness" is a measure of the extent to which management attains its objectives (OECD, 2002; Samset, 2003; Zidane *et al.*, 2016c; Zidane and Olsson, 2017). Samset (2003) defines "impact" as all unexpected positive and/or negative changes and effects of the project, both in the short term and the long term. Zidane *et al.* (2016c) divided "impact" as an evaluation criterion into the following levels: during the project impact, the short-term and midterm impact, and the long-term impact.

Samset (2003) defined relevance as "an overall assessment of whether a project is in harmony with the needs and priorities of the owners, the intended users and other attested parties. A change in policies or priorities could imply that a project is assigned lower priority, or that it loses some of its rationale. It becomes less relevant." According to Zidane *et al.* (2016c), relevance deals with the time needed (T_0 to T_3) to make the right decision (D_3) to start the implementation of the project (i.e., GO). If the decision is GO and the project becomes less relevant because of a change of policies or priorities, the assessment of relevance will instead be handled further by effectiveness, impact and sustainability. Sustainability concerns measuring whether the benefits of an activity are likely to continue after donor funding has been completed and/or withdrawn. Projects need to be environmentally sustainable as well as financially sustainable (OECD, 2002; Samset, 2003 Zidane *et al.*, 2016c).

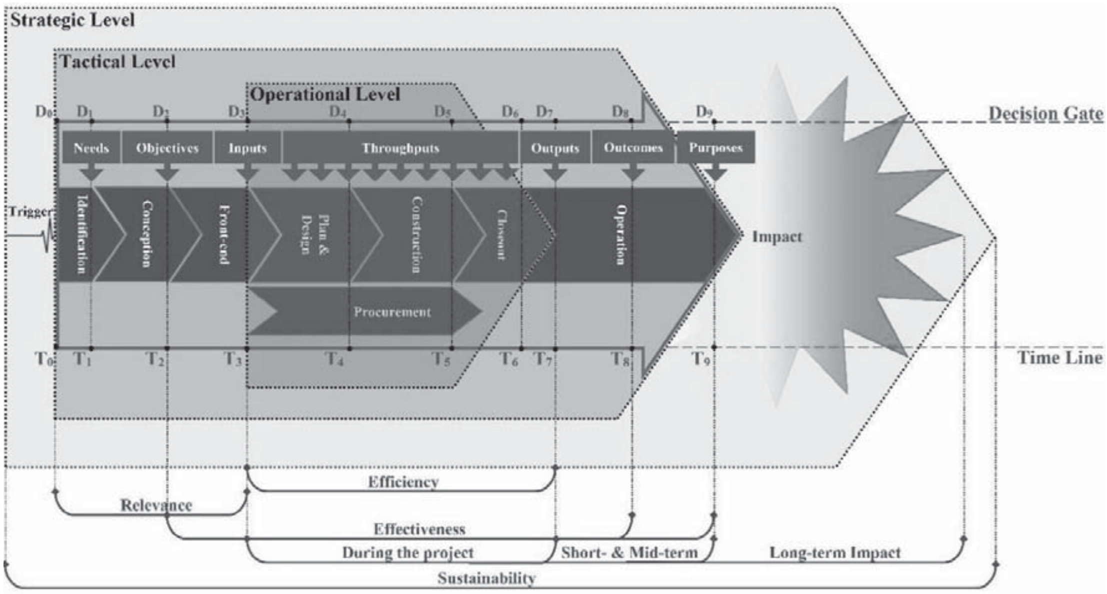

Figure 9.3-7: PESTOL model.
(Adopted from: Zidane *et al.*, 2016c)

The PESTOL model has been used in the case study *Case 1* – details of the evaluation can be found in the paper by Zidane *et al.* (2016c). The evaluation enabled the lessons learned to be extracted, and these lessons could be used for similar upcoming projects, especially for the strategic and tactical level. There is a relationship between the five evaluations listed at the beginning of this subsection; the timing and the relationships in using each type of evaluation are shown in Figure 9.3-8 and Figure 9.3-9. The five evaluations are "*ex ante*," "monitoring," "midterm," "terminal" and "*ex post*" evaluations; these evaluations are defined further next.

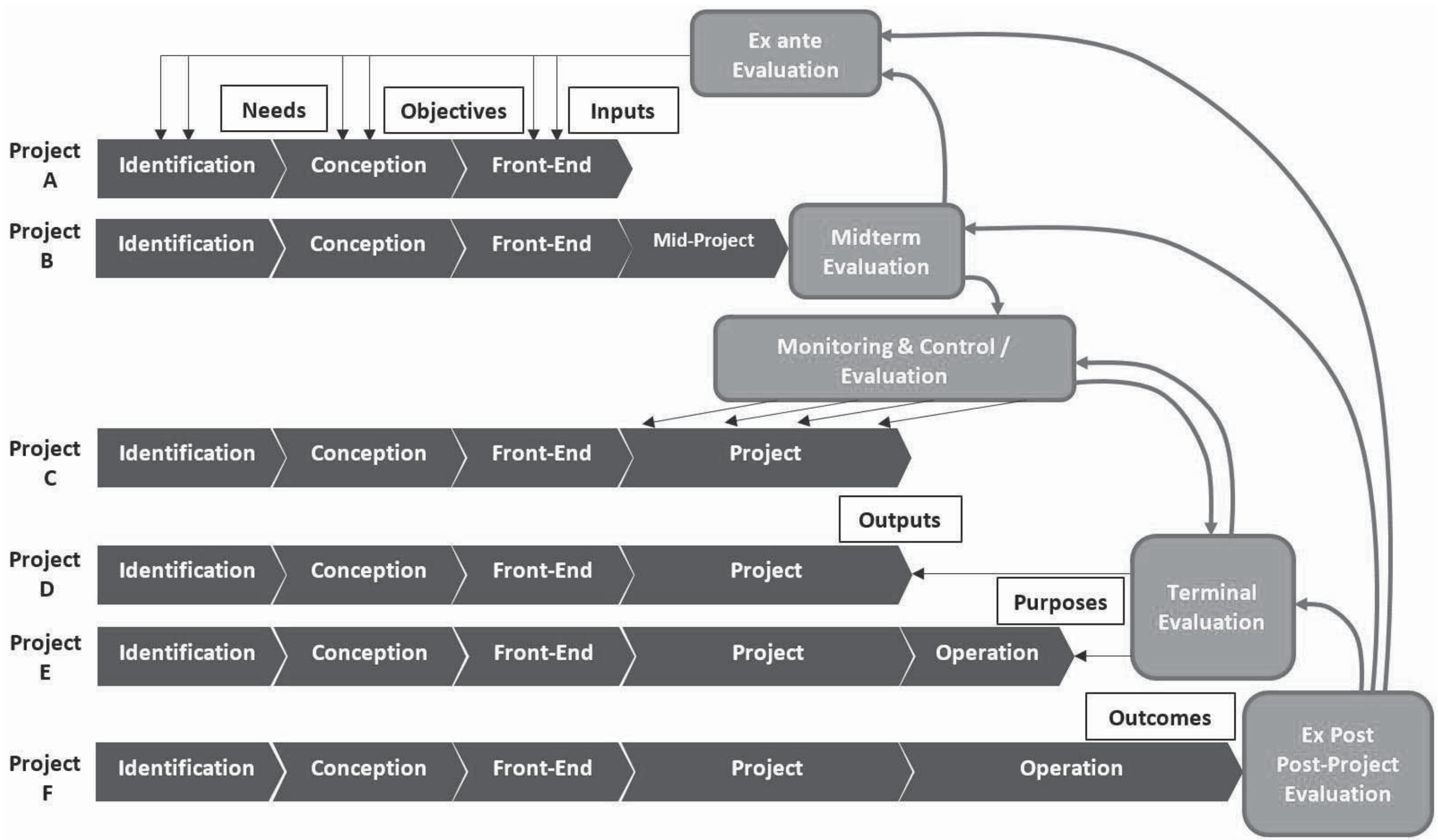

Figure 9.3-8: Timing of each evaluation type used during the PLC.

Ex ante evaluation involves a study of the project to determine its necessity as well as its conformity. Details of the project and its expected outputs are clarified. Then, the relevance of the project is comprehensively examined and evaluated. In *ex ante* evaluation, evaluation indicators are set and used to measure the effect of the project in subsequent evaluation, from the midterm evaluation to the *ex post* evaluation (JICA, 2004). According to Cristiano and Proietti (2014), "*ex ante* evaluation concerns the process of developing a policy program and is performed before its implementation. The evaluation involves a range of stakeholders and acts as a critical mirror for the authorities responsible for program development. It provides an assessment of whether development issues have been diagnosed correctly and should identify any gaps; whether the strategy and objectives proposed are relevant to national and regional needs; whether the approach proposed is coherent, and consistent with Community policies and guidelines; whether the assumptions concerning expected results and impacts are realistic and in line with the resources available. This process should enable successive drafts of the program to be refined and improved so that it is more likely to achieve its objectives in a cost-effective manner. Moreover, *ex ante* evaluation sets the cornerstone for subsequent monitoring and evaluation activities, by ensuring that all necessary information is available and that the system is adequate to provide the data needed to assess the program's results and impacts. This prepares the ground for reliable monitoring and evaluation throughout the programming period, which contributes to successful program steering and demonstration of the program's achievements."

Monitoring is referred to in the PMBOK Guide as follows: "to monitor is to collect project performance data with respect to a plan, produce performance measures, and report performance information." And "monitoring and controlling processes are those processes required to track, review, and regulate the progress and performance of the project; identify any areas in which changes to the plan are required; and initiate the corresponding changes" (PMI, 2013). This process can accumulate lesson learning and knowledge on the project operation level to be used in other similar projects. Monitoring is happening throughout the project (during the implementation of the project as shown in Figure 9.3-10). An example of monitoring is the performance measure system developed in Subsection 9.3.1.

Midterm evaluation is conducted at the midpoint of project implementation, as shown in Figure 9.3-10. This evaluation is aimed at examining the achievements and process of the project, focusing on the efficiency and relevance among the Five Evaluation Criteria. Based upon its results, the original project plan may be revised or the operation structure strengthened if necessary (JICA, 2004).

Terminal evaluation is performed upon completion of a project, focusing on its efficiency, effectiveness and sustainability. Based upon the results of the evaluation, the evaluator determines whether it is appropriate to complete the project or necessary to extend follow-up cooperation (JICA, 2004).

Ex post evaluation is conducted after a certain period has passed since the completion of a project, and it is conducted with an emphasis on the efficiency, effectiveness, relevance, impact and sustainability of the project. This evaluation is aimed at deriving lessons and recommendations for improvement and for the planning and implementation of more effective and efficient projects (JICA, 2004; Samset 2010; Zidane *et al.*, 2016c).

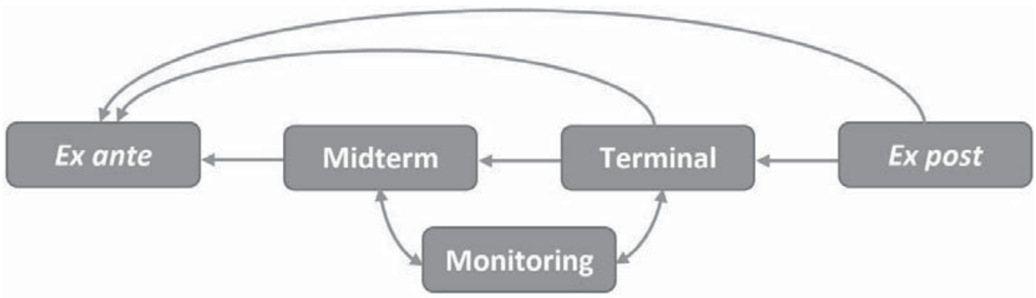

Figure 9.3-9: The relationships between the five evaluation types.

The subject of knowledge sharing and experience transfer in projects has been discussed for many decades. However, there is an increasing focus on knowledge sharing and learning in project-based organizations. Focuses such as project governance (e.g., Müller *et al.*, 2014) and governance of knowledge (e.g., Pemsel *et al.*, 2014) encourage a wider perspective of managing projects and emphasize the importance of knowledge sharing, experience transfer and learning in project environments.

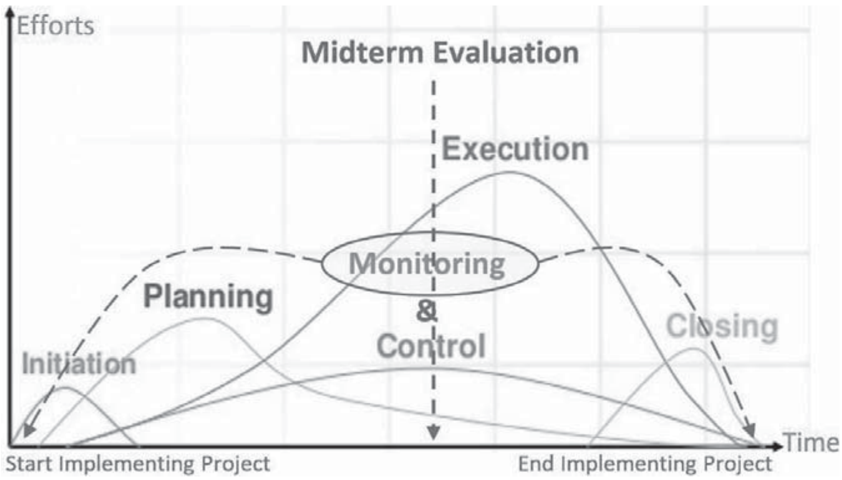

Figure 9.3-10: Project implementation – monitoring and midterm evaluations.

Since a project can be seen as a system, the angle of system thinking is considered here along with how to link it to evaluation and learning. Haskins *et al.* (2010) define system as a "combination of interacting elements organized to achieve one more stated purpose". Similarly, Blanchard (2004) defines system as "a set of interrelated components working together with the common objective of fulfilling some designated need". Thinking about a system is one definition of systems thinking (Moser, 2013). According to Davidz (2006), there are five foundational elements describing a systems thinking framework: componential, relational, contextual, dynamic and modal elements. The componential, relational, contextual and dynamic elements relate to the system.

LSEPs as complex systems have a significantly larger scale and scope than average industry projects; the cost associated with them is higher, the time taken for their completion is much longer and there are a large number of organizations involved. In addition, the effect and impact of the LSEPs on society are high. They are unique in terms of, for instance, the underlying principles and assumptions, the concept, the product, the sheer scale and scope of the process through which the product is made, the degree of complexity, and the effect and impact on the larger society. The uniqueness also indicates that there is a huge potential for the creation of new knowledge, not limited to a product or a service, but a new process through which the products and services are made.

Eriksson (2015) presents a description of exploiting and exploring knowledge: (1) Exploration includes things captured by terms such as "search," "diversity," "adaptability," "risk taking," "experimentation," "flexibility," "innovation" and "long-term orientation"; (2) Exploitation, on the other hand, involves refinement, alignment, control, constraints, efficiency and short-term orientation. According to Eriksson (2015), knowledge exploration can be compared to double-loop learning, in which the predefined boundary will be questioned and subsequently changed. A kind of out-of-the-box thinking (by asking the fundamental questions: Why do we do what we do? and Why do we do it in the way we do?), experimentation and hopefully an innovative solution would then result. LSEPs are possible arenas for the creation of new knowledge. Out-of-the-box thinking can be done through critical reflection, by asking fundamental questions regarding current practices.

Hammer and Champy (1995) first presented these questions when they talked about the concept of business process re-engineering. Asking fundamental questions and reflecting can lead to identifying a gap between current solutions (current practice) and desired solutions (future practice). In order to create the desired solutions that are expected in the LSEP, the existing framework or norms are to be challenged and changed. Double-loop learning can then take place. The five types of evaluations discussed previously can be among the best ways to harness the current practices with a view to establishing better future practices in upcoming similar projects.

Each type of evaluation can feed other evaluations: In particular, ex *post* can feed *ex ante* evaluation, since the lessons learned are more concerned with the strategic and tactical level, and these two evaluations happen at the level of the owner/client/sponsor since this stakeholder is more interested in project effectiveness, relevance, impacts and sustainability. Monitoring, midterm and terminal evaluations are more related to the operation level and the efficiency of the project in general; these evaluations are conducted by the contractor, especially "monitoring evaluation," to control the plans better. The case study *Case 1* shows that similar extension projects had seen better strategic decision-making from the owner (Ministry of Civil Work, MTP). Improvement of the decision-making quality process had saved several months, even years for running road construction megaprojects compared to *Case 1*. This improvement came from the *ex post* evaluation of *Case 1* and using the lessons learned for upcoming projects. However, evaluations are not used to collect lessons learned to improve all aspects of managing projects and programs.

9.4 Yin & Yang, Chronos & Kairos, Efficiency & Effectiveness

This section discusses the polarity and dualism coming from "yin" and "yang," followed by project "efficiency" (doing things right) and project "effectiveness" (doing right things) as polarity. Involving the "chronos" (time) and "kairos"' (timing) is necessary to complete the figure. Based on the Chinese philosophy of Yin and Yang, attempt to conceptualize the project success based on the two criteria, i.e., efficiency and effectiveness, in a more holistic way.

Yin and Yang is a unique Chinese duality thinking bearing some resemblance to the dialectical thinking elsewhere (Peng and Nisbett, 1999; Li, 2012). It captures the Chinese view of paradox as interdependent opposites compared with others' view of paradox as exclusive opposites (Chen, 2002). Yin and yang are two sides of dualism, the tail and the head of a coin. The head cannot exist without the tail, and the tail cannot exist without the head. The tail is yin, and the head is yang, and they exist alongside one another. While Yin signifies the "female" cosmic energy of yieldingness, softness, femininity and submissiveness, Yang indicates the "male" energy that is often associated with unyieldingness, hardness, masculinity and domination (Chen, 2008). In cultures other than the Chinese one, Yin Yang (Tai Chi) as shown in Figure 9.4-1 is a complex concept in which yin and yang are opposite but also complement each other (Wang, 2013). According to Law and Kesti (2014, p.4), there are four main aspects of yin-yang relationships:

1. Yin and Yang are opposites: Yin and Yang form a closed cycle, they are either at the opposite ends of a cycle, like the seasons of the year, or opposites on a continuum of energy or matter. This opposition is relative, and can only be spoken of in relationships. Any given two sides are connected and related, but they are also opposed in some way. It is the tension and difference between the two sides that enables the dynamic energy that comes through their interactions. In addition, this difference enables yin yang as a strategy to act successfully. It must sometimes be more yin and sometimes more yang, depending on the context (Wang 2013), e.g., like light and dark, male and female, and forceful and yielding. Water is yin relative to steam but yang relative to ice. Yin and Yang are never static but in a constantly changing balance.

2. Interdependent: Nothing is totally Yin or totally Yang. As a cyclic loop, as a state of total yin is reached, yang begins to grow. Yin contains the seed of Yang and vice versa. They constantly transform into each other. "Yin creates Yang and Yang activates Yin," as the Chinese saying goes, e.g., there is no day without night. When a day comes to the end, the night grows, and after the whole night, the day comes again. This is the cycle completed.

3. Mutual consumption of Yin and Yang: Relative levels of Yin Yang are continuously changing. Normally this is a harmonious change, but when Yin and/or Yang are out of balance they affect each other, and too much of one can eventually weaken (consume) the other. There are four possible states of imbalance:
   a. Preponderance (excess) of Yin,
   b. Preponderance (excess) of Yang,

c. Weakness (deficiency) of Yin,
d. Weakness (deficiency) of Yang.

With regard to things themselves, even something that is strongly yang can be considered yin in some relations. The constant alternation between yin and yang also entails yang always holding some yin and yin holding some yang. In the cycle of the four seasons, summer is the most yang of the seasons, yet it contains a yin force, which will begin to emerge in the summer, extend through the fall and reach its culmination in the winter. Winter is the highest stage of yin, yet it unfolds a yang force that will attain its own full swing through spring to summer (Wang, 2013).

4. Inter-transformation of Yin and Yang: This refers to the situation that one can change into the other, but it is not a random event, happening only when the time is right. For example, spring only comes when winter is finished.

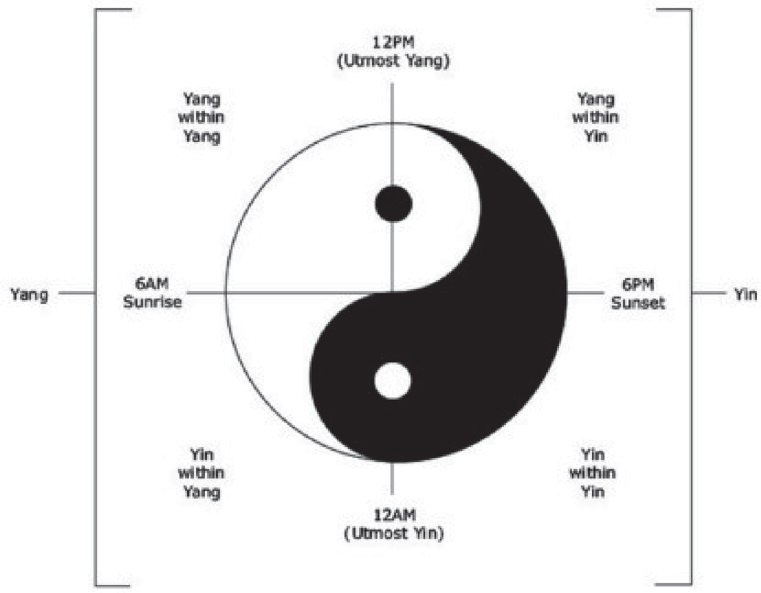

Figure 9.4-1: Yin Yang "everyday cycle."
(Adopted from: Law and Kesti, 2014)

According to Law and Kesti (2014), the Yin is one extreme and the Yang is the opposite extreme of Yin. So, if you are in the Yin state, you are in the Tai Chi state of Yin. If you are in the Yang state, you are in the Tai Chi state of Yang. Furthermore, if you are in between the Yin and the Yang states, you are in a changing state. During the changing phase, if you started in the Yin state, you will be changing toward the Yang state. On the other hand, if you started in the Yang state, you will be changing toward the Yin state. To understand how yin and yang are affecting us in daily life, the example of the nature demonstrating Yin Yang is the "everyday cycle" (see Figure 9.4-1). Two phases of constant cyclical change are observed; the simplest one is the day-and-night cycle. Yin constantly changes into Yang and back into Yin again. This can be seen in the changes of the four seasons, and the changes throughout a single day (24 h cycle).

Efficiency and Effectiveness:

From the Merriam-Webster Dictionary of Synonyms (1984, pp.280–81): The word "efficient" has synonyms such as competent, qualified, able, capable, expert, skillful, skilled, proficient, adept and masterly. In addition, "efficient" may apply to what is actively operative and producing a result. Efficiency implies acting in a manner to minimize the loss or waste of energy in producing.

"Effective" emphasizes the actual production of an effect or the power to produce a given effect. "Efficacious" synonyms are potent, powerful, puissant, cogent, telling, sound, convincing and compelling; "efficacious" implies the possession of the quality or virtue that gives a thing the potency or power that makes it effective. "Effectual" synonyms are accomplishing, achieving, fulfilling, operative, dynamic, active, decisive, determinative and conclusive. "Effectual" suggests the accomplishment of a desired result or the fulfillment of a purpose or intention, so the term frequently becomes synonymous with a decisive or final result and looks backward after the event.

From the three definitions of the terms "efficient," "effective" and "efficacious," I can understand that to be effective I should pass the stage of being efficacious, since being efficacious implies the possession of the quality or virtue that gives a thing the potency or power that makes it effective. On the other hand, being efficient is about being less wasteful and it is about doing things correctly and right (since its synonyms are "competent," "able," "capable," etc.). To sum up: (1) To be efficient is to produce an output in a competent and qualified way. (2) To be efficacious is to possess the quality that gives the produced results the potential to lead to an effective outcome. (3) Being effective is when the results have accomplished their purposes, and give an effective outcome. Figure 9.4-2 reflects the three concepts (efficiency, efficacy and effectiveness) and how they should be used in project management.

Project efficiency is the production of an output in a qualified and competent way in terms of the agreed scope, cost, time and quality, where quality is not a constraint per se, but often a by-product of the other three factors (scope, time and cost). Efficiency is more about comparing the outputs of the project to its inputs (Figure 9.4-2); the question asked before the start of the project is "how will it be done?" and at the end it is "how was it done?" Further discussion about project efficiency can be found in Section 7.2 of this dissertation.

Ika (2009) and Ika *et al.* (2010) are the only ones to have involved efficacy within project success or describe it as part of a project. They stated that project success is about organizational effectiveness (quality of process, policies, deliverables, outputs or intermediate outcomes, and operational efficacy) and development effectiveness (development outcomes such as long-term impacts, which the project tries to aim for and should contribute to). However, I still ignore the real meaning of the operational efficacy in their context. Wong and Wong (2014) argued that time, cost and quality merely represent project performance in terms of efficacy (wherees here, efficacy is obviously meant as efficiency), without due regard to the importance of effectiveness. Project efficacy refers to the success of attaining predetermined goals. In contrast, project effectiveness concerns the ability to accomplish goals (Wong and Wong, 2014); this contradicts most definitions of efficacy applied, but the confusion started when using the concept of efficacy instead of efficiency from the beginning. Going back to Wang *et al.* (2008), Wong and Cheung (2008) and Toor and Ogunlana (2010), whereas Wong and Wong (2014) refer to defining efficacy, I found no existence of the word "efficacy" in the first three. Here again the confusion in considering the concepts efficiency and efficacy as synonyms, knowing that "efficacy" is getting things done and meeting targets, is the ability to produce a desired amount of the desired effect, or success in achieving a given goal (Hickey and Brosnan, 2012). Unlike efficiency, the focus of efficacy is the achievement itself, not the resources spent on achieving the desired effect. Efficiency is doing things in the most economical way (minimum input to maximum output). Effectiveness is "doing the right things" (Drucker, 2000), i.e., setting the right targets to achieve an overall goal. From a holistic viewpoint and system thinking approach, the measures of success are "efficiency" (i.e., are the minimum resources used in goal seeking); "efficacy" (do the means employed enable us to realize our goals?); "effectiveness," which asks whether I are actually achieving what I want to achieve. Moreover, "elegance" is reflected by the question: are the stakeholders and what is proposed tasteful? (Jackson, 2003).

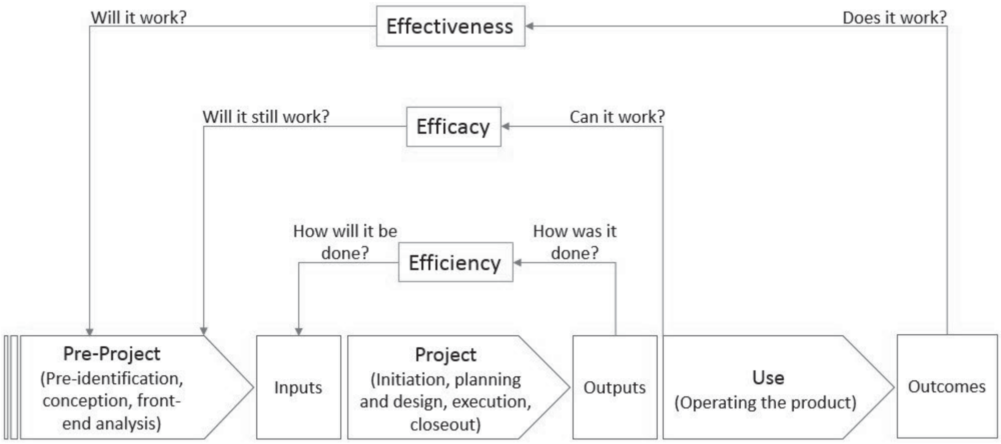

Figure 9.4-2: Model reflecting efficiency, efficacy and effectiveness.
(Adopted from: Zidane and Olsson, 2017)

Martinsuo *et al.* (2013) related effectiveness to long-term impacts and interests. Other authors reflected project effectiveness based on stakeholders' perceptions, mainly clients, sponsors, owners and users (Andersen *et al.*, 2011; Ssegawa and Muzinda, 2016). Dalcher (2012), Bayiley and Teklu (2016) and Yamin and Sim (2016) have linked project effectiveness to the accomplishment of project objectives. This divergence in having a common understanding and interpretation of project effectiveness will make it harder to measure, knowing that the concept of project effectiveness is subjective when it comes to measuring it. Effectiveness is "doing the right things" (Drucker, 2000), i.e., setting the right targets to achieve an overall goal. Samset (2003) defines effectiveness as a measure of the extent to which the management attains its objectives, and the extent to which the objective has been achieved, which is the first-order effect of the project for the users, in the market, in terms of production, etc. Therefore, the measure of effectiveness is more related to project stakeholders. Many organizations and NGOs (e.g., UNIDO, OECD, USAID, UWA and JICA) define project effectiveness based on short-and midterm effects of the outputs on the outcomes of the project and the extent to which the development intervention's objectives were achieved, or are expected to be achieved.

Drucker (2006) claims that effectiveness is a very important practice that can be learned. Effectiveness is not a destination, but a journey. What is effective is not necessarily efficacious, and what is efficacious is not necessarily efficient. The "tragedy" with effectiveness is that it is very hard to measure. Last, but not least, for us, effectiveness is the hardest part to measure. It is about the purpose(s) and the objectives of the project. It happens that a project has a certain purpose(s), but in the end, it serves another purpose(s). Project effectiveness is when the operating of the produced product generates positive impacts in the mid and long terms.

Time (Kronos/Chronos) and Timing (Kairos): This has already been introduced in Section 1.4 of this dissertation. Again, kronos/chronos, which I call here "time," is clock time, chronological, linear, circular or spiral time. Kronos/chronos is used as an exact quantification of time. In terms of managerial performance in project management, this clock time is the dominant factor, particularly in management, administration and the improvement of what already exists and is known (Rämö, 2002).

Kairos occurs at a suitable time, and is seasonable, opportune and well-timed (Merriam-Webster, 1984). While chronos is quantitative, kairos has a qualitative meaning (Liddell and Scott, 1896). In classical Greek culture, the word "Kairos" refers to a kind of time, which is opportune, proper, right, in reference to an action to be accomplished, to a decision to be reached or to an initiative to be undertaken (Cipriani, 2013). Kairos also means "weather" in Modern Greek. Etymological studies of the word "kairos." In archery, kairos denotes the moment in which an arrow may be fired with sufficient force to penetrate a target (Stephenson, 2005).

In English, the translation of kairos is the right or opportune moment that carries ideas of wisdom and judgement in timely situations. All managers face timely situations characterized as "moments of truth," which might imply intelligent actions beyond what has been mechanically learned and beyond timetables (Rämö, 2002). Kaairos signifies a period or season, a moment of indeterminate time in which an event of significance happens (Liddell and Scott, 1896). Below, both are discussed in a bit more detail.

Chronos, whether it is described as clock time, linear, circular or spiral, remains inadequate in such timely situations. Instead, chronos must be complemented by such a nonchronological notion of time as kairos (Rämö, 2002). Kairos is that time that breaks through chronos with a shock of happiness, that time I do not recognize while I are experiencing it. Only afterward in kairos are I completely unselfconscious and yet paradoxically far more real than I can ever be when constantly checking our watches for chronological time. Chronos is about quantity. Kairos is about quality. Chronos is about the present (efficiency) that was the future and is the past before I know it. Kairos is about the now, and especially when the "right now" is the "right time" for what is happening (effectiveness) right now.

9.4.1 Yin Yang & Project Performance

Yin Yang offers a holistic and paradoxical worldview and methodology. Everything has both Yin and Yang aspects, which constantly interact and interplay, never existing in absolute stasis (Chen, 2008).

Yin Yang (Figure 9.4-1) suggests that there exists no absolute borderline between Yin and Yang. A dot of Yin, black, exists in the Yang, white, and a dot of Yang, white, also exists in the Yin, black. Opposites contain within them the seed of each other and together they form a changing unity. As Yin reaches its extreme state, it becomes Yang and vice versa. A balance between these two energies is important and ensures harmony (Chen, 2002).

According to Li (2016), Aristotle's formal logic and Hegel's dialectical logic are insufficient for effectively managing high complexity and high ambiguity, despite the fact that Yin-Yang balancing is well equipped to confront today's new challenges. It is worth noting that Yin-Yang balancing was effective before the end of the sixteenth century, because the practical nature of Yin-Yang balancing was adequate for the organic complexity and ambiguity in the pre-modern era (Li, 2016). Nevertheless, it was inadequate for the mechanistic simplicity and clarity in the modern era, from the beginning of the seventeenth century until recently (Li, 2016; see also Kelso and Engstrom, 2006; Brenner, 2008).

The world today is entering the "trans-modern" era, which requires both organic complexity and ambiguity at the macro level, and mechanistic simplicity and clarity at the micro level (Levine, 1985; Li, 2016). Discussing efficiency and effectiveness is related directly to project success, with the need to involve stakeholders. Efficiency is more concerned with the contractors, subcontractors and suppliers (see Section 5.1). Effectiveness is more related to the sponsor, operator, client and users. Moreover, when it comes to time, chronos is the time, which is one of the constraints in efficiency. Kairos, as defined previously, is about the opportune moment, and is linked to effectiveness.

Efficiency is the Yin; it is contracting, closing, nourishing, shrinking and oppressed. Yin stands for feminine energy such as a woman, sadness, moon, water, darkness and passivity, or intuition, softness, yieldingness and submissiveness (Chen, 2008); that which reflects efficiency, which is oppressed – e.g., continuous changes in the scope to meet the requirements, where the requirements are part of the effectiveness. It is passive, since things come from the changes in effectiveness; the project success does not depend on its efficiency but its effectiveness.

Effectiveness, on the other hand, is Yang, which stands for masculine energy such as the sun, fire, light and activity, rational thought, hardness, expansion, assertiveness, growing and domination (Chen, 2008). That is the case, where effectiveness is rational thought, hardness, expansion, since there are good reasons for the project to exist. Assertiveness regarding the objectives and goals of the project. Domination, since effectiveness is the one leading the project and not the opposite. Growing, as when things progress in time, there will be changes to meet the desired effectiveness.

Everything has its opposite – even though this is never absolute, only comparative. Yin and Yang are opposites, as are efficiency and effectiveness. Yin and Yang form a closed cycle, they are at the opposite ends of a cycle. This opposition is relative, and can only be spoken of in terms of relationships. Efficiency and effectiveness behave in practice in the opposite manner, and in a way, the more the try to be effective (client – meet the goals and objectives) the more we lose our efficiency (contractors – time, cost and scope increase) and vice versa, so they are opposite, the same as Yin and Yang. Also, when talking about time, the opportune moment (kairos) will not always fit the chronological (chronos) sequences designed to complete the project.

Yin and yang are interdependent – nothing is totally Yin or totally Yang. As a cyclic loop, as a state of total yin is reached, yang begins to grow. Yin contains seeds of Yang and vice versa. They constantly transform into each other. Yin and Yang can be further subdivided into Yin and Yang (Figure 9.4-3). Yin Yang both, separately can be further subdivided into Yin and Yang. For example, temperature can be hot or cold. However, hot can be further divided into warm or burning; cold into cool or icy. Within each spectrum, there is a smaller spectrum; every beginning is a moment in time, and has a beginning and an end, just as every hour has a start and finish.

Figure 9.4-3: Yin-Yang within Yin-Yang.

The same can be said about efficiency and effectiveness: We want to be efficient in making the right decision but also effective in doing things fast, cheaply and well. Yin and Yang consume and support each other. "Yin creates Yang and Yang activates Yin" – the same for efficiency and effectiveness; efficiency creates effectiveness – i.e., starting a project based on its inputs (time, cost, scope) will give outputs and a product; by using the product, there will be outcomes, which can be measured if they meet the desired outcomes through effectiveness; therefore, efficiency creates effectiveness. On the other hand, effectiveness activates efficiency: There will be no project (time, cost, scope) if the project is judged to be ineffective and irrelevant. Thus, the effectiveness is the reason why there will be efficiency. Efficiency will never exist without effectiveness and vice versa.

Figure 9.4-4 represents the efficiency (Yin) and effectiveness (Yang) in a project life cycle. The white is effectiveness, whereas the black is efficiency. The figure shows that at the end of the first Yang, there will be a transition of Yin Yang, which is efficacy in this case, then a Yin, which ends in a transition state, that gives efficacy again, then to a Yang state at the end. The effectiveness will end at a certain moment and go into a transit state again; this transit is efficacy again, then efficiency. This going back to a new efficiency is due for example to a nes extension project, maintenance project or any type of project to the existent product to maintain the needed effectiveness or to improve it.

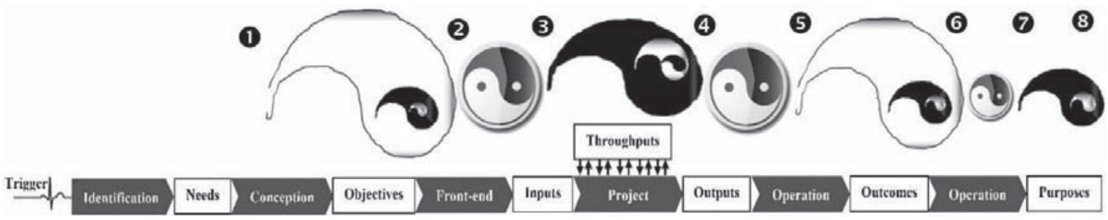

Figure 9.4-4: Yin-Yang analogy to efficiency-effectiveness.

Thus the existence of efficiency within effectiveness (see also Figure 9.4-5); before the start of any project, there will be in the *ex ante* stage several projects (i.e., feasibility, technical studies, financial studies, etc.). These small projects existing before the front-end phase are those shaping the effectiveness of the project. However, since they are projects themselves, they should be managed properly. The front end and the handover of the end product at the end of the project are presented by the whole yin yang because those are the moments when it is decided if the project will be done, then at the end to start operating it and see if the project was really relevant. Thus, those moments are a kind of transit between effectiveness and efficiency, and vice versa.

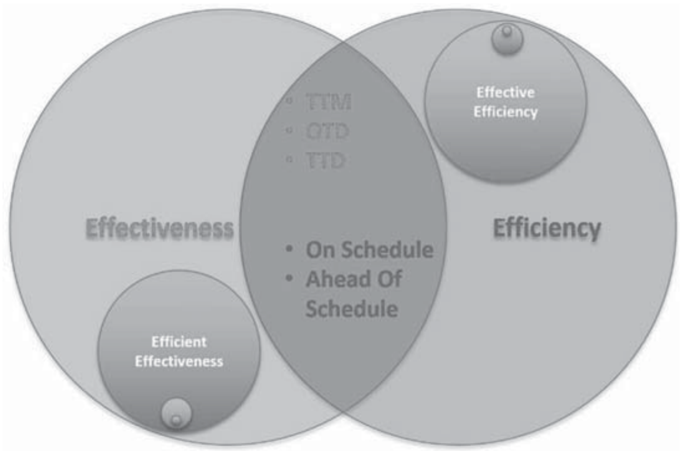

Figure 9.4-5: Time-timing and efficiency-effectiveness.

Figure 9.4-5 shows the relationship between efficiency and effectiveness, and chronos and kairos. it shows that time and timing may clash; this clash occurs when the time to delivery defines the success of the project – e.g., in event management, if the project is delivered behind the event day, there will be no reason for the project to exist. Cipriani (2013) discussed the relation between chronos and kairos in sociology. He said that there is real drama when a clash between chronos and kairos occurs. The clash is due to social exigencies and individual needs.

Mutual: Efficiency and effectiveness consume and support each other. Efficiency and effectiveness are usually held in balance – as one increases, the other decreases. However, imbalances can occur. There are four possible imbalances: excess efficiency (yin), excess effectiveness (yang), efficiency (yin) deficiency and effectiveness (yang) deficiency. They can again be seen as a pair: through excess of effectiveness there is efficiency deficiency and vice versa. The imbalance is also a relative factor: The excess of effectiveness forces efficiency to be more concentrated.

The analogy of Yin-Yang to efficiency-effectiveness: (1) the excess efficiency consumes effectiveness; (2) the excess effectiveness consumes efficiency; (3) deficiency of efficiency results in an increase in effectiveness; (4) deficiency of effectiveness results in an increase in efficiency.

Remaining with the analogy of Yin-Yang: Ultimately, every treatment modality can be summarized by four principles: eliminate excess efficiency; eliminate excess effectiveness; tonify efficiency; tonify effectiveness.

The Yin change is hard; the Yang change is good. By analogy, the efficiency change is hard, the effectiveness change is good, which is always true.

Inter-transformation of efficiency and effectiveness: This refers to the situation that one can change into the other, but it is not a random event, happening only when the time is right. We plan our effectiveness, and then we decide to implement a project that will be measured by efficiency; at the end we get a product to use, which again will be judged by its effectiveness. Figure 9.4-6 is the final representation of all concepts in a single presentation.

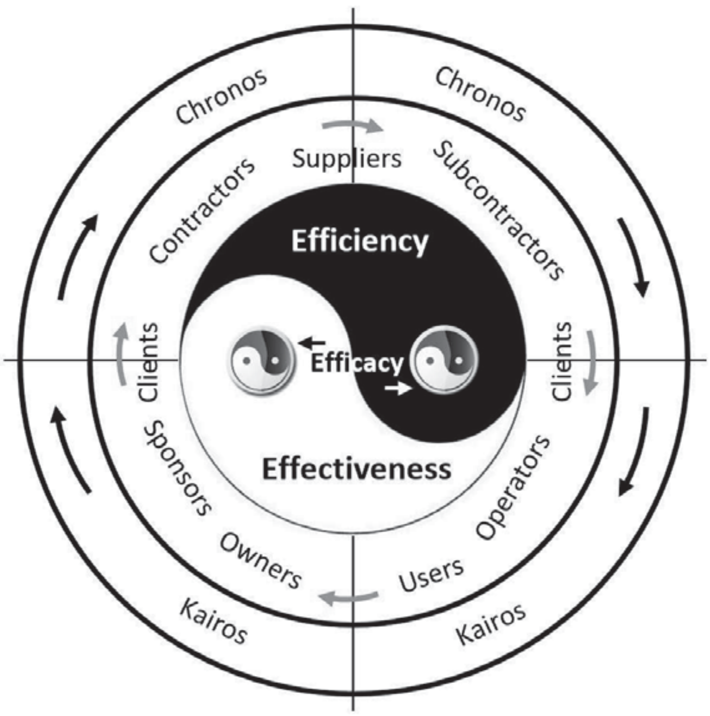

Figure 9.4-6: Yin-Yang, efficiency-effectiveness and chronos-kairos.

To be more to precise about the model in Figure 9.4-6, with regard to the kairos, it is more about the possibility of where it may occur. However, for chronos, it is from the day it is decided to implement the project to its delivery.

Efficiency and effectiveness form a closed cycle (Figure 9.4-6); they are at the opposite ends of a cycle. Efficiency and effectiveness behave in practice in the opposite manner, and in a way, the more we try to be effective (client – meet the goals and objectives) the more we lose our efficiency (contractors – time, cost and scope increase).

On the other hand, the more the contractors, suppliers and subcontractors try to save their costs, and reduce scope or extend time, the more this may affect the effectiveness of the outcomes. So they are opposite, the same as Yin and Yang. Also, when talking about time, the opportune moment (kairos) will not always fit the chronological (chronos) sequences designed to complete the project. However, there are cases where time and timing may clash; cases where being on schedule will affect the use of the delivered product from the project. It can be seen in Case Study 1 that the project starts without a proper front-end planning, and this leads to many mistakes during the execution of the project and interference from the sponsor in the project implementation. The results were disastrous efficiency.

While phases progress (within the project life cycle; see Figure 9.4-4), no phase is totally based on efficiency or effectiveness. As a cyclic loop, as a state of total efficiency (at the project delivery) is reached, effectiveness begins to grow (using the delivered products for their purposes). Efficiency contains seeds of effectiveness and vice versa. They constantly transform into each other. We produce something in an efficient manner; however, we make sure that it is effective. Once it is becoming less effective, this leads to starting again to make it effective by doing something, and that doing something should be done efficiently and so on. This is shown in Figure 9.4-4.

Efficiency and effectiveness can both separately be further subdivided into efficiency and effectiveness. For example, in the conception phase, the team will try to see to what extent the project may be relevant and effective; however, they can be efficient in doing this task. Figure 9.4-5 shows the relationship between chronos and kairos. The figure shows that chronos and kairos clash together; this clash occurs when the time to delivery defines the success of the project. These two concepts of time, chronos and kairos, should not be seen as two sharply distinguished classifications, but rather as a complementary pair of human time concepts (Rämö, 2002).

Based again on Figure 9.4-4; the interval 2–3 is represented by yin-yang. In the project performance, it is efficacy. It is the moment where both effectiveness and efficiency are known. In other words, the effectiveness is seen as expected in the outcomes, and the efficiency is identified and sets the inputs for the project. This occurs again in the interval 5–4, where the efficiency can be measured in relation to its inputs. Then there will be a transit to effectiveness, since, as we discussed previously, effectiveness cannot be measured at the output; efficacy can handle the measure between the moment of handing over the project to operating and using it, until the outcomes are seen in the mid and long term. At a certain moment of time (kairos), the product will start becoming less effective, and thus maintenance projects will be initiated, or extension projects, etc. This leads to starting the closed cycle again as shown in Figure 9.4-6.

Efficiency and effectiveness consume and support each other. Efficiency and effectiveness are usually held in balance – as one increases, the other decreases. However, imbalances can occur, which is the case for Case Study 1, where there was excess in the effectiveness, and that made deficiency in the efficiency. In addition, Case Study 2 shows the same setting, where the excess of effectiveness forces efficiency to be more concentrated. In brief, the efficiency change is hard; the effectiveness change is good. The statement to make here is: The contractor focuses more on the efficiency and wants fewer changes; the client wants more changes to shape the effectiveness better, which is always true (the satment).

Efficiency changes to effectiveness once the project is completed, and the smooth transition between them is efficacy. Effectiveness leads to efficiency before taking the decision to start implementing the project, and again the transition between them is efficacy. This transformation from one to another is not a random event, as it happens only when the time is right, the kairos time. That right time is the more creative aspect of time, when a feeling for the right moment to act can result in clarifying new and gallant ideas. Everything else is a waste of time.

The model in Figure 9.4-6 shows what this is all about. The inner circle, which contains the efficiency and effectiveness closed loop, reflects the performances and the transition is efficacy represented by the small yin-yang symbol. The interaction between these three criteria for measuring project performance will keep turning. Effectiveness leads to the existence of efficiency and the transition between them is efficacy. Once efficiency is completed, effectiveness will be born, and the transit again is efficacy. Once in time (kairos) there is a need to shape the effectiveness again, because the product does not meet the purpose any more, new projects are started for maintenance, extension, development, modernization, etc. to make the existing product effective again. This leads again to efficiency and the transition is efficacy, and so on.

There are stakeholders related to each stage within the closed circle. There are needs, because there will be users. The sponsor/owner/client will produce the conception. All this will happen while defining the effectiveness of the project. This definition needs a Kairos time to happen; we do not know exactly what we want, how we want it, when we want it, why we want it, etc. Thus, the type of time used during this stage of defining effectiveness is the kairos time. Once the effectiveness is defined, things will be handed to the other types of stakeholders to implement the project, i.e., contractors, suppliers and subcontractors. This is the efficiency phase, where we will have inputs and we expect to have outputs to compare the ins and outs to measure our efficiency. The type of time used here is chronos time; the starting date is fixed, as well as the end date.

The model in Figure 9.4-6 is an attempt to group the performance measure criteria, which are efficiency, efficacy and effectiveness, with respect to the project stakeholders, and the two types of time – i.e., chronos and kairos.

Conclusions—How to?—Fast Project Delivery

The research described in this chapter is based mainly on raw data collected from different sources, based on two strategies (survey and case study). Specific findings from this chapter are briefly described and the results of all analyses are combined in this summary. The research question (RQ5) addresses in this chapter is:

RQ5: How can projects be delivered faster?

The findings from this chapter are related to the delay factors, project speed and management methods, evaluation by monitoring and other types of evaluation, and to a combination of Eastern and Western philosophy to balance the efficiency and effectiveness. The findings are summarized as follows:

1. Delays cause projects to run slower. Hence, in Section 9.1, some practical suggestions sourced from the survey and interviews are given as to how to deal with delays.

2. The second finding relating to how projects can deliver faster is based on Case Study 2, which reflects how it was possible to complete a project that was supposed to last two years in just a few months. The schedule compressing was possible because of existing conditions and opportunities, or rather the uncertainty was embraced and all possible opportunities were exploited. However, fast-tracking and schedule compressing may have some negative effects, and in some cases they are irreversible.

3. The fast-tracked project (Case 1) was successfully fast-tracked in terms of meeting the customer's goals and objectives, within schedule and on budget. However, it failed to sustain the use of the resources and in terms of its ability to carry on the next phases of the extension projects. Most fast-tracked projects carry high risks in terms of, for example, people's safety, staff burnout, and product defects, and therefore they should have contingency budgets as well as incentives. The contractor succeeded in fast-tracking the project at the operational level, but failed completely at the tactical level, which led to backtracking and attempts to repair the mistakes instead of progressing with other phases of the megaproject. Fast-tracking may be one solution when dealing with urgent and unexpected problems, which need unfamiliar actions. Fast-tracking may be the best decision if facilities have to be provided swiftly to realize a large increase in revenues due to a change in market conditions. To minimize backtracking, project managers must be aware of the risks of fast-tracking.

4. The fourth investigation related to the barriers in using the CE method in the construction industry. The findings relating to the barriers are explained as integration being very hard to achieve in construction projects due to the timing required to involve the different stakeholders within the early phases and throughout the project life cycle. The absence of the operator/users in all project phases, except the handover and operating phases, leads to lack of knowledge sharing and information sharing about what should be delivered, thereby affecting the effectiveness. Hence, it is necessary to

involve them in early project phases, at least from the needs-identification phase up to the front-end planning phase. Another finding concerns the readiness of each stakeholder. In Norwegian firms, those who are most ready are contractors, followed by the subcontractors and suppliers, whereas most clients and consultants are usually far from ready.

5. Performance measures can be used to monitor project speed during the execution phase. A speedometer based on a set of KPIs is suggested as a way to measure execution speed and to check for irregularities, in order to correct them and improve the practices in similar activities. Speed enhancement is all types of evaluations are used in all project phases and interlinked to each other within similar set of projects. This will reduce risks and feed projects' teams with lessons learned from similar projects.

The last finding presented in this chapter is a more philosophical interpretation of the relationship between the Yin/Yang, Time/Timing, and efficiency and effectiveness, and the necessity to balance between two sides of the same coin.

CHAPTER 10

Conclusions & Further Research

"By three methods we may learn wisdom: First, by reflection, which is noblest; second, by imitation, which is easiest; and third by experience, which is the bitterest."
— *Confucius*

This chapter sums up the findings of previous chapters, discusses the limitations of the study and indicates further areas of research that have become apparent as a result of this work. The first four chapters of the dissertation form a general introduction, describing the methodology, setting a context by defining the project life cycle and project duration in Chapter 3, and in Chapter 4, introducing some TTMPs used in scheduling, planning and managing projects. These chapters are not concluding chapters and thus not included here. There is exception in the methodology chapter, since the limitations of the study are discussed in Section 2 of this chapter. Chapters 5 to 9 are research chapters, each presenting the research work, thus they are directly reflected in Section 1 of this chapter. Chapter 5 discusses the state of affairs vis-à-vis time in LSEPs. Chapter 6 concerns delay factors, or as used by most scholars, the delay causes in LSEPs. Chapter 7 investigates the relationship between project speed as defined in that chapter with project flexibility, uncertainty and complexity. Chapter 8 presents an answer, among many possible answers, to why projects should be delivered faster, on schedule or ahead of schedule. Chapter 9, which is related to the research question "How can projects be delivered faster?" proposes some TTMPs for delivering projects faster or ahead of schedule. The research area of this dissertation is wide; consequently, some limitations had to be introduced to make the research task feasible. Suggestions for future research are added in Section 3.

10.1 Overall Conclusions & Contribution to Theory & Practice

The conclusions drawn in this section are based on Chapters 5, 6, 7, 8 and 9. The conclusions are a summary of the findings and results, and how they are reflected into practice

The section starts by discussing the results from the investigation and answering Research Question 1. The first research question is: "What is the current state of affairs and performance vis-à-vis the elapsed time, the time to delivery and other project aspects in a sample(s) of large-scale engineering projects?" This research question is answered based on observations carried out on data collected about completed projects. The data are related to the projects' cost, scope and duration of different project phases. The findings were from the observations made on the diagrams and patterns.

The second discussion is about delay factors from empirical studies conducted in Norway based on the described survey strategy and two studies performed in Algeria based on a survey strategy and a second study based on a case study, which is *Case 1*. The findings and results from these three studies are about negative factors, which are the delay factors/causes. These factors delay project delivery and/or hinder project speed and progress. The last point in answering this second research question is the summing up of all delay factors from all previous studies and the three empirical studies in this dissertation related to delay factors; the results are to produce a list of the most common delay factors, or in other words the universal delay factors.

The findings from the third research question, which is "What are the relationships between project speed and project flexibility, uncertainty and complexity?," reflect the effects of the concepts of flexibility, uncertainty and complexity on controlling project speed. This understanding of the relationships between the three concepts and project speed may help management to make the right decisions when it comes to TTD of their managed projects.

This research question, if asked in another way, would be "Why is delivering slowly and/or behind schedule a problem, and should projects always go faster?" including "Why should delay factors be dealt with?" There are assumptions that short-term project delivery or ahead-of-schedule delivery is not wanted by all stakeholders; the context of the project mostly decides the speed the project should follow, and thus which types of projects need to be delivered faster and/or whether there is a need for project categorization. There is a need to investigate the reasons for speeding or fast delivery of projects, however project uniqueness may lead to not generalizing the findings. There is no need to speed up project delivery if there are no benefits from that, or if there may be negative impacts from that. This is the context the research question is concerned about.

The answer to the fifth research question is based mostly on the findings from the first three questions; however, it overlaps with the previous research question, *RQ4*. The answers are related to fast project delivery, shortening the project duration and improvements for how to achieve that. The "how" to deliver projects fast is the goal of this study based on the assumption that there is a need for early project delivery or at least on-time project delivery.

***Research Question 1:* What is the current state of affairs and performance vis-à-vis the elapsed time, the time to delivery and other project aspects in a sample(s) of large-scale engineering projects?**

This first research question's answers has contributed in answering the coming research questions. The investigation in this research question was about the current state of affairs and current performance vis-à-vis elapsed time (chronos, chronological, linear and sequential); this part is more related to the time elapsed during the project (starting the implementation to the delivery of the project). In addition, it was about current performance vis-à-vis the time to delivery (TTD) of large-scale engineering projects, which is more related to the timing (Kairos) and effectiveness of the project.

The samples used to answer *RQ1* are sets of projects from medium- to large-scale projects from the construction industry in Norway. The sample is a set of 70 medium- to large-size construction projects. The standpoint was from the whole project life cycle as it is seen from the client standpoint; and that would be better from the stakeholders that initiated the project.

According to the findings, there is a very weak direct proportionality between time and cost. There are many cases where for the same duration there are differences of total project cost and vice versa. However, there is a story behind each project, and it would not be wise to make any judgements based only on the total cost and the project duration observed on the diagrams and graphs. However, the other research questions are designed to answer the reasons behind this weak direct proportionality between time and cost, and it can be seen that there are many factors that contribute to these scenarios, where a small project and a very large project can be completed within the time window. The total project cost at the end of the project does not automatically reflect the time window needed to complete it, and vice versa.

The findings from these data show that and on average around 90% of the total project cost is spent on the construction and the remaining on average less than 10% is spent on the detailed planning, feasibility study and front-end stages. However, it can be seen that some projects spend more than 15% on the pre-project and less than 85% on the construction; and others spend less than 10% on the pre-project and the rest on construction.

The question to ask about the total cost spent on the pre-project is: Will an increase of the total cost in the pre-project stages improve the delivery of the project (i.e., engineering, construction, commissioning and handover)? Unfortunately, this question is not among this study's objectives. It should be noted that the set is uniform to some extent, because the selected projects were completed compared to those projects in a pending state or facing obstacles. It was found that around 90% of the total project cost is spent on the project implementation (i.e., detailed design, engineering, procurement and construction). There is a very weak direct proportionality between time and scope. There are many cases where for the same duration, there are differences in the end project scope and vice versa. However, there is a story behind each project, as has been said previously regarding the relationship between time and cost, and it would not be wise to make any judgements based only on the project scope and project duration; there is a story behind each project that should be considered. The end project scope at the delivery does not automatically reflect the time window needed to complete it, and vice versa.

Most scholars argue that the more time spent on planning the project, the shorter its execution time (Easa 1989; Chan et al. 1996; Hegazy 1999; Gomar et al. 2002; Kandil and El-Rayes 2006; Pinto 2007; Hegazy and Menesi 2008; PMI 2013). However, it can be seen in the studied sample that the time ratio of the used time before execution compared to the time used in the construction does not reflect the theory of longer planning – shorter execution. Based on calculation on a normalized diagram, the time of the project execution represents approximatively 3/8 of the total time. The time before the project execution is more than 5/8 of the total time of the sum of all cases. The planning time is 1/8 of the 5/8 of the before execution, which shows that most of the time is not spent on the planning. The time spent on the pre-project is not inversely proportional to the execution time of the project.

From the used sample, all the cases show that there was less net time in pre-project stages than construction, which can be surmised by interpreting the ratio of construction time to planning time, which is always higher than one. Most of the "net time" use is in construction, which may again contradict the statement made previously regarding the time spent on the pre-project stages and on the construction. However, there is a story behind each project, and there are elements delaying the activities within the project, which are called "factors causing delays." It is important to differentiate between the delays, gaps and waiting time. When it comes to delay, generally a main obstacle (e.g., decision) causes it. Since, for example, the time in the construction stage is not a net time for the construction, however, there are also gaps within the stage. Thus, the time spent within each stage is not the net time; there are gaps within the stage itself beside the gaps between stages.

When it comes to the timing (kairos) of the project delivery and the TTD, most of the projects from the studied sample were delivered ahead of schedule – i.e., ahead of schedule in the sense that the projects were completed but not handed over immediately after completing them for operation and to use the delivered products. However, some projects were still in the execution phase and were in the operators' hands and in use before completing them. This shows that there was no urgent need to start most of the projects, since their TTD was not critical and some were urgent and delayed starting their implementation and delivered behind the desired TTD.

The investigations conducted to answer *RQ1*, based on the sample projects within the Norwegian construction industry, have shown to some extent the relationships between time and cost, and time and scope. However, since there are many other factors that decide the required time to deliver the project, it would be unwise to draw conclusions regarding those two relationships between time and cost, and time and scope. The statements made to answer *RQ1* are aperitifs to the coming *RQs*, and moreover, to start the investigations of the "What" questions. That is why in *RQ2*, there will be findings regarding the time relationship with the gaps between stages, but more with the gaps within the stages. Some of the next findings will draw a more precise picture regarding those delay factors.

***Research Question 2:* What are the factors that cause delays in large-scale engineering projects?**

The purpose of *RQ2* is to identify the major factors that cause delays in large-scale engineering projects. The answers from this research question are a very important move towards other *RQs* related to the reasons for why this is a problem, and how to solve it.

There are numerous studies related to the causes of delay in LSEPs. The 224 delay factors identified from theory are factors based on 104 studies that cover 45 countries. The findings from the studies presented in this dissertation are complementary to the existing studies since they are from other countries than the 45 countries (Algeria and Norway).

In Norway, and based on the survey strategy, the identified major causes of delay in major Norwegian construction projects and the 11 most important factors based on their rankings are: (1) Poor planning and scheduling; (2) Slow/poor decision-making process; (3) Internal administrative procedures and bureaucracy within project organizations; (4) Resource shortage (human resources, machinery, equipment); (5) Poor communication and coordination between parties; (6) Slow quality inspection process of the completed work; (7) Design changes during construction/changed orders; (8) Sponsor/owner/client lack of commitment and/or clear demands (goals and objectives); (9) Office issues; (10) Late/slow/incomplete/improper design; (11) User issues.

In Algeria, and based on a quantitative questionnaire, according to the findings, the 20 most significant delay factors in Algerian telecommunications projects are: (1) Change in specifications, changed orders, extra works; (2) Poor site management and supervision/quality control (QC); (3) Delay in approval of completed work; (4) Unrealistic time estimation and unreasonable project period; (5) Delay in running bill payments to contractor and financial difficulties; (6) Time-consuming and slowness/late/delays in decision-making; (7) Contractor shortage of human resources (skilled, semi-skilled); (8) Delays/irregular/late payments of subcontractors; (9) Poor site layout; (10) Accepting inadequate design drawings; (11) Multiple and high number of contracts and projects by the same contractor; (12) Delay to furnish and deliver to sites; (13) Delay in material procurement; (14) Inadequate planning/scheduling and conflicts of subcontractors' work; (15) Absence of consultant's site engineer; (16) Shortage of materials required on site and in time needed; (17) Delay in manufacturing materials, or special manufactured imported materials; (18) Delay in delivery of materials to sites; (19) High complexity, mistakes and inconsistencies in engineering documents and network architecture; (20) Delay in conducting inspection/ ;testing, and quality control. Most of these delay factors are related directly to the internal project stakeholders (i.e., the main players and parties involved directly in the projects, which are mainly the client, contractor, subcontractors, consultants and suppliers). There are two delay factors that are caused by external factors from the industry. These two factors are "Traffic jam/congestion effects on all project activities at all levels," ranked 22, and "Unforeseen, unfavorable, severe weather conditions (rains, hot/cold temperatures, etc.)," ranked 30. These two factors are out of the control of all the internal stakeholders to the industry. These kinds of factors, which are more related to the context and environment, ought to be considered and treated as risk rather than delay factors.

Still in Algeria, the 17 major delay factors and causes for the Algerian road construction megaproject are:

(1) Interference by sponsor (then owner/client): The minister of the Ministry of Civil Works (Ministère des Travaux Publics et des Transports (MTP)) made all the key project decisions within the project on tactical and operation levels, which led the virtual enterprise to follow his demands. The government (represented by the Ministry of Civil Works) involved itself in all levels of the megaproject (which, as a result, had a negative effect on the schedule and budget). Some key decisions, which should have been made by the virtual enterprise (megaproject management organization), supported by expertise from consultants and main contractors, were made by the government at the operational level and hence led to a redoing of the work.

(2) Optimistic (unrealistic) estimation of project duration and cost: This was one of the major reasons for delay and not meeting the target date. The delivery date was decided by the minister of the Ministry of Civil Works (MTP) based on his own decision and his requests, without reflecting the real world. This led the virtual enterprise to follow the instructions of the project owner, and as the virtual enterprise is in charge of delivering the project, they obliged their contractors to submit their schedules based on that final target date.

(3) External stakeholders (media, landowners, users, etc.): A good example illustrating the wrong timing of involving the stakeholders includes the landowners, the habitants who could be affected by the construction of the road.

(4) Site handover/site change: As mentioned in the previous factor for delay, which was the external stakeholders, the delay in obtaining the land from the landowners to construct the highway delayed the handing over of the sites to the contractors. In addition, the NGOs caused the project owner to make decisions about changing sites, which led to a delay in performing the technical studies and starting construction.

(5) Poor contract management/bidding process: The bidding process for this megaproject did not have its correct time window and sufficient time schedule to follow the right procedures (even skipping some in some cases). The shortening of the conception and front-end phases led to urgency in the bidding process, and that led to not following the process correctly and bad contract quality.

(6) Inadequate contractor experience/building methods and approaches: Contractors had no experience with this scale of project in terms of human resource capacity, machinery and the accumulated experiences from previous projects.

(7) Poor communication and coordination between parties: Because of the size of this megaproject and the high number of organizations (contractors, subcontractors, suppliers, municipalities, authorities, etc.), the communication between all these stakeholders was one of the major challenges.

(8) Delays in contractors' payment: Contractors were delayed in their payment; the reason for this delay was related to another delay factor, which was the delay in carrying out inspection

of the completed work. Almost all of the studies listed in Table 6.3-1 have reported this issue as a major delay factor.

(9) Poor site management and supervision: There were not enough skilled site managers and supervisors. The contractors hired less experienced supervisors, which made the quality of the supervision very bad. More than 50 studies found that this factor was a major delay cause.

(10) Poor planning and scheduling: The tight time window for the project duration made all the schedules for the work packages tighter and even exaggerated in the deadlines and milestones.

(11) Resource shortage (human resources, machinery and equipment): The shortage of resources was partly due to the project size, but more to the urgency of the delivery of this megaproject.

(12) Design changes during construction/changed orders: Because of the rush and short time spent in the front-end phase, there were many mistakes in the pre-study technical reports, which led to the designs being changed, and thus increased the number of changed orders.

(13) Slow quality inspection process of the completed work: Because of missing resources and consultants for completed work, there were other delay factors like delayed contractors' payments, as well as subcontractors' and suppliers' payments.

(14) Poor labor productivity and shortage of skills: Again, because of the size of the megaproject and the rush in delivering it, the shortage of resources led to hiring unexperienced labor.

(15) Shortage of materials: There were often shortages of materials for completing the highway (e.g., bitumen).

(16) Weather conditions: Weather played a role in delaying the progress of the work, especially in winter. Heavy rain, and sometimes snow in some areas, not only stopped the work but even postponed it for weeks.

(17) Unforeseen geological conditions: Unforeseen geological conditions played a role in delaying the work in some parts of the construction of the highway, especially when it came to tunnel building, while digging through different types of rocks. In addition, the type of the soil under layers and landslides caused some rework because of bad quality.

The 17 delay factors reported are considered to be the major causes of delay for this megaproject, which was delayed by five years and had a cost overrun of more than US$ 4.2 billion. Although the interviewees mentioned other delay factors, the interviewer did not consider these because of the frequency of the appearance of these factors on the one hand, and the importance of the impact reported on the other. Other types of factors that are not reported in this paper are those that are closely tailored to the case.

This is an important contribution to the intensive literature review on the top ten delay factors based on 105 studies that cover 45 countries. Based on the findings, the top ten most cited universal delay factors in the construction industry are listed.

The top ten universal delay factors in the construction industry are:

(1) Design changes during construction/changed orders;

(2) Delays in contractor's payment;

(3) Poor planning and scheduling;

(4) Poor site management and supervision;

(5) Incomplete or improper design;

(6) Inadequate contractor experience/building methods and approaches;

(7) Contractor's financial difficulties;

(8) Sponsor/owner/client's financial difficulties;

(9) Resource shortage (human resources, machinery, equipment);

(10) Poor labor productivity and shortage of skills.

If I have a close look at these top ten delay factors, the list of the ten top critical delay factors may be in any country and any project case; these are standard and are not tailored to a specific country or a special context. However, some of them fit only a special context and country (e.g., 29 – "Security and/or unstable political situation" and 28 – "Corruption/fraudulent practices," etc.). Delays in large-scale engineering projects are not exceptional, and from these conducted studies and the presented results, it is clear that some of the delays are universal and all projects are exposed to the factors generating those delays.

The exploration of delay factors and delay causes will help to identify the effects of these delays. Since, as a preliminary assumption, delays are considered negative things, it is necessary to eliminate or reduce them to reduce those negative effects. Delay factors and causes should be considered risks and should be dealt with. There should be clear strategies to identify delays when it comes to the same context (within the same country), and among similar projects and stakeholders. This identification will help the management to be proactive in finding permanent solutions for the delay factors to eliminate them or reduce them, instead of ad hoc solutions and being reactive in repairing the effects of the delays when they happen.

These two points concern (1) the effects of delays (related to the fourth research question, which is why is faster better?) and (2) how to deal with delays (part of the last research question, which is how to deliver projects faster?).

Research Question 3: **What are the relationships between project speed and project flexibility, uncertainty and complexity?**

The definition of project speed is the starting point for answering this research question. The project speed definition used to answer the research question is the ratio of scope to time. Speed is a function of Project Procurement Management, namely outsourcing strategies and parallel supply chains. Scope is treated as an output and time as an input, so the more utility provided per unit of time the faster is the delivery process, where project scope is the work performed to deliver a product, service or result with the logical relationships among the project schedule activities.

Flexibility, uncertainty and complexity are also defined with respect to the research objectives to answer *RQ3*. The aim of this research question is to understand how the aspects flexibility, uncertainty and complexity affect the project speed positively or negatively and vice versa.

The set of projects selected to answer the research question is based on evaluations of telecoms infrastructure projects in Algeria, with the budgets varying from approx. 2 to 42 US$. The data collected are based only on in-depth interviews with project managers. The interviewees, while questioning them, did have access to the documentation and evaluation reports related to the cases to provide them with information about the cases. Based on the descriptive information, an assessment was made of approaches to project speed, flexibility and complexity. This was based on subjective assessments made by the researcher.

Projects take a long time before the client decides to start implementing them; however, when the decision is made the client wants them to finish as soon as possible. This study shows that flexibility in the project with less modularity in the execution and handover phases will have negative effects on the speed of delivering the project (progresses slowly). However, projects with high modularity may be executed at high speed if the resources are available for it. The improper use of flexibility in the execution leads to rework because of changes, modification of agreed plans and waiting time to make new decisions.

All the project managers agreed that flexibility of the process in execution is against the project pace and it is not advised at this stage of the project. However, project managers mentioned that the use of flexibility in the process in the front-end phase was very beneficial for the whole project, although of course, only in the cases where the contractor is involved within that phase. Early involvement will make the contractor's team more informed and share more knowledge about the projects.

Flexibility after the front-end phase will affect the speed and pace of the project if the type of the project is a core network project, where there is no modularity in the execution of the project. However, the access network type has this advantage of modularity, which allows the execution of the project in blocks and in parallel. This will increase the speed of the project (scope/time) if there are enough resources for a parallel execution.

For projects with almost no modularity, the preference of the contractor is to have no flexibility in the process or the product – the best way to avoid flexibility in the execution is to extend the planning phase if the contractor was not well involved in the front-end phase correctly. This extension will of course need time; however, it will save time in the execution phase by avoiding mistakes and uncertainties due to rushing.

The complexity of the project was seen in this study based on the perception of the interviewees. The effect of this complexity on project speed is seen in the front-end and planning phases; once the project team have all the technical answers, the progress and project pace will keep increasing continuously until the end of the project. For the complexity level, in general it appears in early phases, especially in the front-end, or at the end of the front-end phase, since that is the usual time when the project manager from the contractor is involved. Then the level of complexity starts to be reduced in the planning. However, the level may increase dramatically in the execution and handover (HO) phases, due to the unidentified uncertainties and missing information once the team starts the execution of the project; this explains again that uncertainty is a part of complexity.

The complexity of the project affects the speed of the project negatively: The more complex the project is in the eyes of the project manager and his/her team, the more time there is to make decisions and progress. The project complexity based on this study comes from main two reasons: (1) the degree of new technology used in the project, and the ability of the project manager to understand it, and the degree to which the technical team can simplify this complexity to the management; (2) the degree to which the project manager is aware of his organization's process, systems and administration rules.

The project managers suggested some ways to deal with these sources of complexity. Training in the administrative rules, use of company systems, and the organization's structure and processes before appointing him/her as project manager will reduce the ambiguity. Another suggestion is to appoint the project manager as a deputy project manager for running projects for a certain period before appointing him/her as an independent project manager – i.e., this case is only for newly hired experienced project managers. The interviewees mentioned that the project managers who had a background in the industry they are working in will have a greater chance of avoiding any ambiguity by understanding the project scope and dealing with the complexity coming from the technology and the technical side of the project.

Because of the design of the study, to answer this research question, the opportunities to assert the validity or test the reliability of the findings are limited. It cannot be statistically proved that the findings are generally applicable. In this study, reliability cannot be ensured through large, representative samples of research material. The methods for extracting information may be affected by judgemental subjectivity. Validity and reliability associated with the data used are not sufficient, taken separately, to provide solid answers. More valid and reliable results can only be established through a series of replications. This study has to a certain extent indicated some nuances of a common understanding of project speed and its relationship with project flexibility, uncertainty and complexity. Further researches are needed to clarify the extent to which these indications are of a general nature or project-specific.

Research Question 4: **Is faster project delivery always better? If so, why?**

RQ4 is formulated to investigate to some extent “Why delivering slowly and/or behind schedule is a problem, and should we always go faster?” – of course, without neglecting to explain the negative effects of the delay factors identified in Research Question 2. In other words, “Why should delay factors be dealt with?”

While conducting the case study (Case 1), some of the remarkable effects of delays were also collected. However, in this study, the effects are not ranked:

(1) Cost overrun is the excess of planned budget or cost for a project and is considered one of the most important effects of project delays. In the megaproject case, there was a cost overrun of more than US$ 4.2 billion compared to the initial estimate.

(2) Time overrun is also one of the most important effects. The project was completed more than five years behind schedule. The initial plan was to finish the project within three years, but because of the complexity of the project and many technical obstacles (including thousands of internal stakeholders), it was impossible to meet the target date of completion. Factors such as “Interference by sponsor (then owner/client),” “Optimistic (unrealistic) estimation of project duration and cost,” “External stakeholders (media, landowners, users, etc.),” “Site handover/site change,” “Poor contract management/bidding process” and “Delay in the payments for the work completed” directly affect the completion of a project and cause time overrun.

(3) Litigation is also considered an important effect of delay. Sometimes parties involved in projects use litigation as a last alternative to settle disputes. Litigation was caused by the increased demand from the client to meet the delivery date, which was completely impossible.

(4) Arbitration involves the use of a third party to resolve project disputes amicably without going to the courts. Arbitration is mostly necessitated by factors such as a lack of clear understanding of contract documents by all stakeholders and contract flaws.

(5) Termination of contracts happened at the main contractor level, where one of the two contractors entered litigation with the client. This led to termination of their contract, followed automatically by the termination of hundreds of contracts with that contractor and then subcontractors, suppliers and consultants.

(6) Some causes of delays led contractors and subcontractors into financial crises, delays in contractors’ payment being one of the main factors. The reason for these delays was related to other delay factors, which were the delay in carrying out inspection of the completed work, and insufficient resources to complete the inspection. This led to a delay in paying contractors, then subcontractors and suppliers s.

(7) Some fatal accidents were caused by one of the contractors using explosives to speed up the digging of tunnels. This use of explosives led to loss of life and also destroyed some houses

due to a landslide caused by the explosions. This also had an effect on the reputation of the contractor.

Time-cost trade-off relationships are made by searching for the lowest possible total costs (i.e., direct and indirect) that likewise satisfy the area of feasible budgets. Most innovative companies in this new era of globalization are more concerned with time reduction as their first priority than cost reduction. Changes in the "era" present a revealing picture of the evolution towards time-based competition that is almost universal across all industries.

From the investigations, it can be seen that NPD projects went along two paths crossing three major states. The initial state is where many companies are cost-reduction oriented; this is because the markets are closed and fewer newcomers enter the local market. When globalization appeared, the survivors were the companies that changed direction from cost-reduction orientation to time-reduction orientation without caring about the increase in their cost. The value of time (time to market) increased, and this increment led companies to crash their NPD projects to be first in the market, thereby ensuring their survival (i.e., moving gradually from time-reduction orientation to both time- and cost-reduction orientations).

Being maximally effective will ensure the company's competitive advantage in the market. On the other hand, companies want maximum profits from their NPD projects, and they increase efficiency to its maximum while they have maximum effectiveness. The leading companies are those (1) that are highly effective by being the first into the market with high sales and prices and (2) as a secondary objective, are increasingly efficient by improving their NPD projects' delivery management and methods through continuous improvement. This means that effectiveness comes first, followed by efficiency.

The construction industry has another behavior. The number of organizations involved within a single construction project will increase with the increment in project size and complexity. Therefore, when comparing the NPD projects, one main reason behind the bad performance of construction projects in general is the project's attributes – including the project's environment. The motivation behind NPD projects to finish fast is driven more by globalization. However, construction projects cannot be generalized in that way; each project is singular to the point where the motivation behind being fast depends on the definition of project success given/interpreted by its key stakeholders.

A selection of four construction project case studies, which were completed ahead of schedule and under budget, may indicate that being efficient and effective in construction projects is possible too. The author knew that these four projects were using a different methodology, which is based on concurrent engineering philosophy. That means there are possibilities for construction projects to position themselves among successful projects (i.e., due to their efficiency and effectiveness) by first looking for the value of time to delivery, then introducing competitive management methods, and maintaining continuous improvement to their practices. Time to market in NPD projects does not have the same emphasis and value as time to delivery in construction projects. Due to the different attributes, stimuli and environments of each type of project, I cannot apply everything learned from NPD projects directly to construction projects. Nevertheless, knowing that NPD projects exhibited the same behaviors before globalization, and that they transformed gradually to effective and efficient projects after the emergence of globalization, one can assume that the same may happen to construction projects.

Several companies have employed time-based strategies, such as in the telecommunication and ICT industries. Many scholars confirm that speeding up the delivery of new products in these markets reduces costs, increases profits and creates value (e.g., Schmelzer 1992). With the aim of furthering the understanding of project speed, and "why" there is a need to increase it, Case 2 is used to investigate and understand the reasons behind the urgency, and moreover, why the project management team wants to succeed in delivering in such a tight time window.

This case study (Case 2), which is a large-scale telecommunications project, involves a number of actors in both the private and the public sectors. The case project – to expand an existing telecommunications network in Algeria – was the first phase of a megaproject financed through the state budget. The project's legitimacy, and urgency, lay largely in the return on investment (ROI) for the upgraded and implemented network, where ROI related to two factors, savings and investment, and is equal to savings over investment. In this dissertation, ROI is simply the cost-to-benefit ratio. The existing 2G network was to be upgraded to 3G/4G before the Algerian state, currently the sole owner, sold a 49 percent share of the telecommunication operator at an expected four times return on the investment.

There are many organizations involved in this project, each organization having its own motivation for compressing the project schedule. The project's main driver, however, was the government, which had delegated the project to the Ministry of ICT. However, since the project's legitimacy and urgency lay in the financial profitability of the upgraded existing network, it was important to upgrade as soon as possible the existing 2G network to 3G/4G before selling 49 percent of the stocks.

The sooner the network was upgraded, the higher the value of the stocks. Furthermore, the monetary value of the network after a certain time was believed to be caused by the rapid and short-lived technology advances, deregulation and greater competition, since the Algerian market is open for international investments. The assumptions of the government regarding the ROI from the project show in all cases that the sooner the project is delivered, the earlier ROI is realized. The motivation of the main contractor to accept the tight time window and commit to the delivery date was being awarded the whole contract value (frame contract for the whole megaproject), and an expected net profit of approximately 13 percent. The main contractor was also motivated by establishing a strong position within the local and international market, gaining a reputation and improving the partnership with the project owner. For the subcontractors the motivation is more to gain the respect of the contractor since the relationship is not only a limited contract but also long-term cooperation. The same can be applied to suppliers, who are looking for stable long-term clients to supply them with the necessary materials, tools and machinery. In conclusion, from this telecommunications infrastructure megaproject, the main reason behind delivering the project faster is the ROI for the owner and the client.

The importance of TTD, which decides the level of project speed and pace, depends on the project type and the industry. Thus, the categorization of projects is related to the need for speed. The importance of TTD in NPD is crucial; organizations are competing in a global market, where the success of their NPD projects is measured in terms of TTM, and where "timing" (kairos) is decisive for their success; this is explained by the change of the success measure criteria, i.e., efficiency and effectiveness, where time is a shared constraint of these two criteria for achieving project success. These changes are due to globalization, which means an increase in the number of stakeholders from the national market to the international one, and all that follows, from media, competitors, etc. There is an increase in the context pressure for the impetus in the NPD and innovative projects due to external stakeholders, which will increase the pressure on organizations to shorten their project delivery and place their projects on the level of urgency depending on the market needs and competition.

In LSEPs, e.g., construction, oil and gas, and infrastructure, development projects also have an impetus. However, for the construction industry, for example, the impetus cannot be compared to that of the innovation industry. The same can be said for all other types of industry. Each industry has its own driver behind the speed of running projects. That impetus can be decided by many parameters, such as the "needs of the project" urgency, the benefits (all types – e.g., financial, reputational, etc.), the purpose of the project, the country context, etc. According to the findings of *RQ1*, the cost and the scale of the projects do not decide systematically the TTD of the projects. Thus, there are other impetuses behind the TTD. On the other hand, compared again to NPD projects, the number of stakeholders is limited to local stakeholders, or at most to national stakeholders at the TTD, since the short- to medium-term impacts are sensed only by those stakeholders. This is not the case for long-term impacts.

Stakeholders in LSEPs are generally limited to clients/sponsors/owners, contractors, subcontractors, consultants and suppliers as internal stakeholders to the project, or in other words, as the parties involved directly in the projects. The external stakeholders are the local community, users, politicians and in some cases the nation; Case Study 1 is an example of this. However, the cases demonstrated in Chapter 8 are projects that ended ahead of their schedules and under their estimated budgets (compared to the projects' front-end budget and schedule estimations). The projects are fast compared to the plans; the reason according to the findings for completing the projects ahead of schedule is the chosen philosophy to manage the whole project life cycle, which was based on the CE philosophy.

The decision regarding the TTD depends on many parameters in LSEPs, depending on the drivers behind them. The classification of projects is based on those parameters by type, for example: residential construction – e.g., a single-family residence or a residential facility with (usually) many units; commercial construction – e.g., restaurants, grocery stores, skyscrapers, shopping centers, sports facilities, hospitals, private schools and universities, etc.; industrial construction – e.g., power plants, manufacturing plants, solar wind farms, refineries, etc.; infrastructure projects, like road construction, telecommunications network constructions, etc. These classifications will help with better portfolio and program management if the initiators are at the strategic level; these scenarios mostly come from public projects.

Research Question 5: **How can projects be delivered faster?**

RQ5 is excessively broad to some extent. Since a project has the attribute of uniqueness, delivering a fast project can be achieved in numerous ways and will depend in particular on the circumstances of each project. However, the necessity for delivering a fast project should be questioned.

While studies on causes and effects of construction delays are plentiful, there is a shortage of studies on reduction and mitigation measures to address these delay causes and effects. Based on *Survey 1* and conducted in-depth interviews, some recommendations are given for how to deal with delay factors/causes in Chapter 9, Section 9.1 in Table 9.1-1. When it comes to the major delay factors in Norway, it is noticeable that the recommendations from the survey and interviews complement each other when they do not overlap.

Case 2 has shown "How" PLC can be reduced dramatically; the case study has assisted in understanding the management of fast projects in a setting of urgency. What emerges is a novel understanding of the importance of taking a holistic view – i.e., balancing short- and long-term considerations – of projects with urgency. The case project offers an insight into how the idea of embracing uncertainty can be linked with project speed management and time-to-market assessments, and allows us to understand how these concepts are implemented at the project level.

The main contractor in this case project was indeed proactive before even signing the contract. Many of the decisions were made throughout this project – being proactive in accepting a higher cost to cut the duration of project tasks, and thus being willing to invest in order to be able to deliver on time and thereby meet project objectives. From this case study, it can be seen that the urgency of a project may lead to some negative consequences and impacts, and short- and midterm interests are not always sufficient to make decisions about accelerating a project. Holistic thinking and a sustainable approach to managing uncertainty at the business and project level are needed to ensure a long-term perspective and overall profits. In this project case, the organization decided to embrace uncertainty, developing strong strategic and tactical plans combined with a long-term vision of the future. This helped avoid many undesired consequences, but could not avert all of them. This case project could be executed at breathtaking speed, thereby helping to accelerate projects that can benefit from a higher speed while avoiding some of the negative effects of time compression.

Before listing the consequences and impacts of the superfast speed of this fast-tracked project, it is necessary to examine the extent to which it was a success or failure from the perspectives of different stakeholders. The project was considered highly successful from the owner and client perspectives, since they achieved their objectives and the project was effective. Efficiency is more the concern of the main contractor and subcontractors. The project met the expectations of the client, even if the efficiency was less good. The scope was not fully delivered by the deadline. From the human resources perspective, there were several issues. Firstly, the team members involved in the project were exhausted. Secondly, there were safety issues, which might be traced back to cost cutting and a lack of incentives. This caused dissatisfaction and a lack of trust and, combined with cost cutting, led to the resignation of many employees and subcontractors. Consequently, there was a lack of resources for the second phase, which was expanding the coverage area of the radio access network. It should also be noted that decisions made in this project to source equipment from other projects led to the dissatisfaction of clients in other countries because of the delays in delivering their equipment as planned. One of the clients applied the penalty clause.

Case 2, which is the first phase of a megaproject, was successfully fast-tracked and compressed (client perspective); that was due to the nimble and skillful project management team available at the contractor level. However, the project was a complete failure in the midterm for the contractor. Fast-tracked projects with high risks for the safety of people, staff burnout, product defects, etc. should not have any cost cutting, but instead should have contingency budgets beside the incentives. The contractor succeeded in fast-tracking the project at the operational level but failed completely at the tactical level, which led to backtracking and try to repair the mistakes instead of progressing with the other phases of the megaproject.

There are times when market conditions will change radically and quickly in a manner that is hard to predict in advance. Such uncommon changes require unfamiliar actions. Fast tracking may be one of these unfamiliar actions. Fast tracking may be the cleverest decision if facilities must be provided swiftly to realize a large increase in revenues made possible by a change in market conditions. Long-term planning will preserve the option of not fast tracking any project. This, combined with an examination that accurately measures the advantages and disadvantages of fast tracking, will result in far fewer fast-tracked projects. To minimize backtracking, project managers must be aware of the risks of fast tracking. Armed with that evidence, project managers can accomplish their usual project magic. However, the findings in answering the previous *RQ4* show that using CE philosophy in managing projects can solve many issues.

Based on the study conducted on a Norwegian construction company, the results show that there are barriers and challenges behind uncompleted achievement of employing concurrent engineering throughout the project life cycle in the Norwegian construction industry; compared to the oil and gas industry, the concurrent engineering methodology has been used for decades.

Several oil companies on the Norwegian continental shelf have implemented Integrated Operations (IOs), which is a concurrent engineering method, as a strategic method to achieve safe, reliable and efficient operations. CE is both a technological and an organizational issue; in order to solve complex problems and cope with uncertainty, organizations in the oil and gas industry typically require integration of knowledge from such different specialists as geologists, system engineers, civil engineers, economists, managers, drilling personnel, etc. From the study, one of the findings is that oil and gas clients/sponsors/owners/operators involve consultants, contractors, subcontractors and suppliers in the early phases of the project (on the tactical and strategic level), which is possible by using a suitable type of agreement (joint venture, frame contract, partnership, etc.). In the oil and gas industry, the team members from all participant organizations are brought together in the same room to work in concurrent sessions in the early phases of the project (i.e., on tactical and strategic levels of the project). This ensures that the disciplines have quick access to the relevant knowledge and have the opportunity to deal with the problems and challenges in real time, faster than before. With quick and sufficient access to the relevant knowledge (i.e., needed information), it gives the disciplines the opportunity to challenge the parameters and the data early on and to work with the solutions in real time. This will, in the end, save time and consequently money for organizations that are able to structure their work in this more efficient way.

In contrast to the oil and gas industry, the construction industry is organized around projects that are paid for by clients/owners/sponsors who are technically not part of the industry; they step back just after deciding by bids which contractor will be in charge of implementing the project. The same can be said about subcontractors and suppliers. CE stands for two key principles: integration and concurrency. Integration is very hard to achieve in construction projects because of the timing required to involve the different stakeholders within the early phases and throughout the project life cycle. The absence of the operator/users in all project phases, except the handover and operating phase, leads to missing knowledge and information about what should be delivered, thereby affecting the effectiveness and the project outcome (i.e., tactical and strategic levels). Therefore it is necessary to involve them in early project phases, at least from the needs identification phase up to the front-end planning phase. Integration is not the only key principle, which is hard to achieve in the construction industry; the second key principle is concurrency, and it is determined by the way in which tasks are scheduled and the interactions between different actors (people and tools). It is also challenging.

To reach a high level of concurrency throughout the project life cycle, the clients/owners/sponsors, who are the operators/users in our case, took the initiative to implement the CE method, and thus automatically all the following organizations (contractors, suppliers, consultants, subcontractors, etc.) were obliged to adopt it in a systematic manner. The early involvement of all participant firms in the early project phases had permitted a high level of integration and a proper way to use the CE method. On the other hand, the construction industry is fragmented to a high degree (clients, consultants, contractors, subcontractors, suppliers, users, etc.). Clients/owners/sponsors in most cases are technically not part of the industry; they develop construction documents with the support of consultants, then use those documents to invite bids from qualified contractors, with the contract being offered to the lowest bidder. CE as a philosophy requires preparation and dedication to planning and implementation, along with adequate resources. It requires numerous changes in the organization’s and in the employees’ mindsets.

The clients are more aware of the challenges, make themselves involved throughout the life cycle of the project and behave as the leading party for their projects. Use of the CE method by clients makes all other firms follow them, since most firms are customer oriented. In the construction industry, the role of the client is limited to the conception, and rarely to front-end planning; this does not help in implementing CE philosophy properly throughout the project life cycle. There is a chance of applying CE philosophy in LSEPs (construction in general, infrastructure, etc.) for public investment projects. The possibility comes from creating enterprises for each industry type (road construction, telecommunications, hospital and university construction, etc.). These enterprises, of course, will be under the delegation of the concerned ministries. This strategy will allow ministries to focus on the strategic decisions and portfolio management, and leave the tactical and operational decisions to these enterprises. The other question to answer is: "What stopped these enterprises from using the CE philosophy in their management?" – knowing that, for example, in Norway, there are interface independent organizations between the government and the projects selected for implementation. In other words, there is this kind of profile of described enterprises.

Time, delays and speed in construction projects can be managed. Therefore, a project speed framework for the construction phase has been developed based on a set of KPIs. Although two of the KPIs are subjective, as they are difficult to measure, the framework can trigger real consideration for measuring construction speed. Being able to manage the speed of project productivity in real time and on a daily basis will enable the project management team to meet the targets regarding the project's time to delivery. I believe that the development of a performance measurement system for project speed will revolutionize the construction industry. The framework suggested is only a tool for measuring and monitoring the speed of the delivery and not the single key success factor if all the other preconditions are not be available.

There are relationships between the five evaluations; the five evaluations are "*ex ante*,", "monitoring," "midterm," "terminal" and "*ex post*" evaluations. LSEPs are complex systems, with a larger scale and scope than average industry projects; the cost associated with them is higher, the time taken for their completion is much longer, the number of organizations involved is high and they are unique.

The uniqueness also indicates that there is huge potential for the creation of new knowledge. However, the collected lessons learned during the project life cycle can be used in similar type of projects, which will improve the decision-making process. Each type of evaluation can feed other evaluations; *ex post* can feed *ex ante* evaluation in particular, since the lessons learned are more concerned with the strategic and tactical level. Monitoring, midterm and terminal evaluations are more related to the operation level and the efficiency of the project in general; these evaluations are conducted by the contractor, especially "monitoring," to better control the plans.

Enhancing project speed through evaluation and learning is one of the solutions to improve the efficiency of LSEPs. The PESTOL model was used for post-evaluation in *Case 1*. The evaluation enabled lessons learned to be extracted, and those lessons learned can be used for similar upcoming projects, especially at the strategic and tactical level of the upcoming projects. *Case 1* shows that similar extension projects had seen better strategic decision-making from the owner (Ministry of Civil Work (MTP)).

Improvement of the decision-making quality process had saved several months, even years, for the running of construction megaprojects compared to *Case 1*. This improvement came from the *ex post* evaluation of *Case 1* and uses the lessons learned for the upcoming projects. However, evaluations are not used to collect lessons learned to improve all aspects of managing projects and programs.

Discussing efficiency and effectiveness is related directly to project performance, where it is necessary to involve the stakeholders. Efficiency is more concerned with the contractors, subcontractors and suppliers. Effectiveness is more related to the sponsor, operator, client and users. Moreover, when it comes to time, chronos is the time, which is one of the constraints in the efficiency and it is more about doing things right. Kairos is about the opportune moment; it is linked to effectiveness and is more about doing the right things.

Efficiency is the Yin, whereas effectiveness is the Yang. Yin and Yang are opposites, as are efficiency and effectiveness. Efficiency and effectiveness behave in practice in the opposite manner, and in a way, the more I try to be effective (client – meet the goals and objectives) the more I lose our efficiency (contractors – time, cost and scope increase) and vice versa, so they are opposite, the same as Yin and Yang. Also, when talking about time, the opportune moment (kairos) will not always fit the chronological (chronos) sequences designed to complete the project.

Efficacy is the transit from effectiveness to efficiency, then from efficiency to effectiveness.

Efficiency creates effectiveness – i.e., starting the project based on its inputs (time, cost, scope) will give outputs and a product, and by using the product, there will be outcomes, which can be measured if they meet the desired outcomes through effectiveness; therefore, efficiency creates effectiveness. On the other hand, effectiveness activates efficiency: There will be no project (time, cost, scope) if the project is judged as ineffective and irrelevant. Thus, effectiveness is the reason why there is efficiency. Efficiency will never exist without effectiveness and vice versa.

There is a relationship between efficiency and effectiveness, related to chronos and kairos. Time and timing may clash; this clash occurs when the time to delivery defines the success of the project. Efficiency and effectiveness consume and support each other. Efficiency and effectiveness are usually held in balance – as one increases, the other decreases. However, imbalances can occur.

The analogy of Yin-Yang to efficiency-effectiveness: (1) the excess efficiency, consumes effectiveness; (2) the excess effectiveness, consumes efficiency; (3) deficiency of efficiency, results in an increase in effectiveness; (4) deficiency of effectiveness, results in an increase in efficiency. In the analogy of Yin-Yang, ultimately, every treatment modality can be summarized by four principles: eliminate excess efficiency; eliminate excess effectiveness; tonify efficiency; tonify effectiveness. The efficiency change is hard. The effectiveness change is good.

With efficiency and effectiveness, one can change into the other, but it is not a random event, happening only when the time is right: kronos time before efficiency, chronos time for efficiency. I plan my effectiveness, and then I decide to implement the project that will be measured by efficiency (cost, time, scope); at the end I get a product for use, which again will be judged by the effectiveness. The Yin change is hard; the Yang change is good. By analogy, the efficiency change is hard; the effectiveness change is good, which is always true.

10.2 Limitations of the Study

Research using assumptions and limitations for creating an "ideal world" may certainly create remarkable theoretical models and clear responses; nevertheless, it does not help much the understanding of the real world with its complexity. To be of practical application, the research needs to be performed within limits that still make it possible to recognize the situation as experienced in practice and actual life.

This dissertation has numerous limitations with regard to the elucidation of the research results. Both "case study" strategies and "survey" strategies have their own limitations. The constraints regarding carrying out case studies include the lack of generalizability of the findings beyond the immediate case context.

As discussed in the methodology chapter, the conditions to using case study as a research strategy are: (1) a reason why this particular case is worth studying; (2) access to many people in the case, including people who may not be with the organization; (3) access to many documents at the case site, including internal and external, private and public documents. That was the situation for Case Studies 1 and 2; however, that was not the case for the cases used in Chapter 7, where there was a limitation to using only the data from the interviews because of no access to the organization's documentation. Also, the cases used in Subsection 8.2 were a reutilization of case studies conducted by other researchers.

The process of choosing the cases within this study is based on the: 1) choice of industry; 2) choice of specific case project within the industry; 3) choice of the size of the project. However, the initial choice focused on construction projects; the problem of access to resources of many potential available case studies led the author to use the on-hand case studies, and that led to extending the type of industry to, for example, telecommunications.

For both strategies, there was a small sample size; respondents' biases of any type and the subjectivity of the responses are examples of constraints involved with the utilization of the survey strategy. In this dissertation, the generalizability challenge regarding the case study results was addressed through performing case studies among projects from different industries and in dissimilar phases.

The number of cases can be considered low since it never reached saturation point. However, it was more based on the resources available to conduct the studies. In addition, the projects were mainly located in Norway and in Algeria, so it could be argued that the generalization of the results to projects performed in other countries with different organizational and business cultures is low.

These limitations were due to constraints in accessing more case projects within international contexts and due to time constraints involved with the Ph.D. research project. However, the researcher believes that due to common attributes of projects and project organizations worldwide, the main concepts developed in the course of this study are applicable to other project contexts.

The limitation of accessing more data to answer Research Question 3 was based on a case study strategy, in Chapter 7. Consequently, there was no use of triangulation – i.e., triangulating multiple sources of data.

The data collected to answer Research Question 1, in Chapter 5, were from completed construction projects. The author made statements based on the observations after analyzing the data and plotting them. However, there was no continuity to investigate the quality of the observations made based on the patterns and the diagrams.

The author also had the benefit of inside knowledge of Case Study 2, as he was an active participant in the project before becoming a researcher. This enabled the location of relevant archival material and selection of suitable interviewees; however, this may have created slight bias in analyzing the collected data. To avoid this bias, the case study was analyzed by involving other researchers to prevent pre-knowledge of the case introducing bias into the research.

The case was used to partly answer Research Question 5, as presented in Section 9.1; the second part of the data collected was based on other case studies, which were conducted by a master student. The quality of the data is not guaranteed; the researcher did not conduct the case studies by himself because of language limitations (Norwegian language).

The generalizability and reliability challenges regarding the survey results were addressed by choosing the survey respondents among project participants working within a wide range of industries and project organizations in order to capture a big picture of the concept of "delay" in managing projects from multiple angles.

So far, it can be argued that since the results are strongly influenced by the biased mentality of respondents, they are only applicable to projects performed in Norwegian project environments when it comes to the survey conducted in Norway, and in Algerian project environments when it comes to the survey conducted in Algeria. The results would be much more generalizable if the respondents were from different countries. However, the researcher believes that due to the common characteristics of human beings and projects worldwide, there is no reason why the findings cannot be applicable to other projects in different contexts, which is demonstrated by the intensive literature review presented in Chapter 6.

In general, if a truly longitudinal research setting had been possible, the concept of "time" in its two dimensions of "chronos" and "Kairos" could have been evaluated more substantively within a larger number of project industries and countries. The same applies to the survey results, which could have been strengthened by having a wider range of respondents from different countries and a larger number of industries.

The issues studied in this research are clearly relevant to the project management community. The success of project management will always depend on good governance of projects and project management. The successful execution of projects depends on how well the project effectiveness and efficiency are defined in the early phases of PLC. The next chapter presents suggestions on how the mentioned limitations can be overcome through future research.

10.3 Further Research & Work

This study provides enhanced understanding of the "time" phenomenon in its two dimensions, chronos and kairos. However, since research on this topic is in its early stages, further research is still required to provide more empirical evidence and theorizing on this important subject. This dissertation has established the basis for further future studies within this area. Publication 1 addresses the barriers and challenges in using the CE philosophy in Norwegian construction projects at the strategic and tactical levels. These kinds of studies are few and far between, and they are timidly directly or indirectly mentioned within the project management literature when it comes to LSEPs. This may explain why CE has been used recently since it comes from NPD and innovation projects.

Moreover, the findings should be re-examined by conducting similar studies with other organizations and contexts. The analyses are mainly based on the author's perception and understanding of the approaches and drawn from practical implementation of the philosophy based on the observations made. Therefore, more research is needed to reach a concrete statement on the level of usefulness of the philosophy and its strengths and weaknesses in practice. This may be done by testing the philosophy in different case projects or through having project managers put them to use and report their experiences by using the philosophy.

Publications 2, 13 and *14* are based on survey strategies to determine the delay factors in major Norwegian construction projects. In addition, they are based on in-depth interviews regarding the remedies for dealing with these delay factors. However, it is always easy to suggest remedies based on the personal perceptions of respondents from a survey and interviews. Further research is needed to investigate the delay factors and compare them to the findings in this research. Examination of the findings regarding the remedies by applying them and observing the influence on the overall project performance can be carried out in Norway, since the study is done in this context.

Publications 15 and *16* are similar to the studies in *Publications 2, 13* and *14*. However, the studies are conducted in another context – i.e., in Algeria. Similar further research is needed because of the size of the sample. Moreover, more research is needed to identify the remedies and mitigations for the identified delay factors.

Publications 3, 4 and *10* are related to developing a post-project evaluation model and applying it to a megaproject case (*Case 1*). The model can contribute to better project evaluation and extracting lessons learned. The model has been used in *Publication 19* to show the use of evaluation to contribute to lessons learned and using them in similar projects. *Publication 19* is also related to evaluations, and describing the relation between the five types of evaluations, and how they are interconnected for an effective and efficient management of similar projects. It would be interesting to check the strength of the developed model and test it on more cases in different contexts and other industries; this would allow improvements to be made if necessary. Further research should be conducted to link the different existing project evaluation methods (i.e., *ex ante*, midterm, terminal, monitoring and *ex post*) in an integrated systematic approach.

Publication 6 explains how NPD projects set their effectiveness on competition driven by time as competitive advantage. The analysis was based on existing studies and the interpretation was on a conceptual model. A superposition of the same scenario on construction projects, however, shows that because of the different attributes, due to the difference in the industries, it is necessary to find another impetus for construction projects, or better management philosophies – e.g., CE philosophy. Areas for further research on this topic include an empirical study of the developed conceptual model linking efficiency to effectiveness in NPD projects, along with identifying all possible impetuses that can lead LSEPs to identify the value of TTD in improving their effectiveness.

Publication 9 suggests a model for measuring construction project speed. The model is based on KPIs, which were identified based on the definition of project speed and on a road case study. However, this project speedometer needs further improvement and to be made more concrete and practical for use; this will be very interesting for further work.

Publication 11 tends to better clarify the clear definitions of project efficiency, effectiveness and efficacy. This was done through both literature studies and a review of several reports from different industries. Further studies on how the three concepts are used by practitioners would be interesting. The alignment and clarity of the definitions of these three concepts would enable the creation of KPIs for better management and meeting of expectations from managing projects. The case study describing a superfast telecommunication infrastructure project in *Publication 12* would be interesting for conducting similar studies in similar cases, in different industries. These further studies would enable the reasons behind the urgency in different project types to be identified. A similar study to *Publication 17* could be conducted to re-examine the findings, since the study was limited to interviews only.

Finally, the results of the study emphasize the need to understand the questions related – i.e., what, how, why "to deliver projects faster". Based on the overall findings and the results of the analysis of research results, along with the above suggestions for further research, the author includes:

1. Conducting a more detailed examination of real-life projects in different industries within different countries in order to scrutinize the challenges, limitations and obstructions towards effectively managing the speed of a project, and reflecting the concept of flexibility, uncertainty and complexity in the decision-making process.

2. Need for speed: Further work is needed on the parameters feeding the control and pitfalls KPIs, and on finding ways of making their inputs measurable. The development of a performance measurement system for project speed would revolutionize the construction industry.

3. Investigating the behavior of a sample of multiple-project management vis-à-vis within the same organization, this system thinking approach for the investigation will enable a better understanding of the reason for plasticity in ending a project before another even with a different scale and cost (e.g., similar sample in Chapter 5).

References

Aarseth, W., Rolstadås, A. and Andersen, B. (2013), “Managing organizational challenges in global projects”, *International Journal of Managing Projects in Business*, Vol. 7 No. 1, pp. 103-132.

Abbasnejad, B. and Izadi Moud, H. (2013), “Construction delays in Iranian civil engineering projects: An approach to the financial security of construction business”, *Life Science Journal*, Vol. 10 No. 2, pp. 2632-2637.

Abd El-Razek, M. E., Bassioni, H. A. and Mobarak, A. M. (2008), “Causes of delay in building construction projects in Egypt”, *Journal of Construction Engineering and Management*, Vol. 134 No. 11, pp. 831-841.

Abdul-Rahman, H., Berawi, M., Berawi, A., Mohamed, O., Othman, M. and Yahya, I. (2006), “Delay mitigation in the Malaysian construction industry”, *Journal of Construction Engineering and Management,* Vol. 132 No. 2, pp. 125-133.

Acharya, N. K., Im, H. M. and Lee, Y. D. (2006), “Investigating delay factors in construction industry: A Korean perspective”, *Korean Journal of Construction Engineering and Management*, Vol. 7 No. 5, pp. 177-190.

Adam, B. (1990), *Time and social theory*, Polity Press, Cambridge.

Adam, B. (1995), *Time watch: the social analysis of time*, Polity Press, Cambridge.

Adeyemi, A. Y. and Masalila, K. (2016), “Delay factors and time-cost performance of construction projects in Gaborone City Council, Botswana”, *Journal for the Advancement of Performance Information & Value*, Vol. 8 No. 1, pp. 88-105.

Ahmed, A., Kayis, B. and Amornsawadwatana, S. (2007), “A review of techniques for risk management in projects”, *Benchmarking: An International Journal*, Vol. 14 No. 1, pp. 22-36.

Ahmed, S. M., Azhar, S., Castillo, M. and Kappagantula, P. (2003a), “Construction Delays in Florida: An Empirical Study”, Planning Consultant State of Florida Department of Community Affairs.

Ahmed, S. M., Azhar, S., Kappagntula, P. and Gollapudil, D. (2003b), “ Delays in construction: a brief study of the Florida construction industry”, In *Proceedings of the 39th Annual ASC Conference, Clemson University, Clemson, SC*, pp. 257-266.

Ahmed, S. M., Dlask, P. and Hasan, B. (2014), “Deviation in the Cost of Projects”, In *Construction Maeconomics Conference*.

Ahsan, K. and Gunawan, I. (2010), “Analysis of cost and schedule performance of international development projects”, *International Journal of Project Management*, Vol. 28 No. 1, pp. 68-78.

Aibinu, A. A. and Jagboro, G. O. (2002), “The effects of construction delays on project delivery in Nigerian construction industry”, *International Journal of Project Management*, Vol. 20 No. 8, pp. 593-599.

Aibinu, A. A. and Odeyinka, H. A. (2006), “Construction delays and their causative factors in Nigeria”, *Journal of construction engineering and management*. Vol. 132 No. 7, pp. 667-677.

Aitchison, J. (1998), *The Articulate Mammal: An Introduction to Psycholinguistics*, Routledge, NY.

Aiyetan, O., Smallwood, J. and Shakantu, W. (2011), “A systems thinking approach to eliminate delays on building construction projects in South Africa”, *Acta Structilia: Journal for the Physical and Development Sciences*, Vol. 18 No. 2, pp. 19-39.

Akinsiku, O. E. and Akinsulire, A. (2012), “Stakeholders' perception of the causes and effects of construction delays on project delivery”, *Journal of Construction Engineering and Project Management,* Vol. 2 No. 4, pp. 25-31.

Akogbe, R. K. T., Feng, X. and Zhou, J. (2013), “Importance and ranking evaluation of delay factors for development construction projects in Benin”, *KSCE Journal of Civil Engineering*, Vol. 17 No. 6, pp.1213-1222.

Alaghbari, W. E., Kadir M. R. A., M., Salim, A. and Ernawati (2007), “The significant factors causing delay of building construction projects in Malaysia”, *Engineering, Construction and Architectural Management*, Vol. 14 N. 2, pp.192-206.

Alhomadi, A. A., Dehghan, R. and Ruwanpura, J. Y. (2011), “The predictability of fast-track projects”, *Procedia Engineering*, Vol. 14, pp. 1966-1972.

Ali, A. S. B., Anbari, F. T. and Money, W. H. (2008), “Impact of organizational and project factors on acceptance and usage of project management software and perceived project success”, *Project Management Journal*, Vol. 39 No. 2, pp. 5-33.

Aliaga, M. and Gunderson, B. (2000), *Interactive statistics*, Prentice Hall, Saddle River, New Jersey.

Alinaitwe, H., Apolot, R. and Tindiwensi, D. (2013), “Investigation into the causes of delays and cost overruns in Uganda's public sector construction projects”, *Journal of Construction in Developing Countries*, Vol. 18 No. 2, pp. 33-47.

Al-Khalil, M. I. and Al-Ghafly, M. A. (1999), “Important causes of delay in public utility projects in Saudi Arabia”, *Construction Management and Economics*, Vol. 17 No. 5, pp. 647–655.

Al-Kharashi, A. and Skitmore, M. (2009), “Causes of delays in Saudi Arabian public sector construction projects”, *Construction Management and Economics*, Vol. 27 No. 1, pp. 3-23.

Al-Momani, A. H. (2000), “Construction delay: a quantitative analysis”, *International journal of project management*, Vol. 18 No. 1, pp. 51–59.

Alvesson, M. and Sköldberg, K. (2009), *Reflexive methodology: New vistas for qualitative research*, Sage, London.

Alwi, S. and Hampson, K. (2003), “Identifying the Important causes of delays in building construction projects”, Proceeding 9th East Asia-Pacific Conference on Structural Engineering and Construction. 16-18 December 2003. pp. 1-6, Bali, Indonesia. Accessed March 26, http://eprints.qut.edu.au/4156/1/4156.pdf

Amandin, M. M. and Kule, J. W. (2016), “Project Delays on Cost Overrun Risks: A Study of Gasabo District Construction Projects Kigali, Rwanda”, *ABC Journal of Advanced Research*. Vol 5 No. 1, pp. 21-34.

Ameri, F. and Dutta, D. (2004), *Product lifecycle management needs, concepts and components*, University pf Michigan, Ann Arbor, MI.

Ameri, F. and Dutta, D. (2005), “Product lifecycle management: closing the knowledge loops”, *Computer-Aided Design and Applications*, Vol. 2 No. 5, pp. 577-590.

Amoatey, C. T., Ameyaw, Y. A., Adaku, E. and Famiyeh, S. (2015), “Analysing delay causes and effects in Ghanaian state housing construction projects”, *International Journal of Managing Projects in Business*, Vol. 8 No. 1, pp. 198-214.

Amram, M. and Kulatlaka, N. (1999), *Real Options: Managing Strategic Investment in an Uncertain World*, Financial Management Association Survey and Synthesis Series, Harvard Business School Press, Boston.

Andersen B. and Fagerhaug T. (2001), *Performance Measurement Explained: Designing and Implementing your State-of-the-Art System*, ASQ Quality Press Milwaukee, Wisconsin, USA.

Andersen, B., Olsson, N. O., Onsøyen, L. E. and Spjelkavik, I. (2011), “Post-project changes: occurrence, causes, and countermeasures”, *International Journal of Managing Projects in Business*, Vol. 4 No. 2, pp. 308-328.

Ansoff, H. I. (1965), *Corporate Strategy: An Analytic Approach to Business Policy for Growth and Expansion*, McGraw-Hill, Boston.

Anumba, C. J., Baron G. and Evbuomwan N. F. O. (1997), “Communications Issues in Concurrent Lifecycle Design and Construction”, *BT Technology Journal*, Vol. 15 No. 1, pp. 209-216.

Anumba, C. J., Bouchlaghem, N. M., White, J. and Duke, A. K. (2000), "Perspectives on an Integrated Construction Project Model", *International Journal of Co-operative Information Systems*, Vol. 9, No. 3, pp. 283–313.

Anumba, C. J., Kamara, J. and Cutting-Decelle, A. F. (2007), *Concurrent Engineering in Construction Projects* (Vol. 1). (Anumba, C. J. Ed.), Taylor & Francis, Madison Avenue, New York, USA.

Arantes, A., da Silva, P. F. and Ferreira, L. M. D. (2015), "Delays in construction projects-causes and impacts", *In Industrial Engineering and Systems Management, IEEE*, 2015 International Conference on IESM, pp. 1105-1110.

Archibald, R. D. (2003), *Managing high-technology programs and projects* (3rd ed.), John Wiley & Sons, NY.

Archibald, R. D. (2004), A global system for categorizing projects: the need for, recommended approach to, practical uses of, and description of a current project to develop the system, In *2nd Latin American PMIGOVSIG Forum on Project Management In Government*.

Arditi, D. and Pattanakitchamroon, T. (2006), "Selecting a delay analysis method in resolving construction claims", *International Journal of Project Management*, Vol. 24 No. 2, pp. 145-155.

Arditi, D. and Pattanakitchamroon, T. (2008), "Analysis methods in time-based claims", *Journal of Construction Engineering and Management*, Vol. 134 No. 4, pp. 242-252.

Arditi, D., Akan, G. T. and Gurdamar, S. (1985), "Reasons for delays in public projects in Turkey", *Construction management and economics*, Vol. 3 No. 2, pp.171-181.

Arditi, D., Nayak, S. and Damci, A. (2017), "Effect of organizational culture on delay in construction", *International Journal of Project Management*, Vol. 35 No. 2, pp. 136-147.

Aritua, B., Smith, N. J. and Bower, D. (2009), "Construction client multi-projects – A complex adaptive systems perspective", *International Journal of Project Management*, Vol. 27 No. 1, pp. 72-79.

ARPT (2015), "Rapport Annuel 2015", available at: https://www.arpt.dz/fr/pub/raa/ (accessed 11 November 2017).

ASCE – American Society of Civil Engineers (2012), *Quality in the Constructed Project: a Guide for Owners, Designers and Constructors* (3rd eds.), American Society of Civil Engineers, Virginia.

Asnaashari, E., Knight, A., Hurst, A. and Farahani, S. S. (2009), "Causes of construction delays in Iran: project management, logistics, technology and environment", in *Dainty, A. (Ed) Procs 25th Annual ARCOM Conference, 7-9 September 2009, Nottingham, UK,* Association of Researchers in Construction Management, Nottingham, UK, pp. 897-906.

Assaf, S. A. and Al-Hejji, S. (2006), "Causes of delay in large construction projects", *International Journal of Project Management*, Vol. 24 No. 4, pp. 349-357.

Assaf, S. A., Al-Khalil, M. and Al-Hazmi, M. (1995), "Causes of delay in large building construction projects", *Journal of Management in Engineering*, Vol. 11 No. 2, pp. 45-50.

Association of Project Management – APM (2012), *APM Body of Knowledge* (6th eds.), Association of Project Management, UK.

Atkinson, R. (1999), "Project management: cost, time and quality, two best guesses and a phenomenon, it's time to accept other success criteria", *International Journal of Project Management*, Vol. 17 No. 6, pp. 337–342.

Ayudhya, B. I. N. (2011), "Evaluation of common delay causes of construction projects in Singapore", *Journal of Civil Engineering and Architecture*, Vol. 5 No. 11, pp. 1027-1034.

Aziz, R. F. (2013), "Ranking of delay factors in construction projects after the Egyptian revolution", *Alexandria Engineering Journal*, Vol 52 No. 3, pp. 387-406.

Aziz, R. F. and Abdel-Hakam, A. A. (2016), "Exploring delay causes of road construction projects in Egypt", *Alexandria Engineering Journal*, Vol. 55 No. 2, pp. 1515-1539.

Baccarini, D. (1996), "The concept of project complexity – a review", *International Journal of Project Management*, Vol. 14 No 4, pp. 201-204.

Bagaya, O. and Song, J. (2016), "Empirical study of factors influencing schedule delays of public construction projects in Burkina Faso", *Journal of Management in Engineering*, Vol. 32 No. 5, pp. 05016014:1-10.

Bahrami, H. and Evans, S. (2005), *Super-Flexibility for Knowledge Enterprises*, Springer, Berlin.

Ballard, G. (1997), "Lookahead Planning", Proceedings from the 5th Annual Conference of the International Group for Lean Construction, Griffith University, Gold Coast, Australia.

Ballard, G. (2000), "The Last Planner System of Production Control", the University of Birmingham.

Ballard, G. and Tommelein, I. (2012), "Lean management methods for complex projects", *Engineering Project Organization Journal*, vol. 2 No. 1-2, pp. 85-96.

Baloyi, L. and Bekker, M. (2011), "Causes of construction cost and time overruns: The 2010 FIFA World Cup stadia in South Africa", *Acta Structilia Journal*, Vol. 18 No. 1, pp. 51-67.

Banks, J. (1998), *Handbook of simulation: principles, methodology, advances, applications, and practice*, John Wiley & Sons, New York.

Barbour, R. S. (1998), "Mixing qualitative methods: quality assurance or qualitative quagmire?", *Qualitative Health Research*, Vol. 8, No. 3, pp. 352-361.

Bar-Yam, Y. (2002), "Large Scale Engineering and Evolutionary Change: Useful Concepts for Implementation of FORCEnet", New England Complex Systems Institute. Available at: http://necsi.edu/research/engineering/forcenet.html

Bassioni, H., Price, A. and Hassan, T. (2004), "Performance Measurement in Construction", *Journal of Management in Engineering*, Vol. 20 No. 2, pp. 42-50.

Bayiley, Y. T. and Teklu, G. K. (2016), "Success factors and criteria in the management of international development projects: Evidence from projects funded by the European Union in Ethiopia", *International Journal of Managing Projects in Business*, Vol. 9 No. 3, pp. 562-582.

Becker, H. S. (1998), *Tricks of the Trade: How to Think About Research While Doing It*, University of Chicago Press, Chicago.

Bekr, G. A. (2015), "Causes of delay in public construction projects in Iraq", *Jordan Journal of Civil Engineering*, Vol. 9 No. 2, pp. 149-162.

Belanger, T. C. (1997), "Choosing a Project Life Cycle", In: Cleland, D.I. (ed.), *Field Guide to Project Management*, p. 62, Van Nostrand Reinhold.

Belassi, W. and Tukel, O. I. (1996), "A new framework for determining critical success/failure factors in projects", *International Journal of Project Management*, Vol 14 No. 3, pp. 141-51.

Bell, J. (2010), *Doing Research Project* (5th Ed.), Open University Press, Maidenhead.

Ben Mahmoud-Jouini, S., Midler, C. and Garel, G. (2004), "Time-to-market vs. time-to-delivery: Managing speed in Engineering, Procurement and Construction projects". *International Journal of Project Management*, Vol. 22 No. 5, pp. 359-367.

Bennett, C. (1975), "Up the hierarchy", *Journal of Extension*, Vol. 13 No. 2.

Bergman, I., Gunnarson, S. and Räisänen, C. (2013), "Decoupling and standardization in the projectification of a company", *International Journal of Managing Projects in Business*, Vol. 6 No. 1, pp. 106-128.

Berman Brown, R. and Saunders, M. (2008), *Dealing with Statistics: What You Need to Know*, McGraw-Hill Open University Press, Maidenhead.

Besanko, D., Dranove, D., Shanley, M. and Schaefer, S. (2010), *Economics of strategy* (5th eds.), John Wiley & Sons, .

Bhaskar, R. A. and Danermark, B. (2006), "Metatheory, Interdisciplinarity and Disability Research—A Critical Realist Perspective", *Scandinavian Journal of Disability Research*, Vol. 8 No. 4, pp. 278-297.

Biedenbach, T. (2015), "The Paradigm as a steering Mechanism for new Research endeavours", in Pasian, B. (Ed.), *Designs, Methods and Practices for Research of Project Management*, Gower Publishing, New York, pp. 33-42.

Biemer, P. P. and Lyberg, L. E. (2003), *Introduction to survey quality*. Wiley, New York.

Blackburn, J., (1991), *Time-based competition: the next battleground in American manufacturing*, Business One Irwin, Homewood, IL.

Blaikie, N. (2010), *Design Social Research*, (2nd ed.), Polity, Cambridge.

Blanchard, B. S. (2004), *System engineering management*, John Wiley, Hoboken.

Blanchard, B. S. and Fabrycky, W. J. (2011), *Systems engineering and analysis* (5 th eds.), Prentice Hall Englewood Cliffs, New Jersey.

Bluedorn, A. C. and Denhart R. B. (1988), "Time and organizations", *Journal of Management*, Vol. 14 No. 2, pp. 299-320.

Blumberg, B., Cooper, D. R. and Schindler, D. S. (2008), *Business Research Methods*, McGraw-Hill, Maidenhead.

Blyton, P., Hassard, J., Hill, S. and Starkey, K. (1989), *Time, work and organization*, Routledge, London.

Bogus, S., Diekmann, J. E., and Molenaar, K. R. (2002), "A methodology to reconfigure the design-construction interface for fast-track projects", *Computing in Civil Engineering*, pp. 258-272.

Bosch-Rekveldt, M., Jongkind, Y., Mooi, H., Bakker, H. and Verbraeck, A. (2011), "Grasping project complexity in large engineering projects: The TOE (Technical, Organizational and Environmental) framework", *International Journal of Project Management*, Vol. 29 No. 6, pp. 728-793.

Brand, S. (1994), *How buildings learn, what happens after they're built?* Viking Penguin, Penguin Books, New York.

Brennan, M. L. and Trigeorgis, L. (2000), *Project Flexibility, Agency, and Competition: New Developments in the Theory and Application of Real Options*, Oxford University Press, New York.

Brenner, J. E. (2008), *Logic in Reality*, Springer, Dordrecht.

Brown, S. L. and Eisenhardt, K. M. (1998), *Competing on the edge: Strategy as structured chaos*, Harvard Business Press.

Bryman, A. (1989), *Research Methods and Organization Studies*, Unwin-Hyman, London.

Bryman, A. (2006), "Integrating quantitative and qualitative research: How is it done?", *Qualitative Research*, Vol. 6 No. 1, pp. 97-113.

Bryman, A. (2008), *Social research methods* (3rd Ed.), Oxford University Press, Oxford.

Bryman, A. and Bell, E. (2015), *Business research methods*, Oxford University Press, New York.

Bubshait, A. A. and Almohawis, S. A. (1994), "Evaluating the general conditions of a construction contract", *International Journal of Project Management*, Vol. 12 No. 3, pp. 133-136.

Bulinskaya, E. (2001), "Small random perturbations of just-in-time systems", *International Journal of Production Economics*, Vol. 71 No. 1, pp. 287-294.

Burrell, G. (1992), "Back to the future: time and organizations", *In: Reed M, editor. Rethinking organizations: new directions in organization theory and analysis*. Sage, London.

Butler, R. (1995), "Time in organizations: its experience, explanations and effects", *Organization Studies*, Vol. 16 No. 6, pp. 925-50.

Callahan, M. T., Quackenbush, D.G. and Rowings, J.E. (1992), *Construction Project Scheduling*, McGraw-Hill, Boston, Massachusetts, USA.

Cambridge, U. P. (2013), Cambridge Business English Dictionary, Available at: http://dictionary.cambridge.org/dictionary/business-english.

Carden, L. and Egan, T. (2008), "Does our literature support sectors newer to project management? The search for quality publications relevant to nontraditional industries", *Project Management Journal*, Vol. 39 No. 3, pp. 6-27.

Carswell, A. T. (2012), *The encyclopedia of housing,* (2snd eds.), Sage, LA.
Cavendish, P. and Martin, D. M. (1982), *Martin, Negotiating & Contracting for Project Management*, Project Management Institute, PA.
Chan, A. P. C. (1996), *Determinants of project success in the construction industry of Hong Kong*, PhD thesis, University of South Australia, Adelaide.
Chan, A. P. C. and Chan, A. P. L. (2004), "Key performance indicators for measuring construction success". *Benchmarking: An International Journal*, Vol. 11 No. 2, pp. 203-221.
Chan, D. W. M. and Kumaraswamy, M. M. (1995), "A study of the factors affecting construction durations in Hong Kong", *Construction Management and Economics,* Vol. 13 No. 4, pp. 319–333.
Chan, D. W. M. and Kumaraswamy, M. M. (1997), "A comparative study of causes of time overruns in Hong Kong construction projects", *International Journal of project management*, Vol. 15 No. 1, pp. 55-63.
Chan, D. W. M. and Kumaraswamy, M. M. (2002), "Compressing construction durations: lessons learned from Hong Kong building projects", *International Journal of Project Management*, Vol. 20 No. 1, pp. 23-35.
Chan, W. T., Chua, D. K. and Kannan, G. (1996), "Construction resource scheduling with genetic algorithms", *Journal of construction engineering and management*, Vol. 122 No. 2, pp. 125-132.
Chapman, C. and Ward, S. (1997), *Project risk management. processes, techniques and insights*, Wiley, West Sussex.
Charles, C. M. (1995), *Introduction to educational research,* (2nd eds), Longman, San Diego.
Chen, M.-J. (2002), "Transcending paradox: The Chinese 'middle way' perspective", *Asian Pacific Journal of Management*, Vol. 19 No. 2/3, pp. 179–199.
Chen, M.-J. (2008), "Reconceptualizing the competition–cooperation relationship", *Journal of Management Inquiry*, Vol. 17, pp. 288–304.
Christensen, S. and Kreiner, K. (1991), *Prosjektledelse under usikkerhet*, Universitetsforlaget, Oslo.
Cipriani, R. (2013), "The many faces of social time: A sociological approach", *Time & Society*, Vol. 22 No. 1, pp. 5-30.
Clark, P. A. (1985), "A review of theories of time and structure for organizational sociology", *Research in the Sociology of Organizations*, Vol. 4, pp. 35-73.
Clark, P. A. (1990), "Chronological codes and organizational analysis", *In: Hassard J, Pym D, editors. The theory and philosophy of organizations*, Routledge, London.
Cleland, D. I. and Ireland, L. R. (1999), *Project management: strategic design and implementation*, McGraw-Hill, Singapore.
Cleland, D. I. and Kerzner, H. (1985), *A project management dictionary of terms*, Van Nostrand Reinhold.
Clough, R. H., Sears, G. A. and Sears, S. K. (2000), *Construction Project Management*. John Wiley & Sons, New York.
Cohen, L. and Manion, L. (1994), *Research methods in education* (4th ed.), Routledge, London and New York.
Collin, J. (2002), *Measuring the success of building projects–improved project delivery initiatives*, Report for the Queensland Department of Public Works, Australia.
Collis, J. and Hussey, R. (2009), *Business Research: A Practical Guide for Undergraduate & Postgraduate Students*, Palgrave Macmillan, Basingstoke.
Constable, G. (1994), "Concurrent Engineering – its Procedures and Pitfalls", *Measurement and Control*, Vol. 27 No. 8, pp. 245–247.
Construction Industry Institute – CII (1986), "Constructability: A Primer", The University of Texas, Publication 3-1, Austin.

Construction Industry Institute – CII (1993a), "Constructability Implementation Guide", The University of Texas at Austin.
Construction Industry Institute – CII (1993b), "Preview of Constructability Implementation", The University of Texas, Publication 34-2, Austin.
Construction Industry Institute – CII (1995), "Schedule Reduction", The University of Texas, Publication 41-1, Austin.
Construction Industry Institute – CII (1996), "An Investigation of Schedule Reduction Techniques", The University of Texas, Austin.
Construction Industry Institute – CII (2004), "The Project Manager's Playbook to Radical Reduction in Project Cycle Time", The University of Texas, Austin.
Construction Industry Institute – CII (2015), "Successful Delivery of Flash Track Projects", The University of Texas, Austin.
Cook, D. J., Mulrow, C. D. and Haynes, R. B. (1997), "Systematic reviews: Synthesis of best evidence for clinical decisions", *Annals of Internal Medicine*, Vol. 126 No. 5, pp. 376-380.
Cook, S. C. (1998), *Applying critical chain to improve the management of uncertainty in projects*, (Doctoral dissertation), Massachusetts Institute of Technology, Citeseer.
Cook, T. D. and Campbell, D. T. (1979), *Quasi-experimentation: Design and Analysis Issues for Field Settings*, Rand McNally, Chicago.
Cooke-Davies, T. J. (2002), "The "real" success factors on projects", *International Journal of Project Management*, Vol. 20 No. 3, pp. 185-190.
Cooke-Davies, T. J., Cicmil, S. J., Crawford, L. H. and Richardson, K. (2007), "We're not in Kansas anymore, Toto: mapping the strange landscape of complexity theory, and its relationship to project management", *Project Management Journal*, Vil. 38 No. 2, pp. 50-61.
Cooper, D. R. and Schindler, P. S. (2003), *Business research methods* (8th eds), McGraw-Hill, New York.
Cordero, R. (1991), "Managing for speed to avoid product obsolescence", Journal *of product Innovation Management*, Vol. 8 No. 4, pp. 283-94.
Corish, D. (1976), "Aristotle's Attempted Derivation of Temporal Order from That of Movement and Space", *Phronesis*, Vol. 21 No. 3, pp. 241-251.
Cottrell, W. D. (1999), "Simplified program evaluation and review technique (PERT)", *Journal of construction Engineering and Management*, Vol. 125 No. 1, pp. 16-22.
Couto, J. P. and Teixeria, J.C. (2007), "The evaluation of the delays in the Portuguese construction", *in CIB World Building Congress, Cape Town, South Africa, 2007*, pp. 292-301.
Cova, B. and Hoskins, S. (1997), "A twin-track networking approach to project marketing", *European Management Journal*, Vol. 15 No. 5, pp. 546-556.
Cox R., Issa R. and Ahrens D., (2003), "Management's Perception of Key Performance Indicators for Construction." *journal of Construction Engineering and Management*, Vol. 129 No. 2, pp. 142-151.
Crawford, L. and Pollack, J. (2004), "Hard and soft projects: A framework for analysis", *International Journal of Project Management*, Vol. 22 No. 8, pp. 645-653.
Creswell, J. W. (2012), *Educational Research: Planning, Conducting, And Evaluation Quantitative and Qualitative Research* (4th Ed.), Pearson Education, Inc., Boston.
Creswell, J. W. (2013), *Research design: Qualitative, quantitative, and mixed methods approaches*, Sage Publications Ltd., London.
Creswell, J. W. and Clark, V.L.P. (2007), *Designing and conducting mixed methods research*, Sage, CA.
Creswell, J. W. and Miller, D.L. (2000), "Determining validity in qualitative inquiry", *Theory into Practice*, Vol. 39 No. 3, pp. 124-131.

Cristiano, S. and Proietti, P. (2014), "Farm Innovation through Rural Development Programmes 2014-2020: an evaluation model of the EIP", In*: 11th European IFSA Symposium, Farming Systems Facing Global Challenges: Capacities and Strategies, Proceedings, Berlin, Germany, 1-4 April 2014* (pp. 141-152). International Farming Systems Association (IFSA) Europe.

Crocker, L. and Algina, J. (1986), *Introduction to classical and modern test theory*, Holt, Rinehart, and Winston, Inc., Toronto.

Crotty, M. (1998), *The Foundation of Social Research*, Sage, London.

Cui, Y. and Olsson, N. O. (2009), "Project flexibility in practice: An empirical study of reduction lists in large governmental projects", *International Journal of Project Management*, Vol. 27 No. 5, pp. 447-455.

Czaja, R. and Blair, J. (2005), *Designing surveys: A guide to decisions and procedures* (2nd ed.), Sage, Thousand Oaks, CA.

Czarnacka-Chrobot, B. (2014), "Analysis of the Workflow System Enhancement Project Speed and Duration – A Case Study", *Software Engineering*, Vol. 4 No. 1, pp. 10-18.

Dalcher, D. (2012), "The nature of project management: a reflection on the anatomy of major projects by Morris and Hough", *International Journal of Managing Projects in Business*, Vol. 5 No. 4, pp. 643-660.

Dancey, C.P. and reidy, J. (2008), *Statistics Without Maths for Psychology: Using SPSS for Windows* (4^{th} eds), Prentice Hall, Harlow.

Dash, D. P. (2005), "Logic of leadership research: A reflective review of 'Geeks & Geezers' by Bennis and Thomas", *Journal of Research Practice*, Vol. 1 No.1, pp.

Datar, S., Jordan, C., Kekre, S., Rajiv, S. and Srinivasan, K. (1997), «New product development structures and time-to-market", *Management Science*, Vol. 43 No. 4, pp. 452-464.

Davidz, H. L. (2006), *Enabling systems thinking to accelerate the development of senior systems engineers*, Massachusetts Institute of Technology, Cambridge.

Davies, D. and Dodd, J. (2002), "Qualitative research and the question of rigor", *Qualitative Health research*, Vol. 12 No. 2, pp. 279-289.

Dawood, N., Sikka, S., Marasini, R. and Dean, J. (2006), "Development of key performance indicators to establish the benefits of 4D planning", In: *Boyd, D., (Ed) Proceedings 22nd Annual ARCOM Conference*, Association of Researchers in Construction Management, Birmingham, pp. 709-718.

De la Garza, J. M. and Hidrobo, D. E. (2006), "Schedule Acceleration Techniques Using a CM", Virginia Polytechnique Institute and State University, Blacksburg, Virginia.

De la Garza, J. M., Alcantara, P., Kapoor, M. and Ramesh, P. S. (1994), "Value of Concurrent Engineering for A/E/C Industry", *Journal of Management in Engineering*, Vol. 10, No. 3, pp. 46-55.

De Leeuw, E. D. and Dillman, D. A. (2008), *International handbook of survey methodology*, Lawrence Erlbaum Associates.

De Leon, G. P. (2009), "Graphical Planning Method®", PMICOS 5th Annual Conference, Chicago, IL.

De Marco, A. (2011), *Project management for facility constructions: A guide for engineers and architects*, Springer Science & Business Media, New York.

Demartini, C. and Mella, P. (2011), "Time competition. The new strategic frontier", *IBusiness*, Vol. 3 No. 02, pp. 136-146.

Deming, W. E. (1944), "On errors in surveys", *American Sociological Review*, Vol. 9, pp. 359-369.

Denscombe, M. (2007), *The Good Research Guide*, OUP, Maidenhead.

Denzin, N. K. and Lincoln, Y.S. (2011), "Introduction: The discipline and practice of qualitative research", in Denzin, N.K. and Lincoln, Y.S. (ed.), *Handbook of Qualitative Research*, Sage, CA.

Department of Defense – DOD (2006), "Value Engineering Program", available at: http://ve.ida.org/ve/ve.html.

DeVaus, D. A. (2002), *Surveys in Social Research* (5th Ed.), Routledge, London.

Dey, I. (1993), *Qualitative Data Analysis*, Routledge, London.

Dillma, D. A. (2009), *Internet, Mail and Mixed Mode Surveys: The Tailored Design Method* (3rd ed.), Wiley, New York.

Dills, C. R. and Romiszowski, A. J. (1997), "The instructional development paradigm: An introduction", In: Dills, C.R. and Romiszowski, A.J. (Ed.), *Instructional development paradigms*, Educational Technology Publications Inc., Englewood, New Jersey.

Dlakwa, M. M. and Culpin, M. F. (1990), "Reasons for overrun in public sector construction projects in Nigeria", *International journal of project management*. Vol 8 No. 4, pp. 237-241.

Dochartaigh, N. Ó. (2012), *Internet research skills: How to do your literature search and find research information online*. Sage, London.

Doloi, H., Sawhney, A. and Iyer, K. C. (2012a), "Structural equation model for investigating factors affecting delay in Indian construction projects", *Construction Management and Economics*, Vol. 30 No. 10, pp. 869-884.

Doloi, H., Sawhney, A. and Rentala, S. (2012b), "Analysing factors affecting delays in Indian construction projects", *International journal of project management,* Vol. 30 No. 4, pp. 479-489.

Dowlatshahi, S. (1994), "A Comparison of Approaches to Concurrent Engineering", *International Journal of Advanced Manufacturing Technology*, Vol. 9, pp. 106-113.

Drucker P. F. (2006), *The Effective Executive: The Definitive Guide to Getting the Right Done*, HarperCollins Publishers Inc, New York, NY.

Drucker, P. F. (2000), *The essential Drucker: The best of sixty years of Peter Drucker's essential writings on management*, HarperCollins Publishers Inc., New York.

Durdyev, S., Omarov, M., Ismail, S. (2017), "Causes of delay in residential construction projects in Cambodia", *Cogent Engineering*, Vol. 4 No. 1, pp. 1291117.

Dursun, O. and Stoy, C. (2011), "Time–cost relationship of building projects: statistical adequacy of categorization with respect to project location", *Construction Management and Economics*, Vol. 29 No. 1, pp. 97-106.

Easa, S. M. (1989), "Resource leveling in construction by optimization", *Journal of construction engineering and management*, Vol. 115 No. 2, pp. 302-316.

Easterby-Smith, M., Thorpe, R. and Jackson, P. R. (2012), *Management research: Introduction*, (2ed.) Sage Publications, London.

Eastham, G. (2002), *The fast track manual: A guide to schedule reduction for clients and contractors on engineering and construction projects*, European Construction Institute, UK.

Easton, G. (2010), "Critical realism in case study research", *Industrial Marketing Management*, Vol. 39 No. 1, pp. 118-128.

Egan, J. (1998), *'Rethinking Construction', Report of the Construction Task Force on the Scope for Improving the Quality and Efficiency of UK Construction*, Department of the Environment, Transport and the Regions, HMSO, London.

Eisenhardt, K. M. (1989), "Building theories from case study research", *Academy of management review*, Vol. 14 No. 4, pp. 532-550.

Eisenhardt, K. M. and Graebner, M. E. (2007), "Theory building from cases: Opportunities and challenges", *Academy Management Journal*, Vol. 50 No. 1, pp. 25-32.

Eisner, E. W. (1991), *The enlightened eye: Qualitative inquiry and the enhancement of educational practice*, Macmillan Publishing Company, New York, NY.

Elawi, G. S. A., Algahtany, M., Kashiwagi, D. and Sullivan, K. (2015), "Major Factors Causing Construction Delays in Mecca", *Journal for the Advancement of Performance Information & Value*, Vol 7 No. 1, pp. 1-11.

Elhag, T. M. S. and Boussabaine, A. H. (1999), "Evaluation of construction costs and time attributes", *In Proceedings of the 15th ARCOM Conference15-17 September*, Vol. 2, pp. 473-80.

Emam, H., Farrell, P. and Abdelaal, M. (2015), "Causes of delay on infrastructure projects in Qatar", *In Proceedings of the 31st Annual ARCOM Conference, Lincoln, UK*, Association of Researchers in Construction Management, Nottingham, UK, pp. 773-782.

Enshassi, A., Al-Najjar, J. and Kumaraswamy, M. (2009), "Delays and cost overruns in the construction projects in the Gaza Strip", *Journal of Financial Management of Property and Construction*, Vol. 14 No. 2, pp. 126-151.

Enshassi, A., Arain, F. and Al-Raee, S. (2010), "Causes of variation orders in construction projects in the Gaza Strip", *Journal of Civil Engineering and Management*, Vol. 16 No. 4, pp. 540-551.

Eriksson, T. (2015), "Developing routines in large inter-organisational projects: A case study of an infrastructure megaproject", *Construction Economics and Building*, Vol. 15 No. 3, pp. 4-18.

Eskerod, P. and Östergren, K. (2000), "Why do companies standardize project work", *Project Management*, Vol. 6 No. 1, pp. 34-39.

Evbuomwan, N. F. O., Sivaloganathan, S. and Jebb, A. (1994), "A State of the Art Report on Concurrent Engineering", in Paul, A. J. and Sobolewski, M. (eds), Proceedings of Concurrent Engineering: Research and Applications, 1994 Conference, 29–31 August, Pittsburg, Pennsylvania, PA, pp. 35-44.

Ezeldin, A. S. and Abdel-Ghany, M. (2013), "Causes of construction delays for engineering projects: An Egyptian perspective", *In AEI 2013: Building Solutions for Architectural Engineering*. pp. 54-63.

Fallahnejad, M. H. (2013), "Delay causes in Iran gas pipeline projects", *International Journal of Project Management*, Vol. 31 No. 1, pp. 136-146.

Faridi, A. S. and El-Sayegh, S. M. (2006), "Significant factors causing delay in the UAE construction industry", *Construction Management and Economics*, Vol. 24, pp. 1167-1176.

Filimonau, V. (2015), *Life cycle assessment (LCA) and life cycle analysis in tourism: A critical review of applications and implications*. Springer, New York.

Filippini, R. (1997), "Operations management research: Some reflections on evolution, models and empirical studies in OM", *International Journal of Operations and Production Management*, Vol. 17 No. 7, pp. 655-670.

Flin, R. H. (1997), "Crew resource management for teams in the offshore oil industry", *Team Performance Management*, Vol. 3 No. 2, pp. 121-129.

Flyvbjerg, B. (2006), "Five misunderstandings about case-study research", *Qualitative Inquiry*, Vol. 12 No. 2, pp. 219-245.

Flyvbjerg, B., Bruzelius, N., and Rothengatter, W. (2003). *Megaprojects and risk: An anatomy of ambition*. Cambridge University Press.

Fontana, A. and Frey, J. H. (2005), "The interview: From neutral stance to political involvement". In: Denzin, N. K. and Lincoln Y. S. (Ed.), *The Sage handbook of qualitative research*, Sage, Thousand Oaks, pp. 695-726.

Forbes, L. H., Ahmed, S. M. and Barcala, M. (2002), "Adapting lean construction theory for practical application in developing countries", *Proceedings of the first CIB W107 International Conference*, Stellenbosch, South Africa.

Forsberg, K. M. and Cotterman, H. (2000), *Visualizing project management: a model for business and technical success* (2nd eds.), John Wiley and Sons.

Forza, C. (2009), "Surveys", In: Karlsson, C. (Ed.), *Researching operations management*, Routledge, New York, pp. 84-162.

Fowler, F. J., Gallagher, P. M., Stringfellow, V. L., Zalavsky, A. M., Thompson, J. W. and Cleary, P. D. (2002), "Using telephone interviews to reduce nonresponse bias to mail surveys of health plan members". *Medical Care*, Vol. 40, pp. 190–200.

Fraenkel, J. R. and Wallen, N. E. (2000), *How to design and evaluate a research in education* (4th ed.), McGraw-Hill, Boston.

Frame, J. D. (1998), "Closing Out the Project", In: Pinto, J.K. (ed.*), Project Management Handbook*, Jossey-Bass, pp. 238.

Frimpong, Y. and Oluyowe, J. (2003), "Significant factors causing delay and cost overruns in construction of groundwater projects in Ghana", *Journal of Construction Research*. Vol. 4 No. 2, pp. 175-187.

Frimpong, Y., Oluwoye, J. and Crawford, L. (2003), "Causes of delay and cost overruns in construction of groundwater projects in developing countries: Ghana as a case study", *International Journal of Project Management*, Vol 21 No. 5, pp. 321-326.

Fugar, F. D. and Agyakwah-Baah, A. B. (2010), "Delays in building construction projects in Ghana", *Construction Economics and Building*, Vol. 10 No. 1-2, pp. 103-116.

Galbraith, J. R. (1973), *Designing Complex Organizations*, Adison-Wesley, Reading, MA.

Gao, S. and Low, S. P. (2014), "The Last Planner System in China's construction industry - A SWOT analysis on implementation", *International Journal of Project Management*, Vol. 32 No. 7, pp. 1260-1272.

Gardezi, S. S. S., Manarvi, I. A. and Gardezi, S. J. S. (2014), "Time extension factors in construction industry of Pakistan", *Procedia Engineering*, Vol. 77, pp.196-204.

Geraldi, J., Maylor, H. and Williams, T. (2011), "Now, let's make it really complex (complicated) — a systematic review of the complexities of projects", *International Journal of Operations and Production Management*, Vol. 31 No 9, pp. 966-990.

Ghauri, P. N. and Grönhaug, K. (2010), *Research methods in business studies: A Practical Guide*, (4th ed.), Prentice Hall, Harlow.

Gidado, K. and Niazai, G. A. (2012), "Causes of project delay in the construction industry in Afghanistan", *In Engineering, Project and Production Management (EPPM) Conference EPPM2012*, University of Brighton, UK, 10-11 September, 2012.

Golafshani, N. (2003), "Understanding reliability and validity in qualitative research", *The Qualitative Report*, Vol. 8 No. 4, pp. 597-606.

Gomar, J. E., Haas, C. T. and Morton, D. P. (2002), "Assignment and allocation optimization of partially multiskilled workforce", *Journal of construction Engineering and Management*, Vol. 128 No. 2, pp. 103-109.

González, P., González, V., Molenaar, K. and Orozco, F. (2014), "Analysis of causes of delay and time performance in construction projects", *Journal of Construction Engineering and Management*. Vol. 140 N. 1, pp. 04013027:1-9

Gould, F. (2012), *Managing the Construction Process: Estimating, Scheduling, and Project Control*, Pearson Education Inc., USA.

Gray, B. (2004), "Informal learning in an online community of practice", *Journal of Distance Education*, Vol. 19 No. 1, pp. 20-35.

Greenwood, D. J. and Levin, M. (2007), *Introduction to action research; social research for social change* (2nd ed.), Sage Publications Ltd., CA.

Groves, R. M. (1989), *Survey Errors and Survey Costs*, Wiley, New Jersey, NJ.

Groves, R. M. and Couper, M. P. (1998), *Nonresponse in household interview surveys*. Wiley, New York.

Groves, R. M., Fowler, F. J., Couper, M. P., Lepkowski, J. M., Singer, E. and Tourangeau, R. (2004), *Survey methodology*. Wiley, New York.

Guba, E. G. (1990), *The paradigm dialog*, Sage Publications Ltd., New Bury park, CA, New York.

Guba, E. G. and Lincoln, Y. S. (1994), "Competing paradigms in qualitative research", in Denzin, N.K. and. Lincoln, Y.S (Ed.), *Handbook of Qualitative Research*, Sage Publications Ltd., Thousand Oaks, pp. 105-117.

Guerrero, M. A., Villacampa, Y. and Montoyo, A. (2014), "Modeling construction time in Spanish building projects", *International Journal of Project Management*, Vol 32 No. 5, pp. 861-873.

Gul, S. and Khan, S. (2011), "Revisiting Project Complexity: Towards a Comprehensive Model of Project Complexity", *2nd International Conference on Construction and Project Management. Singapore, IACSIT Press. IPEDR*, Vol.15, pp. 148-155.

Gündüz, M. and AbuHassan, M. H. (2016), "Causes of Construction Delays in Qatar Construction Projects". *International Journal of Civil, Environmental, Structural, Construction and Architectural Engineering*, Vol. 10 No. 4, pp. 516-521.

Gündüz, M., Nielsen, Y. and Özdemir, M. (2013a), "Fuzzy assessment model to estimate the probability of delay in Turkish construction projects", *Journal of Management in Engineering*, Vol. 31 No. 4, pp. 04014055.

Gündüz, M., Nielsen, Y. and Özdemir, M. (2013b), "Quantification of delay factors using the relative importance index method for construction projects in Turkey", *Journal of Management in Engineering*, Vol. 29 No. 2, pp. 133-139.

Hajikazemi, S., Ekambaram, A., Andersen, B. and Zidane, Y. J-T. (2016), "The Black Swan–Knowing the unknown in projects", *Procedia – Social and Behavioral Sciences*, Vol. 226, pp.184-192.

Hammer, M. and Champy, J. (1995), *Reengineering the corporation – A manifesto for business revolution*, Harper Business, New York.

Hammer, M. and Champy, J. (2003), *Reengineering the corporation: a manifesto for business revolution*, Harper Collins, New York.

Harmelink, D. J. and Rowings, J. E. (1998), "Linear scheduling model: Development of controlling activity path", *Journal of Construction Engineering and Management*, Vol. 124 No. 4, pp. 263-268.

Harris, F. and McCaffer, R. (1989), *Modern Construction Management*, Collins, London.

Harris, R. B. and Ioannou, P. G. (1998), "Scheduling projects with repeating activities", *Journal of Construction Engineering and Management*, Vol. 124 No. 4, pp. 269-278.

Hart, C. (1998), *Doing a Literature Review: Releasing the social science research imagination*, Sage Publications, London.

Haseeb, M., Lu, X., Bibi, A., Dyian, M. and Rabbain, W. (2011a), "Problems of projects and effects of delays in the construction industry of Pakistan", *Australian Journal of Business and Management Research*, Vol. 1 No. 5, pp. 41-50.

Haseeb, M., Lu, X., Hoosen, A. B. and Rabbani, W. (2011b), "Causes and effects of delays in large construction projects of Pakistan", *Kuwait Chapter of Arabian Journal of Business and Management Review*, Vol. 1 No. 4, pp. 18-42.

Haskins, C., Forsberg, K., Krueger, M., Walden, D. and Hamelin, R. D. (2010), *INCOSE Systems Engineering Handbook v. 3.2: A guide for system life cycle processes and activities*, INCOSE, San Diego, CA.

Hastak, M., Gokhale, S., Goyani, K., Hong, T. and Safi, B. (2008), "Analysis of techniques leading to radical reduction in project cycle time", *Journal of construction engineering and management*, Vol. 134 No. 12, pp. 915-927.

Hastings, N. A. J. (2010), *Physical Asset Management A Practitioner's Guide*, Springer, London.

Hayes, R., Pisano, G., Upton, D. and Wheelwright, S. (2005), *Pursuing the Competitive Edge*, John Wiley & Sons, New York, NY.

Healey, M. J. and Rawlinson, M. B. (1994) “Interviweing techniques in business and management research”, in: Wass, V.J. and Wells, P.E. (ed.), *Principles and Practice in Business and Management Research*, Dartmouth, Aldershot, pp. 123-145

Healy, M. and Perry, C. (2000), “Comprehensive criteria to judge validity and reliability of qualitative research within the realism paradigm”, *Qualitative Market Research*, Vol. 3 No. 3, pp. 118-126.

Hebert, J. E. (1979), “Applications of simulation in project management”, In *Proceedings of the 11th conference on Winter simulation IEEE Press*, Vol 1, pp. 211-219.

Hegazy, T. (1999), “Optimization of resource allocation and leveling using genetic algorithms”, *Journal of construction engineering and management*, Vol. 125 No. 3, pp. 167-175.

Hegazy, T. and Menesi, W. (2008), “Delay analysis under multiple baseline updates”, *Journal of Construction Engineering and Management*, Vol. 134 No. 8, pp. 575-582.

Hepsø, V. (2009), “Common Information Spaces in Knowledge-Intensive Work: Representation and Negotiation of Meaning in Computer-Supported Collaboration Rooms”, In *Handbook of Research on Knowledge-Intensive Organizations*, IGI Global Publ, Hershey.

Hess, D. J. (1997), *Science studies: An advanced introduction*. New York University Press, New York.

Hickey, J. V. and Brosnan, C. A. (2012), *Evaluation of health care quality in advanced practice nursing,* Springer Publishing Company, New York, NY.

Hillson, D. (1997), “Towards a risk maturity model”, *International Journal of Project & Business Risk Management*, Vol. 1 No. 1, pp. 35-45.

Hillson, D. (1998), “Project risk management: future developments”, *International Journal of Project & Business Risk Management*, Vol. 2 No. 2, pp. 181-95.

Hoepfl, M. C. (1997), “Choosing qualitative research: A primer for technology education researchers”, *Journal of Technology Education*, Vol. 9 No. 1, pp. 47-63.

Holden, M. T. and Lynch, P. (2004), “Choosing the appropriate methodology: Understanding research philosophy”, *The Marketing Review*, Vol. 4 No.4, pp. 397-409.

Howe, K. R. (1988), “Against the quantitative-qualitative incompatibility thesis or dogmas die hard”, *Educational researcher*, Vol. 17 No. 8, pp. 10-16.

Hsie, M., Chang, C. J., Yang, I. T. and Huang, C. Y. (2009), “Resource-constrained scheduling for continuous repetitive projects with time-based production units”, *Automation in Construction*, Vol. 18 No. 7, pp. 942-949.

Hunt, R. G. and Franklin, W. E. (1996), “LCA – How it came about”, *The International Journal of Life Cycle Assessment*, Vol. 1 No. 1, pp. 4-7.

Hussein, B. A. (2012), “An Empirical Investigation of Project Complexity from the Perspective of a Project Practitioner”, *Proceedings of IWAMA 2012 - The Second International Workshop of Advanced Manufacturing and Automation, Tapir Akademisk Forlag*, pp. 335-342.

Hussein, B. A., Ahmad, S. B. S. and Zidane, Y. J-T. (2015), “Problems Associated with Defining Project Success”, *Procedia Computer Science*, vol. 64, pp. 940-947.

Hussein, B. A., Pigagaite, G. and Silva, P. P. (2014), “Identifying and dealing with complexties in new product and process development projects”, *Procedia-Social and Behavioral Sciences*, Vol. 119, pp. 702-710.

Hutchinson, R. (2007), *The impact of time-based accounting on manufacturing performance*, Doctoral dissertation, University of Toledo, Ohio.

Hwang, B. G., Zhao, X. and Ng, S. Y. (2013), “Identifying the critical factors affecting schedule performance of public housing projects”, *Habitat International*, Vol. 38, pp. 214-221.

Ika, L. A. (2009), “Project success as a topic in project management journals”, *Project Management Journal*, Vol. 40 No. 4, pp. 6-19.

Ika, L. A., Diallo, A. and Thuillier, D. (2010), "Project management in the international development industry: the project coordinator's perspective", *International Journal of Managing Projects in Business*, Vol. 3 No. 1, pp. 61-93.

Ioannou, P. G. and Yang, I. T. (2016), "Repetitive scheduling method: Requirements, modeling, and implementation", *Journal of Construction Engineering and Management*, Vol. 142 No. 5, pp. 04016002.

Jackson, M. C. (2003), *Systems Thinking: Creative Holism for Managers"*, John Wiley & Sons, Ltd, The Atrium, Southern Gate, Chichester, West Sussex, England.

Japan International Cooperation Agency – JICA (2004), *JICA Guideline for Project Evaluation*, JICA, Tokyo.

Jensen, C., Johansson, S. and Löfström, M. (2006), "Project relationships – A model for analyzing interactional uncertainty", *International Journal of Project Management*, Vol. 24 No. 1, pp. 4-12.

Johnson, B. R. (1997), "Examining the validity structure of qualitative research", *Education*, Vol. 118 No. 3, pp. 282-292.

Johnson, R. B. and Onwuegbuzie, A. J. (2004), "Mixed methods research: A research paradigm whose time has come", *Educational Researcher*, Vol. 33 No. 7, pp. 14-26.

Johnson, R. B., Onwuegbuzie, A.J. and Turner, L.A. (2007), "Toward a definition of mixed methods research", *Journal of mixed methods research*, Vol. 1 No. 2, pp. 112-133.

Joppe, M. (2000), "The Research Process".

Joslin, R. and Müller, R. (2015), "Relationships between a project management methodology and project success in different project governance contexts", *International Journal of Project Management*, Vol. 33 No. 6, pp. 1377-1392.

Judgev, K. and Müller, R. (2005), "A retrospective look at our evolving understanding of project success", *Project Management Journal,* Vol. 36 No. 4, pp. 19–31.

Judgev, K., Thomas, J. and Delisle, C. L. (2001), "Rethinking project management: old truths and new insights", *International Journal of Project Management,* Vol. 7 No. 1, pp. 36–43

Juran, J. M. and Gryna, F. M. Jr. (1980), *Quality planning and analysis: From product development through use*, McGraw-Hill, New York.

Kaliba, C., Muya, M. and Mumba, K. (2009), "Cost escalation and schedule delays in road construction projects in Zambia", *International Journal of Project Management*, Vol. 27 No. 5, pp. 522–531.

Kamanga, M. J. and Steyn, W. V. (2013), "Causes of delay in road construction projects in Malawi: Technical paper", *Journal of the South African Institution of Civil Engineering*, Vol. 55 No. 3, pp. 79-85.

Kaming, P. F., Olomolaiye, P. O., Holt, G. D. and Harris, F. C. (1997), "Factors influencing construction time and cost overruns on high-rise projects in Indonesia", *Construction Management and Economics*, Vol. 15 No. 1, pp. 83-94.

Kandil, A. and El-Rayes, K. (2006), "Parallel genetic algorithms for optimizing resource utilization in large-scale construction projects", *Journal of Construction engineering and Management*, Vol. 132 No. 5, pp. 491-498.

Kannan, S. R. and Senthil, R. (2014), "Production based scheduling method for linear construction in road projects", *KSCE Journal of Civil Engineering*, Vol. 18 No. 5, pp. 1292-1301.

Karlsen, J. (2011), "Supportive culture for efficient project uncertainty management", *International Journal of Managing Projects in Business*, Vol. 4 No. 2, pp. 240-256.

Karlsen, J. T. (1998), *Mestring av omgivelsesusikkerhet*, PhD thesis, Norwegian University of Science and Technology, Trondheim.

Karlsson, M., Lakka, A., Sulankivi, K., Hanna, A. S. and Thompson, B. P. (2008), "Best practices for integrating the concurrent engineering environment into multipartner project management", *Journal of construction engineering and management*, Vol. 134 No. 4, pp. 289-299.

Kazaz, A., Ulubeyli, S. and Tuncbilekli, N. A. (2012), "Causes of delays in construction projects in Turkey", *Journal of Civil Engineering and Management*, Vol. 18 No. 3, pp.426-435.

Keane, P. J., Caletka, A. F. (2015), *Delay Analysis in Construction Contracts*, John Wiley & Sons, UK.

Kelemen, M.L. and Rumens, N. (2008), *An introduction to critical management research*, Sage, London.

Kelso, J. A. S. and Engstrom, D. A. (2006), *The Complementarity Nature*, The MIT Press, Cambridge, MA.

Kerzner, H. (2009), *Project Management: A Systems Approach to Planning, Scheduling and* Controlling (10th ed.), John Wiley and Sons Publishers, New York.

Kessler, E. H. and Chakrabarti, A. K. (1996), "Innovation speed: A conceptual model of context, antecedents, and outcomes", *Academy of Management Review*, Vol. 21 No. 4, pp. 1143-1191.

Khalfan, M. M. A., Anumba, C. J., Siemieniuch, C. E. and Sinclair, M. A. (2001), "Readiness Assessment of the Construction Supply Chain for Concurrent Engineering", *European Journal of Purchasing and Supply Management*, Vol. 7 No. 2, pp. 141–153.

Khisty, C. J. (1970). "The application of the line of balance technique to the construction industry", *Indian Concrete Journal,* Vol. 44 No. 7, pp. 297-300.

Khodakarami, V., Fenton, N. and Neil, M. (2007), "Project Scheduling: Improved approach to incorporate uncertainty using Bayesian Networks", *Project Management Journal*, Vol. 38 No. 2, pp. 39-49.

Khoshgoftar, M., Bakar, A. H. A. and Osman, O. (2010), "Causes of delays in Iranian construction projects". *International Journal of Construction Management*, Vol. 10 No. 2, pp. 53-69.

Kikwasi, G. J. (2012), "Causes and effects of delays and disruptions in construction projects in Tanzania", *In Australasian Journal of Construction Economics and Building-Conference Series*, Vol. 1 No. 2, pp. 52-59.

Kim, J., Kang, C., and Hwang, I. (2012), "A practical approach to project scheduling: considering the potential quality loss cost in the time–cost tradeoff problem", *International Journal of Project Management*, Vol. 30 No. 2, pp. 264-272.

Kim, S., Tuan, K. N. and Luu, V. T. (2016), "Delay factor analysis for hospital projects in Vietnam", *KSCE Journal of Civil Engineering*, Vol 20 No. 2, pp. 519-529.

Kim, W. C. and Mauborgne, R. (2005), *Blue ocean strategy, expanded edition: How to create uncontested market space and make the competition irrelevant*, Harvard Business School Press, US.

Kim, Y., Kim, K. and Shin, D. (2005), "Delay analysis method using delay section", *Journal of Construction Engineering and Management*, Vol. 131 No. 11, pp. 1155–1164.

King, N. (2004), "Using interviews in qualitative research", in: Cassel, C. and Symon, G. (eds), *Essential Guide to Qualitative Methods in Organizational Research.* Sage, London, pp. 11-22.

Kirk, J. and Miller, M. L. (1986), *Reliability and validity in qualitative research*, Sage Publications, Beverly Hills.

Kirkman, B. L., Rosen, B., Tesluk, P. E. and Gibson, C. B. (2004), "The impact of team empowerment on virtual performance: The moderating role of face-to-face interaction", *Academy of Management Journal*, Vol. 47 No. 2, pp. 175-192.

Klakegg, O. J. (2015), "Ontology and Epistemology", in Pasian, B. (Ed.), *Designs, Methods and Practices for Research of Project Management*, Gower Publishing, pp. 57-66.

Klöpffer, W. (2006), "The role of SETAC in the development of LCA", *International Journal of LCA*, Vol. 11 No. 1, pp. 116–122.

Klöpffer, W. and Grahl, B. (2014), *Life Cycle Assessment (LCA). A guide to best practice*, Wiley-VCH Verlag GmbH & Co, Weinheim.

Kogan, K., and Khmelnitsky, E. (2013), *Scheduling: control-based theory and polynomial-time algorithms* (Vol. 43), Springer Science & Business Media, US.

Kometa, S. T., Olomolaiye, P. O. and Harris, F. C. (1994), "Attributes of UK construction clients influencing project consultants' performance", *Construction Management and Economics*, Vol. 12 No. 5, pp. 433-443.

Kosaroglu, M. and Hunt, R. A. (2009), "New product development projects and project manager skill sets in the telecommunications industry", *International Journal of Managing Projects in Business*, Vol. 2 No. 2, pp. 308-317.

Koushki, P. A., Al-Rashid, K. and Kartam, N. (2005), "Delays and cost increases in the construction of private residential projects in Kuwait", *Construction Management and Economics*. Vol. 23 No. 3, pp. 285–294.

Kreiner, K. (1995), "In search of relevance: Project management in drifting environments", *Scandinavian Journal of Management*, Vol. 11 No. 4, pp. 335-346.

Kuhn, T. (1962), *The structure of scientific revolutions*, University of Chicago Press, Chicago.

Kvale, S., Brinkmann, S., Anderssen, T. M. and Rygge, J. F. (2009), *Det kvalitative forskningsintervju*, Oslo, Gyldendal akademisk.

Lam, E. W., Chan, A. P. and Chan, D. W. (2007), "Benchmarking the performance of design-build projects: Development of project success index", *Benchmarking: An International Journal*, Vol. 14 No. 5, pp. 624-638.

Langston, C., (2013), "Development of generic key performance indicators for PMBOK® using a 3D project integration mode", *Australasian Journal of Construction Economics and Building*, Vol. 13 No. 4, pp. 78-91.

Law, K. M. and Kesti, M. (2014), *Yin Yang and organizational performance: Five elements for improvement and success*, Springer Science & Business Media.

Lee, H. and Liebenau, J. (1999), "Time in organization studies: towards a new research direction", Organization *Studies*, Vol. 20 No. 6, pp. 1035-1058.

Lee, S. G., Ma, Y. S., Thimm, G. L. and Verstraeten, J. (2008), "Product lifecycle management in aviation maintenance, repair and overhaul", *Computers in industry*, Vol. 59 No. 2, pp. 296-303.

Leech, N. L. and Onwuegbuzie, A. J. (2009), "A typology of mixed methods research designs", *Quality and Quantity*, Vol. 43 No. 1, pp. 265-275.

Leedy, P. D. and Ormrod, J. E. (2005), *Practical Research: Planning and Design* (8^{th} ed.), Printice Hall, Upper Saddle River.

Le-Hoai, L., Dai Lee, Y. and Lee, J. Y. (2008), "Delay and cost overruns in Vietnam large construction projects: A comparison with other selected countries", *KSCE journal of civil engineering*, Vol. 12 No. 6, pp. 367-377.

Levine, D. N. (1985), *The Flight From Ambiguity*, University of Chicago Press, Chicago, IL.

Li, P. (2012), "Toward an integrative framework of indigenous research: The geographic implications of Yin-Yang balance", *Asia Pacific Journal of Management*, Vol. 29, pp. 849–872

Li, P. P. (2016), "Global implications of the indigenous epistemological system from the East: How to apply Yin-Yang balancing to paradox management", *Cross Cultural & Strategic Management*, Vol. 23 No. 1, pp. 42-77.

Liddell, H. G., and Scott, R. (1896), *An intermediate Greek-English lexicon: founded upon the seventh edition of Liddell and Scott's Greek-English lexicon*, Harper & Brothers.

Lim, C. S. and Mohamed, M. Z. (1999), "Criteria of project success: an exploratory re-examination", *International Journal of Project Management*, Vol. 17 No. 4, pp. 243-248.

Lincoln, Y. S. and Guba, E. G. (1985), *Naturalistic Inquiry*, Sage, Beverly Hills, CA.

Liu, L., Liu, Y. and Tang, Y. (2016), "Production Rate Determination for Linear Construction Projects Based on Linear Scheduling Method", *International Journal of Smart Home*, Vol. 10 No. 4, pp. 143-152.

Lo, T. Y., Fung, I. W. and Tung, K. C. (2006), "Construction delays in Hong Kong civil engineering projects", *Journal of Construction Engineering and Management*, Vol. 132 No. 6, pp. 636-649.

Lofland, J. (1971), *Analyzing a social settings*, Wadsworth, Belmont, CA.

Lumsden, P. (1968), *The line-of-balance method*, Pergamon Press Limited.

Luu, T. V., Kim, S., Tuan, N. V. and Ogunlana, S. O. (2009), "Quantify schedule risk in construction projects using Bayesian belief networks", *International Journal of Project Management*, Vol. 27 No. 1, pp. 39-50.

Luu, V. T., Sang, N. M. and Viet, N. T. (2015), "A conceptual model of delay factors affecting government construction projects", *ARPN Journal of Science and Technology*, Vol. 5 No. 2, pp. 92-100.

Mahalingam, A. and Levitt, R. (2007), "Institutional theory as a framework for analyzing conflicts on global projects", *Journal of Construction Engineering and Management*, Vol. 133 No. 7, pp 517–528.

Mahamid, I. (2011), "Risk matrix for factors affecting time delay in road construction projects: owners' perspective", *Engineering, Construction and Architectural Management*, Vol. 18 No. 6, pp. 609-617.

Mahamid, I. (2013), "Frequency of time overrun causes in road construction in Palestine: Contractors' View", *Organization, Technology & Management in Construction: An International Journal*, Vol. 5 No. 1, pp. 720-729.

Mahamid, I., Bruland, A. and Dmaidi, N. (2012), "Causes of delay in road construction projects", *Journal of Management in Engineering*, Vol. 28 No. 3, pp. 300–310.

Mahdi, I. M. (2004), "A new LSM approach for planning repetitive housing projects*", International Journal of Project Management*, Vol. 22 No. 4, pp. 339-346.

Malhotra, M. K. and Grover, V. (1988), "An assessment of survey research in POM: From constructs to theory", *Journal of Operations Management*, Vol. 16 No. 17, pp. 297–326.

Manavazhi, M. R. and Adhikari, D. K. (2002), "Material and equipment procurement delays in highway projects in Nepal", *International Journal of Project Management*, Vol. 20 No. 8, pp. 627-632.

Mansfield, N. R., Ugwu, O. O. and Doran, T. (1994), "Causes of delay and cost overruns in Nigerian construction projects", *International Journal of Project Management*, vol. 12 No. 4, pp. 254-260.

Marshall, C. and Rossman, G. B. (1995), *Designing Qualitative Research*. Thousand Oaks, Calif., Sage.

Marshall, C. and Rossman, G. B. (2006), *Design Quality Research* (4th eds), Sage, Thousand Oaks, CA.

Martinsuo, M., Suomala, P. and Kanniainen, J. (2013), "Evaluating the organizational impact of product development projects", *International Journal of Managing Projects in Business*, Vol. 6 No. 1, pp. 173-198.

Marzouk, M. M. and El-Rasas, T. I. (2014), "Analyzing delay causes in Egyptian construction projects", *Journal of Advanced Research*, Vol. 5 No. 1, pp. 49-55.

Mascitelli, R. (2007), *The lean product development guidebook: everything your design team needs to improve efficiency and slash time-to-market*, Technology Perspectives.

Masterman, M. (1970), "The nature of a paradigm", In: Latakos, I. and Musgrave, A. (Ed.), *Criticism and the growth of knowledge*, Cambridge University Press, Cambridge.

Mathison, S. (1988), "Why triangulate?", *Educational Researcher*, Vol. 17 No. 2, pp. 13-17.

Maxwell, J. A. (1992), "Understanding and validity in qualitative research", *Harvard Educational Review*, Vol. 62 No. 3, pp. 279-300.

Meredith, J. and Mantel Jr. S. (2000), *Project Management–A Managerial Approach*, John Wiley & Sons, New York.

Merriam-Webster (1984), *Merriam-Webster's Dictionary of Synonyms: A Dictionary of Discriminated Synonyms with Antonyms and Analogous and Contrasted Words*, Merriam-Webster Inc., Springfield, Massachusetts.

Mezher, M. M. and Tawil, W. (1998), “Causes of delays in the construction industry in Lebanon”, *Engineering Construction and Architectural Management*, Vol. 5 No. 3, pp. 252-260.

Midler, C., (1993), *L'auto qui n'existait pas, Management des Projets et transformation de l’entreprise*, Intereditions, Paris.

Miles, M. B. and Huberman, A. M. (1994), *Qualitative Data Analysis: An Expanded Sourcebook* (2nd eds.), Sage Publications Ltd., Thousand Oaks, CA.

Miller, R. and Lessard, D. (2000), *The strategic management of large engineering projects, shaping institutions, risks and governance*, Massachusetts Institute of Technology; USA.

Miltenburg, J. and Sparling, D. (1996), “Managing and reducing total cycle time: models and analysis”, *International Journal of Production Economics*, Vol. 46-47, pp. 89-108.

Mingers, J. (2006), “A critique of statistical modelling in management science from a critical realist perspective: Its role within multimethodology”, *Journal of the Operational Research Society*, Vol. 57 No. 2, pp. 202-219.

Ministère des Travaux Publics et des Transports – MTP (2013), “The East-West Highway”, MTP, available at: http://www.mtp.gov.dz/ . Retrieved 2014-10-31.

Mitchell, V. (1996), “Assessing the reliability and validity of questionnaires: An empirical example”, *Journal of Applied Management Studies*, Vol. 5 No. 2, pp. 199-207.

Mobbs, G. N. (1982), “Speeding up construction”, *The Quantity Surveyor*, Vol. 38 No. 1, pp. 2-3.

Momigliano, A. (1966), “Time in ancient historiography”, *History and Theory*, Vol. 6, pp. 1-23.

Moran, R. T., Abramson, N. R. and Moran, S. V. (2014), *Managing cultural differences*, Routledge.

Morris, C, (2012), *Quantitative Approaches in Business Studies* (8th eds), Prentice Hall, Harlow.

Morris, P. W. and Pinto, J. K. (2004), *The Wiley Guide to Managing Projects*, John Wiley & Sons, Hoboken, New Jersey, USA.

Morris, P. W. G. (1998), “Key Issues in Project Management”, In: Pinto, J.K. (ed.*), Project Management Handbook*, Jossey-Bass, pp. 5.

Morris, P. W. G. and Hough, G. H. (1987), *The Anatomy of Major Projects: A Study of the Reality of Project Management*, Wiley, New York.

Morton, S. C., Dainty, A. R. J., Burns, N. D., Brookes, N. J. and Backhouse, C. J. (2006), “Managing relationships to improve performance: A case study in the global aerospace industry”, *International Journal of Production Research*, Vol. 44 No. 16, pp. 3227-3241.

Moser, H. A. (2013), *Systems Engineering, Systems Thinking, and Learning: A Case Study in Space Industry*, Springer, Switzerland.

Motaleb, O. and Kishk, M. (2013), “An investigation into the risk of construction project delays in the UAE”, *International Journal of Information Technology Project Management*, Vol. 4 No. 3, pp. 1149-1157.

MPTIC (2016), “Evolution du secteur de la poste et des TIC depuis 1962”, available at: https://www.mptic.dz/fr/content/ (accessed 10 November 2016).

Mubarak, S. (2010), *Construction Project Scheduling and Control*, (2nd Eds.), John Wiley and Sons.

Muhwezi, L., Acai, J. and Otim, G., (2014), “An assessment of the factors causing delays on building construction projects in Uganda”, *International Journal of Construction Engineering and Management*. Vol. 3 No. 1, pp. 13-23.

Muijs, D. (2011), *Doing quantitative research in education with SPSS* (2nd Ed.), Sage Publications Ltd., Thousand Oaks, CA.

Muller, A., Happe, D. and Wilson, S. (2005), *Virtualization with VMware ESX server*, Oreilly & Associates, Sebastopol, CA.

Müller, R. and Turner, R. (2007), “The influence of project managers on success criteria and project success by type of project”, *European Management Journal*. Vol. 25 No. 4, pp. 298-309.

Müller, R., Pemsel, S. and Shao, J. (2014), "Organizational enablers for governance and governmentality of projects: A literature review", *International Journal of Project Management*, Vol. 32 No. 8, pp. 1309-1320.

Munns, A. K. and Bjeirmi, B. F. (1996), "The role of project management in achieving project success", *International Journal of Project Management*, Vol. 14 No. 2, pp. 81-7.

Muspratt, M. A. (1988), "HiTech for construction project", *Computers in Industry*, Vol. 10 No. 3, pp. 197-208.

Muya, M., Kaliba, C., Sichombo, B. and Shakantu, W. (2013), "Cost escalation, schedule overruns and quality shortfalls on construction projects: The case of Zambia", *International Journal of Construction Management*, Vol. 13 No. 1, pp. 53-68.

Mydin, M. O., Sani, N. M., Taib, M., Alias, N. M. (2014), "Imperative causes of delays in construction projects from developers' outlook", *In MATEC Web of Conferences*, Vol. 10, p. 06005.

Næss, P. (2004), "Prediction, Regressions and Critical Realism", *Journal of Critical Realism*, Vol. 2 No. 2, pp. 133-164.

Naoum, S.G., (1994), "Critical analysis of time and cost of management and traditional contracts", *Journal of Construction Engineering and Management*, Vol. 120 No. 4, pp. 687-705.

Nastasi, B. K., Hitchocock, J. H. and Brown, L. M. (2010), "An inclusive framework for conceptualizing mixed methods typologies", in: Tashakkori, A. and Teddlie, C. (eds.), *The Sage Handbook of Mixed Methods in Social and Behavioural Research* (2nd ed.), Sage, CA.

Neville, C. (2007), *Introduction to research and research methods*, Bradford University School of Management, Bradford.

Ng, T. S., Mak, M. M., Martin Skitmore, R., Lam, K. C. and Varnam, M. (2001), "The predictive ability of Bromilow's time–cost model", *Construction Management & Economics*, Vol. 19 No. 2, pp. 165-173.

Nkado, R. (1995), "Construction time-influencing factors: the contractor's perspective", *Construction Management and Economics*, Vol. 13 No. 1, pp. 81-89.

Norwegian Agency for Development Cooperation – NORAD (1999), *The Logical Framework Approach, Handbook for objectives-oriented planning*, NORAD, Norway.

Nyoni, T. and Bonga, W. G. (2017), "Towards Factors Affecting Delays in Construction Projects: A Case of Zimbabwe", *Dynamic Research Journals - Journal of Economics and Finance*, Vol. 2 No. 1, pp. 12-28.

Odeh, A. M. and Battaineh, H. T. (2002), "Causes of construction delay: Traditional contracts", *International Journal of Project Management,* Vol 20 No. 1, pp. 6773.

Odeyinka, H. A. and Yusif, A. (1997), "The causes and effects of construction delays on completion cost of housing project in Nigeria", *Journal of Financial Management of Property and Construction*, Vol. 2 No. 3, pp. 3144.

OECD (2002), *Glossary of key terms in evaluation and results based management*, OECD, Paris.

Ogunlana, S. O., Promkuntong, K. and Jearkjirm, V. (1996), "Construction delays in a fast-growing economy: comparing Thailand with other economies", *International Journal of Project Management*, Vol. 14 No. 1, pp. 3745.

Okpala, D. and Aniekwu, A. (1988), "Causes of high costs of construction in Nigeria", *Journal of Construction Engineering and Management*, Vol. 114 No. 2, pp. 233-244.

Olsson, N. O. (2006), "Management of flexibility in projects", *International Journal of Project Management*, Vol. 24 No. 1, pp. 66-74.

Omoregie, A. and Radford, D. (2006), "Infrastructure delays and cost escalation: Causes and effects in Nigeria", *In Proceedings of the 6th International Postgraduate Research Conference in the Built and Human Environment,* International Council for Research and Innovation in Building and Construction.

Oppenheim, A. N. (2000), *Questionnaire Design, Interviewing and Attitude Measurement*, Continuum International, London.

Oshungade, O. O. and Kruger D. (2017), “A comparative study of causes and effects of project delays and disruptions in construction projects in the South African construction industry”, *Journal of Construction Engineering and Project Management*, Vol. 7 No. 1, pp. 13-25.

Øxnevad, K. I. (2000), “The NPDT – The Next Generation Concurrent Design Approach”, EUSEC 2000, 2nd European Systems Engineering Conference, Munich, Germany.

Pacheco, D. A. D. J., Pergher, I., Jung, C. F. and Scwenberg ten Cate, C. (2014), “Strategies for increasing productivity in production systems”, *Independent Journal of Management and Production*, Vol. 5 No. 2, pp. 344-359.

Patel, M. and Morris, P. W. G. (1999), *Guide to the project management body of knowledge*, University of Manchester, Centre for research in the management projects, UK.

Patton, M. Q. (1997), *Utilization-focused evaluation: the new century text*, Sage Publications, Thousand Oaks, London.

Patton, M. Q. (2002), *Qualitative evaluation and research methods* (3rd eds), Sage Publications Inc., Thousand Oaks, CA.

Pelhalm, B. W. and Blanton, H. (2006), *Conducting research in psychology: measuring the weight of smoke*, Wadsworth Publishing Company, UK.

Pellegrinelli, S. (2011), “What’s in a name: Project or programme?”, *International Journal of Project Management*, Vol. 29 No. 2, pp. 232-240.

Pemsel, S., Wiewiora, A., Müller, R., Aubry, M. and Brown, K. (2014), “A conceptualization of knowledge governance in project-based organizations”, *International Journal of Project Management*, Vol. 32 No. 8, pp. 1411-1422.

Peng, K. and Nisbett, R. E. (1999), “Culture, dialectics, and reasoning about contradiction”, *American Psychologist*, Vol. 54 No. 9, pp.741–754.

Petticrew, M. (2001), “Systematic reviews from astronomy to zoology: Myths and misconceptions”, *British Medical Journal*, Vol. 322 No. 7278, pp. 98-101.

Physics Classroom, (2016), “1-D Kinematics”, available at: http://www.physicsclassroom.com/class/1DKin/Lesson-1/Scalars-and-Vectors (accessed 30 March 2017).

Pinsonneault, A. and Kraemer, K. L. (1993), “Survey research methodology in management information systems: an assessment”, *Journal of management information systems*, Vol. 10 No. 2, pp. 75-105.

Pinto, J. K. (2007), *Project Management: Achieving Competitive Advantage*, Pearson Prentice Hall, Upper Saddle River, NJ, USA:

Pinto, J. K. (2013), “Lies, damned lies, and project plans: Recurring human errors that can ruin the project planning process”, *Business Horizons*, Vol. 56 No. 5, pp. 643-653.

Pinto, J. K. and Slevin, D.P. (1988), “Critical success factors across the project life cycle”, *Project Management Journal*, Vol. 19 No. 3, pp. 67-74.

Porter, M. E. (2008), *On Competition*, Harvard Business School Press, Boston.

Pourrostam, T. and Ismail, A. (2011), “Significant factors causing and effects of delay in Iranian construction projects”, *Australian Journal of Basic and Applied Sciences*, Vol. 5 No. 7, pp. 450-456.

Pourrostam, T. and Ismail, A. (2012), “Causes and effects of delay in Iranian construction projects”, *International Journal of Engineering and Technology*, Vol 4 No 5, pp. 598-601.

Prasad, B. (1996), *Concurrent Engineering Fundamentals: Integrated Products and Process Organization*, Prentice Hall, NJ.

Pristker, A. A. B., & Happ, W. W. (1966). GERT: graphical evaluation and review techniques, Part I (Fundamentals). Journal of Industrial Engineering, 17(5), 267-274.

Pritsker, A. A. B. (1966), "GERT: Graphical Evaluation and Review Technique", *The Rand Corporation*, available at: http://www.rand.org/pubs/research_memoranda/RM4973

Project Management Institute – PMI (2013), *A Guide to Project Management Body of Knowledge (PMBOK® GUIDE)*, (5th Ed.), Newtown Square, PA, USA.

Prosjektnorge (2014), "SpeedUp", available at: http://www.prosjektnorge.no/index.php?subsite=speedup

Rahman, M. D., Lee, Y. D. and Ha, D. K. (2014), "Investigating Main Causes for Schedule Delay in Construction Projects in Bangladesh", *Journal of Construction Engineering and Project Management*, Vol. 4 No. 3, pp. 33-46.

Rahsid, Y., Haq, S. and Aslam, M. (2013), "Causes of delay in construction projects of Punjab–Pakistan: an empirical study", *Journal of Basic and Applied Scientific Research*, Vol. 3 No. 10, pp. 87-96.

Raimond, P. (1993), *Management Projects*, Chapman Hall, London.

Ramanathan, C., Narayanan, S. P. and Idrus, A. B. (2012), "Construction delays causing risks on time and cost - A critical review", *Australasian Journal of Construction Economics and Building*, Vol. 12 No. 1, pp. 37-57.

Rämö, H. (1999), "An aristotelian human time-space manifold: from chronochora to kairotopos", *Time and Society*, Vol. 8 No. 2, pp. 309-328.

Rämö, H. (2000), "Ancient ideas in a new setting. Chronos, kairos, chora, and topos in a post-industrialized world", *In: Soulsby M, Fraser JT, editors. Time. Perspectives at the millennium*, Bergin & Garvey, Westport.

Rämö, H. (2002), "Doing things right and doing the right things Time and timing in projects", *International Journal of Project Management*, Vol. 20 No. 7, pp. 569-574.

Reich, B. (2015), "Considering Case studies in Project Management", in Pasian, B. (Ed.), *Designs, Methods and Practices for Research of Project Management*, Gower Publishing, Ltd., pp. 203-209

Reinertsen, D. G. and Smith, P. G. (1991), "The strategist´s role in shortening product development", *The Journal of Business Strategy*, Vol. 12 No. 4, pp. 18-22.

Ren, Z., Atout, M. and Jones, J. (2008), "Root causes of construction project delays in Dubai", *in Dainty, A. (Ed) Procs 24th Annual ARCOM Conference,, 1-3 September 2008, Cardiff, UK,* Association of Researchers in Construction Management, Cardiff, UK, pp. 749-757.

Rich, N. and Hines, P. (1997), "Supply-chain management and time-based competition: the role of the supplier association", *International Journal of Physical Distribution & Logistics Management*, Vol. 27 No. 3/4, pp. 210-225.

Robinson, D. and Reed, V. (1998), *The A – Z of social research jargon*. Ashgate, Aldershot.

Robson, C. (2011), *Real World Research: A resource for Users of Social Research Methods in Applied Settings* (3rd eds). John Willey, Chi Chester.

Rogers, C. R. (1961), *On Becoming a Person*, Constable, London.

Rolstadås, A. (2008). *Applied Project Management*, Tapir Academic Press, Trondheim.

Rong Chang, B., Tsai, H. F., Chen, C. M. and Huang, C. F. (2014), "Analysis of virtualized cloud server together with shared storage and estimation of consolidation ratio and TCO/ROI", *Engineering Computations*, Vol. 31 No. 8, pp. 1746-1760.

Rosendahl, T., Egir, A. and Rolland, E. (2013), "How to Implement Multidisciplinary Work Processes in the Oil Industry; A Statoil Case", In *Integrated Operations in the Oil and Gas Industry: Sustainability and Capability Development* (pp. 155-170), IGI Global, Hershey, PA.

Rossman, G. B. and Rallis, S. F. (2003), "Everyday ethics: reflections on practice", *International Journal of Qualitative Studies in Education*, Vol. 23 No. 4, pp. 379-391.

Rowley, J. (2002), "Using case studies in research", *Management Research News*, Vol. 25 No. 1, pp. 16-27.

Ruijtenbeek, R., Buijs, C., Kolet, F., van Atten, J. and Stolwijk, H. (2013), "Halftime-An Ambitious Goal!", In *IABSE Symposium Report*, Vol. 99 No. 15, pp. 1121-1128.

Ruqaishi, M., Bashir, H. A. (2013), "Causes of delay in construction projects in the oil and gas industry in the gulf cooperation council countries: a case study", *Journal of Management in Engineering*, Vol. 31 No. 3, pp. 05014017.

Saeb, S., Khayat, N. and Telvari, A. (2016), "Causes of delay in Khuzestan steel company construction projects", *Industrial Engineering & Management Systems*, Vol. 15 No. 4, pp. 335-344.

Sager, T. (1994), *Communicative Planning Theory*, Ashgate Publishing Company, Brookfield, Vermont.

Salant, P. and Dillman, D.A. (1994), *How to conduct your own survey*, Wiley & Sons, New York, NJ.

Sambasivan, M. and Soon, Y. W. (2007), "Causes and effects of delays in Malaysian construction industry", *International Journal of Project Management*, Vol. 25 No. 5, pp. 517-526.

Samset, K. F. (2003), *Project evaluation – Making investment succeed*, Tapir Academic Press, Trondheim.

Samset, K. F. (2010), *Early project appraisal: making the initial choices*, Palgrave Macmillan, Basingstoke.

Santoso, D. S., Soeng, S. (2016), "Analyzing delays of road construction projects in Cambodia: Causes and effects", *Journal of Management in Engineering*, Vol. 32 No. 6, pp. 05016020.

Sarhan, S. and Fox, A. (2013), "Performance measurement in the UK construction industry and its role in supporting the application of lean construction concepts", *Australasian Journal of Construction Economics and Building*, Vol. 13 No. 1, pp. 23-35.

Sarkar, S. (2012), "Transition from Critical Path to Critical Chain: A Case Research Analysis", *International Journal of Scientific and Engineering Research,* Vol. 3 No. 9, pp. 1-10.

Saunders, M. N. K., Lewis, P. and Thornhill, A. (2012), *Research methods for business students*, Pearson, Harlow.

Sauser, B. J., Reilly, R. R. and Shenhar, A. J. (2009), "Why projects fail? How contingency theory can provide new insights–A comparative analysis of NASA's Mars Climate Orbiter loss", *International Journal of Project Management*, Vol. 27 No. 7, pp. 665-679.

Sayer, A. (1992), *Method in Social Sciences: A realist approach* (2nd edition). Routledge, London, UK.

Scheuren, F. (2004), What is a survey? Alexandria, VA: American Statistical Association.

Schmelzer, H. J. (1992), *Organisation und Controlling von Produktentwicklungen: Praxis des wettbewerbsorientierten Entwicklungsmanagement*, Schäffer-Poeschel.

Scriven, M. (1991), *Evaluation thesaurus*, Sage Publications, Newbury Park, California.

Seawright, J. and Gerring, J. (2013), "Case selection techniques in case study research: A menu of qualitative and quantitative options", *Political Research Quarterly*, Vol. 61 No. 2, pp. 294–308.

Seboru, M. A. (2015), "An investigation into factors causing delays in road construction projects in Kenya", *American Journal of Civil Engineering*, Vol. 3 No. 3, pp. 51-63.

Sepasgozar, S. M., Razkenari, M.A. and Barati, K. (2015), "The importance of new technology for delay mitigation in construction projects", *American Journal of Civil Engineering and Architecture*, Vol. 3 No. 1, pp. 15-20.

Serrat, O. (2009), "Understanding complexity", *Knowledge Solutions*, Vol. 66 No. 1, pp. 1-8.

Shebob, A., Dawood, N., Xu, Q. (2011), "Analysing construction delay factors: a case study of building construction project in Libya", in *Egbu, C. and Lou, E.C.W. (Eds), Procs 27th Annual ARCOM Conference, Association of Researchers in Construction Management,* Bristol, pp. 1005-1012.

Shenhar, A. J. and Dvir, D. (2007), *Reinventing project management: the diamond approach to successful growth and innovation*, Harvard Business Review Press, Boston, US.

Shenhar, A., Levy, O. and Dvir, D. (1997), "Mapping the dimensions of project success", Project *Management Journal*, Vol. 28 No. 2, pp. 5-13.

Shi, J., Cheung, S. and Arditi, D. (2001), "Construction delay computation method", *Journal of Construction Engineering and Management*, Vol. 127 No. 1, pp. 60-65.

Sikka, S., Dawood, N., Marasini, R. and Dean, J. (2006), "Identification and development of key performance indicators to establish the value of 4D planning", In: *ARCOM Doctoral Workshop on Emerging Technologies in Construction*, School of the Built Environment, University of Salford.

Skarholt, K., Næsje, P., Hepsø, V. and Bye, A. B. (2009), "Integrated operations and leadership – How virtual cooperation influences leadership practice", In *Safety, Reliability and Risk Analysis: Theory, Methods and Applications*. Taylor & Francis Group.

Smith, J. E. (1969), "Time, Times, and The Right Time; "Chronos" and "Kairos"", *The Monist*, Vol. 53 No. 1, pp. 1-13.

Smyth, H. J. and Morris, P. W. (2007), "An epistemological evaluation of research into projects and their management: Methodological issues", *International Journal of Project Management*, Vol. 25 No. 4, pp. 423-436.

Söderlund, J. (2004), "Building theories of project management: Past research, questions for the future", *International Journal of Project Management*, Vol. 22 No. 3, pp. 183-191.

Songer, A. D. and Molenaar, K. R., (1997), "Project characteristics for successful public-sector design-build", *Journal of Construction Engineering and Management*, Vol. 123 No. 1, pp. 34-40.

Sonnemann, G. and Margni, M. (2015), *Life Cycle Management*, Springer Open, New York.

Sørensen, K. H. (2006), *Forskning of samfunn*, NTNU, Trondheim.

Ssegawa, J. K. and Muzinda, M. (2016), "Using RBM approach in managing projects beyond the development sector", *International Journal of Managing Projects in Business*, Vol. 9 No. 2, pp. 337-363.

Stalk G. Jr. and Hout T. M. (1990), *Competing Against Time: How Time-based Competition Is Reshaping Global Markets*, Free Press, New York.

Stalk G. Jr. and Hout T. M. (2003), *Competing Against Time: How Time-based Competition Is Reshaping Global Markets*, Free Press, New York.

Stark, J. (2015), *Product Lifecycle Management*, Springer International Publishing.

Stelth, P., Le Roy, G., Popov, A., Freinberg, S. L., Malais, J., Haegeman, H., Sharma, S. and Sharma, J. (2009), "Business Management and Economics Section", *School of Doctoral Studies European Union*, Vol. 9, pp. 9-46.

Stenbacka, C. (2001), "Qualitative research requires quality concepts of its own", *Management Decision*, Vol. 39 No. 7, pp. 551-555.

Stephenson, H. W. (2005), *Forecasting opportunity: Kairos, production, and writing*, University Press of America, Oxford.

Stevenson, A. (2010), *Oxford dictionary of English*, Oxford University Press, USA.

Strauss, A. and Corbin, J. (1998), *Basics of Qualitative Research* (2nd eds), Sage, Thousand Oaks, CA.

Stuckenbruck, L. C. (Ed.). (1981), *The implementation of project management: The professional's handbook* (Vol. 7260), Project Management Institute; Reading, Mass.: Addison-Wesley Publishing Company, Drexel Hill, PA.

Suchman, E. (1967), *Evaluative Research: Principles and Practice in Public Service and Social Action Programs*. Russell Sage Foundation, New York.

Suddaby, R. (2006), "What grounded theory is not", *Academy of Management Journal*, Vol. 49 No. 4, pp. 633-643.

Sun, M. and Meng, X. (2009), "Taxonomy for change causes and effects in construction projects", *International Journal of Project Management*, Vol. 27 No. 6, pp. 560-572.

Sweis, G. J. (2013), "Factors affecting time overruns in public construction projects: the case of Jordan", *International Journal of Business and Management*. Vol. 8 No. 23, pp. 120-129.

Sweis, G. J., Sweis, R., Abu Hammad, A. and Shboul, A. (2008), "Delays in construction projects: The case of Jordan", *International Journal of Project Management*, Vol. 26 No. 6, pp. 665-674.

Syed, A., Andy, G., Therese, L.-W., Richard, K., Ali, K. and Mehmood, A. (2010), "The importance of soft skills in complex projects", *International Journal of Managing Projects in Business*, Vol. 3 No. 3, pp. 387-401.

Tafazzoli, M. (2017), "Investigating Causes of Delay in U.S. Construction Projects", paper presented in the 53rd ASC Annual International Conference Proceedings. Associated Schools of Construction.

Takim, R. and Akintoye, A., (2002), "Performance indicators for successful construction project performance", *in: Proceeding of the 18th Annual ARCOM Conference*, University of North Umbria, pp. 545-555.

Talodhikar, M. H. and Pataskar, M. S. V. (2015), "Implementation of Line of Balance Method for Scheduling High-rise Building", *International Journal of Engineering Research and Applications*, Vol. 5 No. 3, pp. 09-12.

Tang, Y., Liu, R. and Sun, Q. (2014), "Schedule control model for linear projects based on linear scheduling method and constraint programming", *Automation in construction*, Vol. 37, pp. 22-37.

Tashakkori, A. and Teddlie, C. (2010), *The Sage Handbook of Mixed Methods in Social and Behavioural Research* (2nd ed.), Sage, CA.

Tawil, N. M., Khoiry, M. A., Arshad, I., Hamzah, N., Jasri, M. F., Badaruzzaman, W. H. (2013), "Factors contribute to delay project construction in higher learning education case study UKM", *Research Journal of Applied Sciences, Engineering and Technology*, Vol. 5 No. 11, pp. 3112-3116.

Teddlie, C. and Tashakkori, A. (2009), *Foundations of Mixed Methods Research: Integrating Quantitative and Qualitative Approaches in the Social and Behavioural Sciences*, Sage, CA.

Tesch, R. (1990), *Qualitative research: Analysis types and software tools,* Falmer, Bristol, PA.

Thamhain, H. J. andWilemon, D. L. (1986), "Criteria for controlling projects according to plan", *Project Management Journal*, Vol. 17 No. 2, pp. 75-81.

Thimm, G., Lee, S. G. and Ma, Y. S. (2006), "Towards unified modelling of product life-cycles", *Computers in Industry*, Vol. 57 No. 4, pp. 331-341.

Tighe, J. J. (1991), "Benefits of fast tracking are a myth", *International Journal of Project Management*, Vol. 9 No. 1, pp. 49-51.

Tishler, A., Dvir, D., Shenhar, A. J. and Lipovetsky, S. (1996), "Identifying critical success factors in defense development projects: a multivariate analysis", *Technological forecasting and social change*, Vol. 51 No. 2, pp. 151–71.

Tjora, A. H. (2012), *Kvalitative forskningsmetoder i praksis*, Gyldendal akademisk, Oslo.

Tong, M. and Thomson, C. (2015), "Developing a Critical Literature review for Project Management Research", in Pasian, B. (Ed.), *Designs, Methods and Practices for Research of Project Management*, Gower Publishing.

Toor, S. U. R. and Ogunlana, S. O. (2008), "Problems causing delays in major construction projects in Thailand", *Construction Management and Economics*, Vol. 26 No. 4, pp. 395-408.

Toor, S. U. R. and Ogunlana, S. O. (2010), "Beyond the 'iron triangle': Stakeholder perception of key performance indicators (KPIs) for large-scale public sector development projects", *International journal of project management*, Vol. 28 No. 3, pp. 228-236.

Tranfield, D., Denyer, D. and Smart, P. (2003), "Towards a methodology for developing evidence-informed management knowledge by means of systematic review", *British Journal of Management*, Vol. 14 No. 3, pp. 207–222.

Trauner, Jr. T. J., Manginelli, W. A., Lowe, J. S., Nagata, M. F. and Furniss, B. J. (2009), *Construction delays: understanding them clearly, analyzing them correctly*, Elsevier Butterworth-Heinemann, London, UK.

Tumi, S. A., Omran, A. and Pakir, A. H. (2009), "Causes of delay in construction industry in Libya", paper presented at the International Conference on Economics and Administration 4-15 November 2009, Faculty of Administration and Business, University of Bucharest, Romania.

UNEP/SETAC Life Cycle Initiative. (2011). Towards a Life Cycle Sustainability Assessment. Making informed choices on products. available at: http://www.lifecycleinitiative.org

United Nations Environment Programme UNEP (2007), "Life Cycle Management. A business guide to sustainability", available at: http://www.lifecycleinitiative.org.

United Nations Industrial Development Organization – UNIDO, Dasgupta, P., Marglin, S.A. and Sen, A. (1972), *Guidelines for project evaluation*, United Nations, New York.

United States Agency for International Development – USAID. (1979), *Practical Concepts Incorporated, The Logical Framework, A Manager's Guide to a Scientific Approach to Design and Evaluation*, Practical Concepts Incorporated, Washington DC.

United Way of America – UWA (1996), *Measuring program outcomes: A practical approach*, United Way of America, Arlington, VA.

University of Leeds, (2015), "Megaproject", http://www.mega-project.eu/

Van der Lei, T., Herder, P. and Wijnia, Y. (2012), *Asset management*, Springer, London.

Van Slyke, R. R. (1963), "Monte Carlo methods and the PERT problem", *Operations Research*, Vol. 11, pp. 839-860.

Voss, C. A., Chiesa, V. and Coughlan, P. (1987), *Just-in-time Manufacture*, Springer, Berlin.

Wainer, H. and Braun, H.I. (1988), *Test validity*, Lawrence Earlbaum Associates, Hilldale, NJ.

Wang, E. T., Ju, P. H., Jiang, J. J. and Klein, G. (2008), "The effects of change control and management review on software flexibility and project performance", *Information & Management*, Vol. 45 No. 7, pp. 438-443.

Wang, R. R. (2013), "Understanding of Yin Yang", *Religion Compass*, Vol. 7, pp. 214-224.

Watkins, D. C. (2012), "Qualitative research: The importance of conducting research that doesn't 'count'", *Health Promotion Practice*, Vol. 13 No. 2, pp. 153-158.

Watson, T. J. (2011), "Ethnography, reality, and truth: the vital need for studies of 'how things work'in organizations and management", *Journal of Management studies*, Vol. 48 No. 1, pp. 202-217.

Weisbrod, B. A. (1960), "Does better health pay?", *Public health reports*, Vol. 75 No. 6, pp. 557-560.

Weiss, C. H. (1972), *Evaluation research*, Prentice-Hall, Englewood Cliffs, NJ.

Whipp, R. A. (1994), "time to be concerned: a position paper on time and management", *Time & Society*, Vol. 3 No. 1, pp. 99-116.

Whitty, S. J. and Maylor, H. (2009), "And then came Complex Project Management (revised)", *International Journal of Project Management*, Vol. 27 No. 3, pp. 304-310.

Wideman, R. (2004), "The role of the project life cycle (life span) in project management", *AEW Services*, Vancouver, BC. Available at: http://www.maxwideman.com

Williams, T. M. (1999), "The need for new paradigms for complex projects", *International journal of project management*, Vol. 17 No. 5, pp. 269-273.

Wilson, J. M. (2003), "Gantt charts: A centenary appreciation", *European Journal of Operational Research*, Vol. 149 No. 2, pp. 430-437.

Winner, R. I., Pennell, J. P., Bertrend, H. E. and Slusarczuk, M. M. G. (1988), "The Role of Concurrent Engineering in Weapons System Acquisition", IDA Report R-338, Institute for Defense Analyses, Alexandria, VA.

Winter, G. (2000), "A comparative discussion of the notion of validity in qualitative and quantitative research", *The Qualitative Report*, Vol. 4 No.3.

Witherspoon, G. (1977), *Language and art in the Navajo universe*, University of Michigan Press, Michigan.

Wolk, A., Dholakia, A. and Kreitz, K. (2009), *Building a Performance Measurement System: A How-to Guide*, Rootcause, USA.

Wong, K. and Vimonsatit, V. (2012), "A study of the factors affecting construction time in Western Australia", *Scientific Research and Essays*, Vol. 7 No. 40, pp. 3390-3398.

Wong, P. S. P. and Wong, S. K. (2014), "To learn or not to learn from project monitoring feedback: In search of explanations for the contractor's dichromatic responses", *International Journal of Project Management*, Vol. 32 No. 4, pp. 676-686.

Wong, P.S.P. and Cheung, S.O. (2008), "An analysis of the relationship between learning behaviour and performance improvement of contracting organizations", *International Journal of Project Management*, Vol. 26 No. 2, pp. 112–123.

Worsley, T. (2015), Ex-post assessment of transport investments and policy interventions: Prerequisites for ex-post assessments and methodological challenges. Summary and conclusions of the roundtable. International Transport Forum Discussion Paper.

Wu, C. H., Hsieh, T. Y. and Cheng, W. L. (2005), "Statistical analysis of causes for design change in highway construction on Taiwan", *International journal of project management*, Vol. 23 No. 7, pp. 554-563.

Yaghootkar, K. and Gil, N. (2012), "The effects of schedule-driven project management in multi-project environments", *International Journal of Project Management*, Vol. 30 No. 1, pp. 127-140.

Yalaoui, A., Chehade, H., Yalaoui, F. and Amodeo, L. (2012), *Optimization of logistics*, John Wiley & Sons, NJ.

Yamin, M. and Sim, A. K. (2016), "Critical success factors for international development projects in Maldives: Project teams' perspective", *International Journal of Managing Projects in Business*, Vol. 9 No. 3, pp. 481-504.

Yang, J. B. and Wei, P. (2010), "Causes of delay in the planning and design phases for construction projects", *Journal of Architectural Engineering*, Vol. 16 No. 2, pp. 80-83.

Yang, J. B., Chu, M.Y. and Huang, K. M. (2013), "An empirical study of schedule delay causes based on Taiwan's litigation cases", *Project Management Journal*, Vol. 44 No. 3, pp. 21-31.

Yang, J. B., Yang, C. C. and Kao, C. K. (2010), "Evaluating schedule delay causes for private participating public construction works under the Build-Operate-Transfer model", *International Journal of Project Management*, Vol. 28 No. 6, pp. 569-579.

Yin, R. K. (2013). *Case study research: Design and methods* (5th ed.), Sage publications, London.

Youker, R. (1989), "Managing the project cycle for time, cost and quality: lessons from World Bank experience", *International Journal of Project Management*, Vol. 7 No. 1, pp. 52-57.

Zaneldin, E. K. (2006), "Construction claims in United Arab Emirates: Types, causes, and frequency", *International Journal of Project Management*, Vol. 24 No. 5, pp. 453-459.

Zeng, J., An, M., and Smith, N. J. (2007), "Application of a fuzzy based decision making methodology to construction project risk assessment", *International journal of project management*, Vol 25 No. 6, pp. 589-600.

Zerubavel, E. (1979), *Patterns of time in hospital life: a sociological perspective*, University of Chicago Press, Chicago.

Zewdu, Z. T. (2016), "Construction Projects Delay and Their Antidotes: The Case of Ethiopian Construction Sector", *International Journal of Business and Economics Research*, Vol. 5 No. 4, pp. 113-122.

Zhang, L., Lee, K. O., Zhang, Z. and Banerjee, P. (2003), "Critical success factors of enterprise resource planning systems implementation success in China", *In: Proceedings of the 36th Hawaii international conference on systems sciences.*

Zhou, L., Xie, J., Gu, X., Lin, Y., Ieromonachou, P. and Zhang, X. (2016), "Forecasting return of used products for remanufacturing using Graphical Evaluation and Review Technique (GERT)", *International Journal of Production Economics*, Vol. 181 No. B, pp. 315-324.

Zidane, Y. J-T. and Olsson, N. O. (2017), "Project Efficiency, Effectiveness and Efficacy", *International Journal of Managing Projects in Business*, Vol. 10 No. 3, pp. 1-22.

Zidane, Y. J-T., Andersen, B., Johansen, A. and Ahmad, S. B. S. (2016a), "Need for speed: Framework for measuring construction project pace—case of road project", *Procedia—Social and Behavioral Sciences,* Vol. 226, pp. 12–19.

Zidane, Y. J-T., Ekambaram, A. and Johansen, A. (2012), "An overall framework for understanding changes in megaprojects – a Norwegian approach", paper presented at 26th IPMA World Congress, Crete, Greece.

Zidane, Y. J-T., Hussein, B. A., Gudmundsson, J. Ø. and Ekambaram, A. (2016b), "Categorization of organizational factors and their impact on project performance", *Procedia – Social and Behavioral Sciences*, Vol. 226, pp. 162-169.

Zidane, Y. J-T., Johansen, A. and Ekambaram, A. (2013), "Megaprojects-Challenges and Lessons Learned". *Procedia – Social and Behavioral Sciences*, Vol. 74, pp. 349-357.

Zidane, Y. J-T., Johansen, A. and Ekambaram, A. (2015a), "Project Evaluation Holistic Framework – Application on Megaproject Case", *Procedia Computer Science*, Vol. 64, pp. 409-416.

Zidane, Y. J-T., Johansen, A., Andersen, B. and Hoseini, E. (2015b), "Time-Thieves and Bottlenecks in the Norwegian Construction Projects", *Procedia Economics and Finance*, Vol. 21, pp. 486–493.

Zidane, Y. J-T., Johansen, A., Ekambaram, A. and Hald, L. C. (2015c), "When Stakeholders Shape Successes or Bring Failures -A Case Study of an Algerian Megaproject", *Procedia Computer Science*, vol. 64, pp. 844-851.

Zidane, Y. J-T., Johansen, A., Hussein, B. A. and Andersen, B. (2016c), "PESTOL – Framework for «Project Evaluation on Strategic, Tactical and Operational Levels»", *International Journal of Information System and Project Management*, Vol. 4 No. 3, pp. 25-41.

Zidane, Y. J-T., Rolstadås, A., Johansen, A., Ekambaram, A. and Sriram, P. K. (2015d), "«The fast and the fantastic»: Time-cost trade-offs in new product development vs. construction projects", in *Advances in production management systems* (Vol. 459), *IFIP Advances in Information and Communication Technology*, Springer International Publishing, Tokyo, Japan, pp. 589–597.

Zidane, Y. J-T., Stordal, K. B., Johansen, A. and Raalte, S. V. (2015e), "Barriers and Challenges in Employing of Concurrent Engineering within the Norwegian Construction Projects", *Procedia Economics and Finance*, Vol. 21, pp. 494–501.

Zidane, Y. J-T., Klakegg, O. J., Andersen, B. and Hussein, B. (2018), ""Superfast!" Managing the Urgent: Case Study of Telecommunications Infrastructure Project in Algeria", *International Journal of Managing Projects in Business*.

Zidane, Y. J-T. and Andersen, B. (2018), "Top Ten Universal Delay Factors in Construction Projects ", *International Journal of Managing Projects in Business*.

Zidane, Y. J-T. and Hussein, B. (2018), "Significant Factors Causing Delay in Telecommunication Projects in Algeria", *Working Paper*.

Zidane, Y. J-T. (2018), "Delay Factors in Road Construction Project – Case of an Algerian Highway Megaproject", Working Paper.

Zidane, Y. J-T. and Andersen, B. (2018), "Causes of Delay and their Cures in Major Norwegian Projects", *Journal of Modern Project Management*, Vol. 5 No. 3, pp. 80–91.