Stimulating Flexibility in Construction Project Management in terms of Planning & Decision-Making

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TU Delft

MSc Thesis Report

AT OSBORNE
CONSULTANTS & MANAGERS

Cover page: Construction site at Delft station,
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MSc. Thesis

Stimulating Flexibility in Construction Project Management in terms of Planning & Decision-Making

By

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in partial fulfillment of the requirements for the degree of

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in Construction Management and Engineering
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PREFACE

Hereby I would like to present to you the final results of my graduation research completed over the past seven months with which I shall conclude my journey as a master's student in track Construction Management & Engineering from the Delft University of Technology. On gaining experience as a Project Coordinator after pursuing Civil Engineering and following the MSc CME track advanced my interest in the field of Project Management. Throughout my studies, my curiosity grew towards various project management methodologies, most of which were conventional. I had an opportunity to learn about the PRINCE2 methodology in-depth during my internship at AT Osborne. During this time, I decided to explore newer project management methodologies and consider it as a potential topic for my graduation research. That was the starting point of my research, which first began from agile project management and gradually shifted to flexible project management.

Over the past half-year, I have dived into the subject of flexible project management, its implicit applicability and newness in the construction industry and the challenges faced in its implementation. A deep dive, which I have come to enjoy in the process and learn from it. Besides the relevance of the subject, it was a real privilege to appear in conversations with practitioners and listen to their experiences in managing complex projects, a large part of this is due to my team of supervisors. This research would not have been possible without them. Firstly, heartfelt gratitude to my company supervisor Erik Dijkman, who always believed in me and motivated me to improve my work throughout the process. Thank you for always taking out extensive time for me from your extremely busy schedule to discuss the topic, the findings and brainstorm about the next steps. I enjoyed working with you. Special thanks to Afshin Jalai Sohi for his time and dedication for guiding me throughout this research whenever needed. Sincere thanks to Dr. John Heintz for your encouraging views on my research and providing constructive and comprehensive feedback, that surely inspired me. It was always clarifying to talk to you. Many thanks to Prof. Dr. Hans Bakker for your precise comments and clear notes on my research findings and report. It tremendously helped me improve my thesis. I am very grateful for all your support.

Furthermore, I want to thank all the interviewees for collaborating in my research as well as the people at AT Osborne who were always open to discuss the aspects of research, especially Geertje van Engen who always brainstormed with me about my research findings and was always available for any doubts at any given time. It was surely valuable, and it was wonderful working at AT Osborne!

On a personal note, I would like to thank my mom, dad and my sister Anuja, for their unconditional love and support throughout my thesis. A profound thanks to Aditya for encouraging and supporting me throughout the graduation process right from the day I began. Discussing every single thing about my thesis with you was always fun. Finally, thanks to all my friends who provided their valuable support for me, directly or indirectly, during this graduation research!

Hope you enjoy reading this thesis!

Madhura Surve

Delft, August 2020

EXECUTIVE SUMMARY

Project Management or the traditional approach of project management as we know it today, has seen rapid development, evolving from the well-known Gantt charts, CPM and PERT to modern methods like PRINCE2. Despite these developments and the available tools and techniques, there are several limitations to this approach. Due to which it has been increasingly argued that traditional project management is unable to fully cope with the growing complexities and changing dynamics of the projects in today's environment. As a result, the emphasis was laid on developing practices that are flexible in nature to adapt according to the project requirements. This led to the development of flexible practices like agile that had a widespread application and gained rapid success in industries like software and manufacturing. However, because of the rigid and traditional nature of construction industry, the application and development of flexible practices in this field, both in literature and practice is very limited. This triggered the need to explore flexible project management practices in construction and overcome the difficulties experienced in implementing these practices in order to stimulate its implementation. On exploring the literature and gap in practice, the following problem statement was formulated:

"There is a lack of practical recommendations or information on how to add flexibility into the practice of project management in the construction industry and to overcome the barriers that occur in the process of implementing flexibility, in order to deal with the growing complexities and dynamics in projects."

Flexibility in project management being a broad concept, in this research it was decided to focus on flexibility in planning and decision-making, with the starting point being the five flexibility enablers from the PhD research by Jalali Sohi (2018). These five flexibility enablers are- iterative planning, iterative delivery, short feedback loops, late locking and continuous locking, which are categorized under the WHEN category *(planning and decision-making process)* of flexibility enablers. Keeping this as the base, the objective of the research was to facilitate the incorporation of these five flexibility enablers by investigating the barriers that occur in its implementation and providing recommendations to overcome them. To achieve this objective, the following main research question was formulated:

"How can flexibility in project management in terms of planning and decision-making (the WHEN category) in the construction industry be stimulated?"

One of the ways to stimulate a process is to understand how it is done, find the barriers in its implementation (process), try to overcome its barriers followed by implementing it again. Based on this idiosyncrasy, the answer to the main research question was substantiated with five sub-research questions.

With an aim to achieve the research objective and answer the research questions, qualitative research was performed in four phases. First, a literature review is conducted that lays the foundation for research. It defines and explains the concept of flexibility in project management and flexibility in terms of planning and decision-making. It explains the five flexibility enablers in detail and its implications in the construction industry. Further, it provides the list of barriers classified into five clusters (Lack of awareness/methodologies, change resistance, organizational behavior, management processes and miscellaneous) that occur in implementing the enablers, based on which a theoretical framework has been established.

In the second phase, using a case study methodology, four case studies from the infrastructure sector and healthcare real estate sector were performed, which were supplemented with document review and semi-structured interviews. This resulted in exploring if the five flexibility enablers are identified and implemented in the construction industry. It was observed that most of the practitioners were unable to identify some of the flexibility enablers. For the enablers that the practitioners recognized, certain methods were identified, viz., time-chainage diagram and integral planning for iterative planning, release management for iterative delivery, scrum and reflective meetings as short feedback loops. However, no specific methods were observed for implementing late locking and continuous locking.

Further, the case study also resulted in identifying several barriers that occurred in incorporating the enablers, which were compared with the theoretical framework. Here, it was observed that the occurrence of identified barriers is enabler-specific and not industry-specific. Following this a cross-case analysis was performed, the results of which show that the enablers of iterative planning and iterative delivery are identified and implemented by practitioners from infrastructure sector. In contrast, the enablers of late locking and continuous locking are identified and implemented by practitioners from healthcare real estate sector. The enabler short feedback loop was found to be recognized and incorporated in both these sectors with major applications in the former. Moreover, it resulted in identifying the most commonly occurring barriers in four cases, which were used in the next phase of the research. It was observed that eleven barriers occurred commonly, most of which occurred due to lack of awareness and lack of methodologies to incorporate these enablers in the construction sector and due to the resistance of team members to change and adopt flexible practices.

In the third phase of the research, a conceptual framework was developed, along with proposing suggestions from literature and that observed in practice to overcome the barriers in order to implement the flexibility enablers. In total, twelve suggestions were proposed that reflect on overcoming the identified barriers based on their classified clusters. In the final phase, the proposed framework and the suggestions were validated by the experts in the expert interviews for its applicability and workability. Following this, results were discussed, and conclusions were drawn, further providing with the recommendations and limitations of this research.

Based on the research findings, several conclusions were drawn. In the context of the construction industry, the five flexibility enablers are not well-established, as a result of which it lacks recognition and incorporation in practice. It lacks awareness of these enablers and fails to recognize its own flexible practices. Besides, the reluctancy of practitioners to shift from a rigid and traditional approach to a flexible approach further hampers its incorporation. Thus, it is important to create awareness by providing proper training so that the practitioners identify the enablers and acknowledge if they have used these enablers in their practice. In addition to this, there is no explicit application of flexibility enablers in the construction sector even when the practitioners felt the need to be flexible in their adopted project management methodologies. Hence, it is important to make the enablers explicit, which can be done by providing insights from other projects on implementing these enablers. Also, pilot tests can be conducted to verify the applicability of the enablers. Further, as the construction industry is not accustomed to applying the flexibility enablers in its practice, a sense of urgency in using these enablers needs to be created, and the practitioners must be encouraged to incorporate these enablers. The management should take the initiative to encourage the project teams to implement the flexibility enablers. Thus, creating awareness, providing insights and encouraging the project teams can stimulate the implementation of flexibility enablers, thereby stimulating flexibility in terms of planning and decision-making, as reflected in the validated proposed framework shown in the figure below.

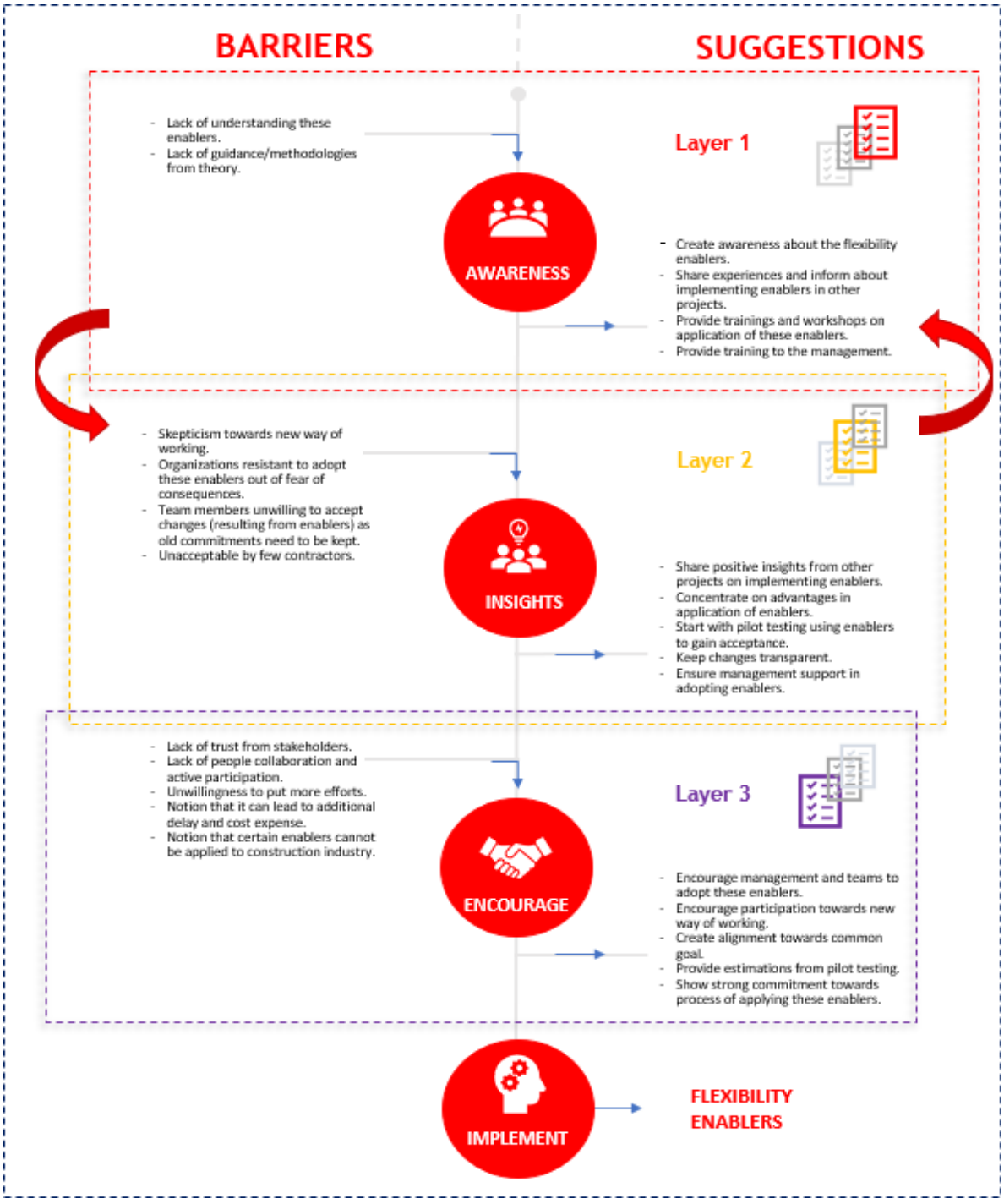


Figure 0.1: *AIEI Framework*

In addition to the suggestions for overcoming barriers and implementing the framework, the overall recommendations for the company and further research are to make explicit the already existing practices that resemble the flexibility enablers, and further investigate, develop and establish methods/techniques that can facilitate the implementation of flexibility in the context of the construction industry. This is also the limitation of the research as this research focused on providing recommendations to overcome barriers and not on developing new methods to incorporate the flexibility enablers.

Table of Contents

List of Abbreviations

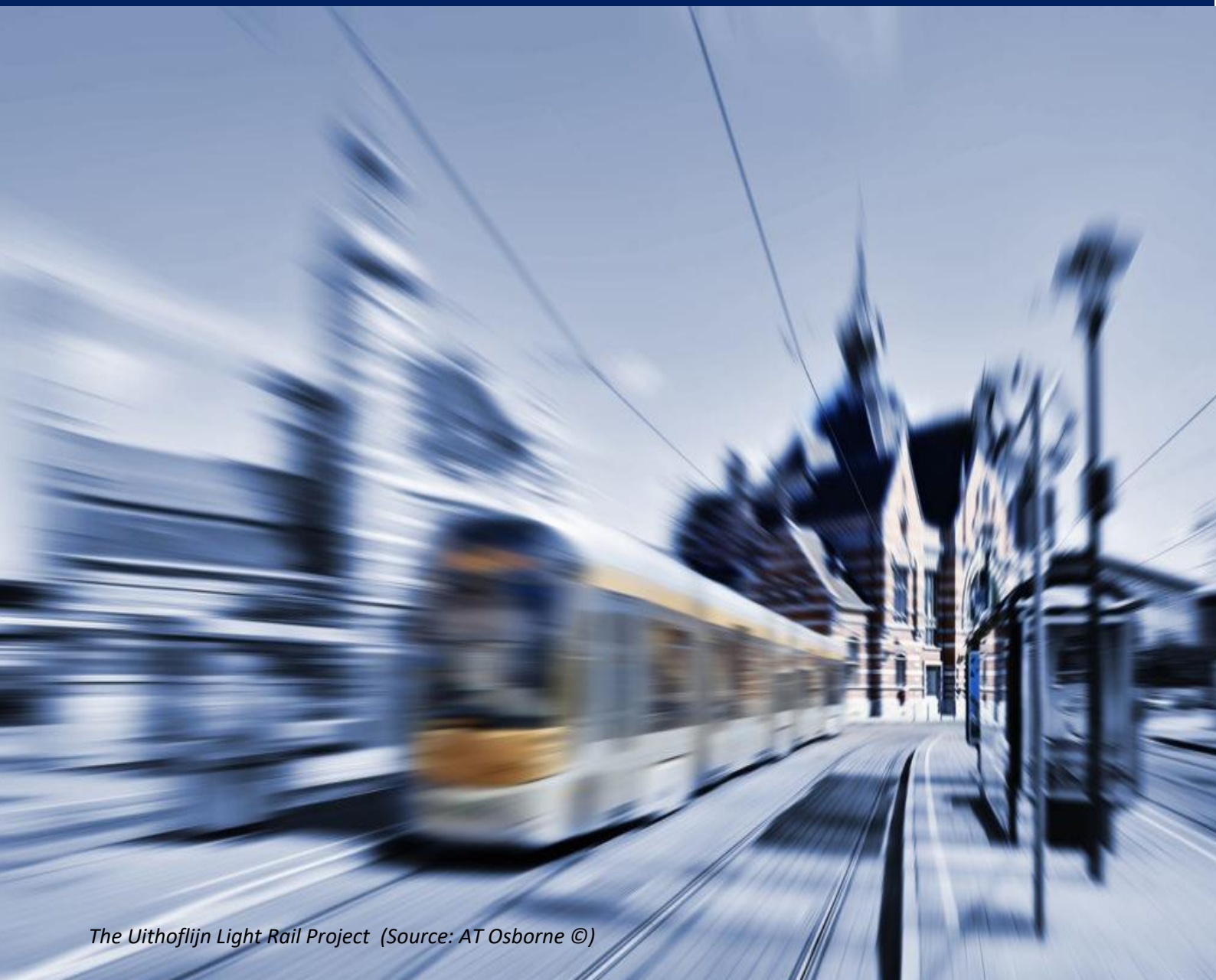
TPM- Traditional Project Management
WBS- Work Breakdown Structure
ASD- Adaptive Software Development
DB- Design Build
DBFM- Design Build Finance Maintain
EPC- Engineering Procurement Control
POUHL- Project Organization Uithoflijn
NSL- North South Line

List of Figures

List of Tables

1

Introduction



The Uithoflijn Light Rail Project (Source: AT Osborne ©)

Chapter 1: INTRODUCTION

The first chapter of the thesis illustrates an overall introduction to the research. It begins with explaining the research context, followed by the research gap and gap in practice, and further states the problem description. Following this, it contains the research questions, research objectives, the scientific relevance for research and the relevance for the company. It concludes with illustrating the structure of the research.

1.1. Research Context

There has been a continuous evolution in the definition of project management over the period of years as compared to its first definition applied in the context of modern project management in the early 1950s. There are several "standard" guidelines describing project management and project management tools to successfully manage a project (Nicholas & Steyn, 2017). These guidelines primarily focus on 'Traditional Project Management' methodologies as we know it today- a practice based on developing a set of techniques/ methodologies for managing projects in a sequential cycle: initiation, planning, execution, monitoring, controlling and closing (PMI, 2010). All these tools and techniques aim to achieve the project goals within the desired time, budget and quality (Atkinson, 1999). While most of the scholars like Baccarini & Collins (2004), Papke-Shields, Beise, & Jing (2010) and Wells (2012) have proven the success of the traditional project management methodologies in various industries like construction, manufacturing, software and many others, a few other scholars like Pollack (2007) and Gustavsson & Hallin (2014) argue that these methods are mainly control-focused (Eriksson, Larsson & Pesamaa, 2017) which attempt to eliminate or diminish the factors of uncertainty and complexity in a project (Koppenjan, Veeneman, Voort, & Leijten, 2011).

Projects today are often beset with heavy cost overruns and delays (Eriksson, Larsson, & Pesamaa, 2017; Flyvberg, 2011). Research has investigated various causes for these phenomena, most of which attributes towards growing complexities (Flyvberg, 2011), increasing uncertainties (Olsson, 2006) and changing dynamics (Bosch-Rekveldt, 2011) in the nature of the project and project environment. Despite the available tools and techniques for managing projects, for most of the projects the traditional methods seem to be insufficient in dealing with such complexities and uncertainties occurring during the project (Shenhar, 2014). Although these tools and techniques stand as a base and a formal establishment for traditional project management practices, there is now a need to shift from more control-focused practices to adaptable and flexibility-focused approaches (Geraldi et al., 2008) in order to cope with challenges faced by projects in today's environment. Even the project owners have felt an increasing desire to have leeway in order to adapt to changing requirements (Sun & Meng, 2009), which is quite limited in the traditional approach due to its linear process, disciplined planning and control methods. As a result, in the construction industry, more and more emphasis is laid on developing practices that would evolve to fit the complex projects and are more flexible to tackle the changing situations and dynamics of the projects (Jalali Sohi, 2018), thereby shifting towards flexible project management (Koppenjan, Veeneman, Voort, & Leijten, 2011).

Flexible project management or incorporating flexibility in project management is not a new concept (Olsson, 2006). Based on the literature review, it was observed that the term flexibility in project management was widely used in the early 1990s, references in literature then diminished until 2000s, but again flourished after the advent of newly emerging project management practices- like agile, in

the software industry after the year 2005. The term 'flexibility' has different meanings in different literature, but the most common definition summarises as "the capability to respond to changing requirements" (Lim, Ling, & Ofori, 2007). The software industry, manufacturing industry and production industry have seen widespread and successful use of flexible approaches (Jetter & Albar, 2015). However, it has seen a limited application in the construction industry (Jalali Sohi, 2018).

As flexible project management practices have conquered success in the software, manufacturing and production industries, it triggers an opportunity for exploring and developing its practices in the construction industry. Additionally, in order to encounter the changing demands and evolving nature of the construction industry, there is a need to introduce and facilitate the implementation of flexibility in the construction process, which is the essence of this thesis.

1.2. Research Gap

Flexibility being a vague concept, literature provides different definitions of flexibility. Different researchers have provided different perceptions of flexibility in various disciplines like manufacturing, management, information technology, business process, and software engineering (Nurdiani, Borstler, & Fricker, 2017). One of the pioneering researches in the field of flexibility was done by Sager (1990), who provided approaches for incorporating flexibility in planning to cope with the effects of uncertainty. Gallo & Gardiner (2007) identified environmental and internal elements that trigger the application of flexibility in project management. A few authors have quantified flexibility in projects in terms of monetary and financial approaches, like the real options (Brennan & Trigeorgis, 2000).

Literature also identifies the distinction between process flexibility and product flexibility which are two completely different aspects (Olsson, 2006). Importance was also given to adapting flexibility in decision-making process and decision theory (Mandelbaum & Buzacott, 1990), which should be first looked upon if we want to induce flexible management techniques (Sharfman & Dean, 1997). Miller & Lessard (2001) and Eskerod & Ostergren (2000) examined flexibility in hard factors, focusing on the models of late-locking and decision-gates. Research in inducing flexibility in various project phases gave an understanding that it is more valued in the front-end phases (Jalali Sohi, 2018) than in the execution phases (Loch & Sommer, 2019). With the advent of newly emerging project management methodologies like agile, which is so far proven to be one of the most flexible project management methodologies (Rico, 2008), the focus shifted to implementing flexibility in terms of agile project management. Studies have indicated the prospects, potentiality and need for implementation of flexible project management practices (Koppenjan, Veeneman, Voort, & Leijten, 2011), but the question of how flexibility is incorporated in practice is still left unanswered in the literature.

Efforts were made by Jalali Sohi (2018) to explore what makes project management flexible by identifying flexibility enablers and developing a flexibility framework. The identified enablers in his research were categorized into five areas, viz., What, How, Who, When and Where, with a total of 26 enablers. The research by Jalali Sohi (2018) and the list of 26 enablers is the starting point of this research. However, his research does not test the application of its identified enablers in practice in the construction industry. His research as well as other researches on flexible project management have not explored and identified the barriers that could occur in implementing flexibility enablers in the construction industry and have not provided any measures to overcome these barriers. Evidently, this has created a gap in the research on the implementation of flexible approaches, which now needs to be addressed and acted upon.

1.3. Gap in practice

This research was conducted in a Dutch consultancy firm – AT Osborne in their Infrastructure and Healthcare real estate domain. AT Osborne is a multidisciplinary agency that works towards providing practical solutions to complex problems in the society, by focusing on issues affecting our living environment in the domains of infrastructure, healthcare, mobility, sustainable living environment, water, area development, legal and governance, social real estate, and offices and buildings. In order to acknowledge and investigate the status of flexibility in practice in the construction industry and also at AT Osborne, to find out what flexibility means and whether it has been implemented in the construction projects, six semi-structured exploratory interviews were conducted. The interviewees were six project managers and consultants from AT Osborne, involved in traditional project management practices, as there was no availability of project managers involved in flexible practices. These interviewees had a role as a project manager in complex projects like the North South Line, the High-Speed Line, HollandPTC, BV Cyclotron, and metro projects. An overview of the respondents is provided in the following table:

Respondent	Domain	Current Role/ Function	Work Experience	Educational Background
1	Infrastructure	Project Manager, Trainer & Coach	23 years	MSc Civil Engineering
2	Infrastructure	Program Director	25 years	MSc Strategy & Organization, BSc Civil Engineering & BSc Economics
3	Healthcare	Project Manager	17 years	MSc Real Estate & Housing
4	Infrastructure	Program Director	11 years	MSc Technology, Policy & Management
5	Healthcare	Project Manager & Project Leader	10 years	MSc Construction Management & Engineering
6	Healthcare	Project Manager	14 years	MSc Civil Engineering

Table 1.1: *Exploratory Interviewees Overview*

The interview protocol is listed in Appendix A1. The duration of each interview was between 40- 60 minutes. The interviewees were asked about the project management practices applied by them in various projects they are managing/ have managed, the difficulties they face in those practices and their views on flexible project management.

Based on the interview data analysis, it was observed that five out of six interviewees were mainly involved in traditional project management practices, while one was involved with moderate use of agile methodology, specifically Scrum. Four of them made use of PRINCE2 methodologies with traces of Sprint methods, while the remaining two did not make use of any specific methodology but preferred to club the good practices from different methodologies. All the interviewees specified that they have been facing difficulty in managing large projects successfully using traditional approaches. A few reasons stated by them were uncontrolled environments, the involvement of a large number of stakeholders, delays in decision, traditional methods focusing on hard aspects, current methods do not allow to adapt changes quickly, larger risks, and so on. Five out of six interviewees mentioned one similar reason to be the most important factor that they were unable to change their decisions and planning during a sudden change in scope or during meeting the deadline, the reason being pre-planned and locked decisions followed in traditional approach. One similar reason mentioned in the

interview by one of the project managers was: "*defensive nature of some of the project managers to adapt to flexibility and rigidly follow pre-defined procedures and plan of action*." According to interviewees the above-mentioned difficulties could be minimized or resolved if- "*there is certain level of flexibility in their planning and decision-making processes*".

As traditional practices didn't seem to cope with projects in today's environment, even these project managers felt the need to shift to flexible approaches. But when asked if they have induced any flexibility in the projects they manage(d), there was no positivity in their answers. According to them, they try to induce flexibility at organizational level and organize sprint meetings to monitor flexibility. From their responses, it was identified that the project managers were unaware of the aspects that could enable flexibility in the processes used to manage large and complex construction projects. Moreover, as a response to their previous statements of achieving certain level of flexibility in planning and decision-making, they were unaware of how it could be achieved in practice and hence felt the need to explore the same.

Next, the interviewees were asked to list the factors that hamper or cause hesitation for implementing flexible practices in construction project management. This included an increase in costs, lower acceptance by clients and contractors to deviate from pre-planned decisions and scope, probability of delay in the project and lack of understanding of flexible practices. Despite this, the project managers are inclined towards flexibility, since there is a lot of development from the time the project has started until the project ends. Today, due to increasing developments in technologies, there are often changes in scope and project requirements and it becomes essential for the project managers to make some alterations in their schedule and planning and even their decisions (Drury & O'Dwyer, 2012). As a result, the project managers now feel the need to adapt flexible practices instead of managing projects in a controlled, rigid fashion.

Thus, the exploratory interviews provided a need to research the topic of flexible approaches in the construction industry, especially flexibility in terms of planning and decision-making processes (as mentioned by the interviewees); and the challenges that occur in its application, which if can be overcome, can help implement flexibility in the construction projects.

1.4. Problem Statement

Even after many developments in project management tools and techniques, there is still a loophole in the traditional approaches, due to which it is no longer effective for managing projects in a dynamic environment (Spundak, 2014). As a result, there is a rising urge amongst the practitioners to implement flexible approaches in large complex projects for its successful completion (Priemus, Bosch-Rekveldt, & Giezen, 2013). Literature has addressed the need for inducing flexibility in construction project management, yet there is a limitation to the research done in this aspect. Moreover, there is a scarce availability of literature that provides an answer to the question of how flexibility can be induced in practice. Also, as seen from the exploratory interviews, there is a rising urge amongst the project managers who are inclined towards implementing flexible methods in their projects, but due to certain barriers they face difficulties in incorporating these practices as well as the enablers. With the limitation of literature on implementing flexibility within the context of the construction industry and its application in practice, there is now a need to fill this gap. Thus, the problem statement of this research is:

"There is a lack of practical recommendations or information on how to add flexibility into the practice of project management in the construction industry and to overcome the barriers that occur in the process of implementing flexibility, in order to deal with the growing complexities and dynamics in projects."

1.5. Starting Point of the Research

The starting point of this research, as mentioned previously is based on the PhD research by Jalali Sohi (2018), titled- 'Flexibility in project management Towards improving project performance', wherein the researcher has identified the enablers of flexibility. However, the applicability of these 26 enablers has so far not been explored and tested in practice. Also, the barriers and challenges that occur in the implementation of these enablers in practice have not been explored. As testing the applicability of all 26 enablers would be a too broad scope for this research, only a few enablers were selected based on the exploratory interviews to narrow down the research scope. It was thus identified from the exploratory interviews, that the most important factor the practitioners considered as a flaw in their currently applied project management approach was their limited ability to alter decisions and planning based on sudden requirements due to rigid decisions and prior planning due to the adopted traditional methodology. The practitioners felt the need to explore on flexibility in terms of planning and decision-making processes as mentioned previously in the exploratory interviews. On this basis, it was decided to narrow down the scope of research to testing the 5 enablers out of 26, that deal with the issue mentioned by the practitioners. Thus, the enabler category "WHEN" was chosen from the research of Jalali Sohi (2018), which deals with the ability to change the project schedule without influencing the final deadlines. The "WHEN" category comprises of 5 enablers: Iterative planning, Iterative delivery, Short feedback loops, Locking at the last responsible moment, Continuous locking.

This research will emphasize on flexibility in construction project management with a focus on the enablers responding to the process of planning and decision making. Based on the PhD research it is assumed that the five enablers of WHEN category incorporate flexibility in project management. This research will thus explore the applicability of the five enablers in practice by exploring the manner in which these are currently implemented in practice and the barriers that occur in its implementation, which was the limitation of the PhD research.

1.6. Research Objective

Based on the research context, research gap and gap in practice, the main objective of the thesis is formulated, which is:

"To contribute to the knowledge of flexible project management in the construction industry by identifying the flexibility enablers that can be incorporated, investigating the barriers and providing recommendations to overcome them, thereby facilitating the implementation of flexibility in project management."

1.7. Research Questions

In order to achieve the research objective, the following main research question is formulated:

How can flexibility in project management in terms of planning and decision-making (the WHEN category) in the construction industry be stimulated?

Subsequently, to support the main research question, the following sub-research questions are formulated:

SQ1: What is flexibility in project management?

SQ2: What is flexibility in terms of planning & decision-making and what are its enablers?

SQ3: How are these enablers currently implemented in practice?

SQ4: What are the barriers to incorporate these enablers?

SQ5: How can these barriers be overcome?

1.8. Scientific relevance

Following the section research context and research gap, the need for this research is highlighted in the literature by several researchers. Although flexibility in project management was introduced in literature a couple of years ago, its research in the field of the construction industry is still immature. Owing to the growing complexities and uncertainties in the project and project environment, a transition is needed from more rigid and control-focused towards more flexibility-focused managerial practices, that can aid in improving the project execution and thereby its performance (Shahu, Pundhir, & Ganapathy, 2012). However, there is very limited research describing the concept of flexibility in the construction industry and its translation to practice (Eriksson, Larsson, & Pesamaa, 2017). Moreover, there is no extensive research that spots the difficulty of its application in practice and provides recommendations to overcome the difficulties, thereby facilitating smooth implementation. It is believed that this research would make a significant contribution to strengthening the knowledge of flexibility in the construction industry, not alone theoretically, but also in practice. It will also fulfill one of the limitations mentioned in the PhD research of testing the applicability of identified flexibility enablers in practice. In addition to this, since the focus of this research is on flexibility in terms of planning and decision-making, it will nourish the knowledge of incorporating flexibility in project management through concepts like iterative planning, iterative delivery, short feedback loops, late locking and continuous locking, and further provide suggestions to improve its incorporation, which so far has not been touched upon in the construction industry.

1.9. Relevance for company (Practical relevance)

This research has been conducted in a Dutch consultancy firm- AT Osborne, in its infrastructure and healthcare real estate domains. AT Osborne has extensive experience in the field of project management, with major involvement in traditional practices. Due to the growing needs of flexible approaches in managing complex projects, they felt the need to explore the concept of flexibility. Firstly, this research will introduce the concept of flexibility in AT Osborne and provide the company with the

recognition of its own practices in flexible project management, which are being used implicitly. It will also provide the company with the enablers of flexibility in terms of planning and decision-making process, which in the exploratory interviews was identified as the concerned aspect in managing projects with the currently employed methodology. Furthermore, this research will also investigate the barriers in the application of flexibility enablers and provide recommendations to minimize them. Doing so would prevent the hesitation that the company might have to incorporate the enablers in practice, thereby encouraging the implementation of flexibility and its enablers. Most importantly, this research will enhance their practices and provide guidelines towards the development of their new strategy of Flexible and Adaptable project management in the year 2020 and beyond. This research would not only contribute towards practical implications of AT Osborne but also contribute widely to the knowledge of the construction industry in the direction of flexible project management.

1.10. Scope of Research

The term "flexibility" is being used in a multidisciplinary manner and has several concepts for several purposes. It is important to acknowledge the scope of the research and set the limitations in order to ensure that the main objective of this research has been achieved, which is focused on – 'Stimulating flexibility in construction project management in terms of project planning and decision-making.'

This research strictly focuses on defining flexibility in terms of process and not product as in the construction sector flexibility is identified in the management processes and not products, unlike the manufacturing industry. The research will emphasize on one of the many aspects of flexibility, which is flexibility in project planning and decision making, i.e. the 'WHEN' category of enablers. Further, it will deal with projects in the infrastructure and healthcare real-estate sector of the construction industry. As this research will be conducted in only one consultancy company- AT Osborne, the implications of the results will be based on the managerial practices with regards to the projects managed by this company alone.

1.11. Research Methodology

In this section, the research approach to answer the main research question is introduced. It is schematically represented in the following figure 1.1.

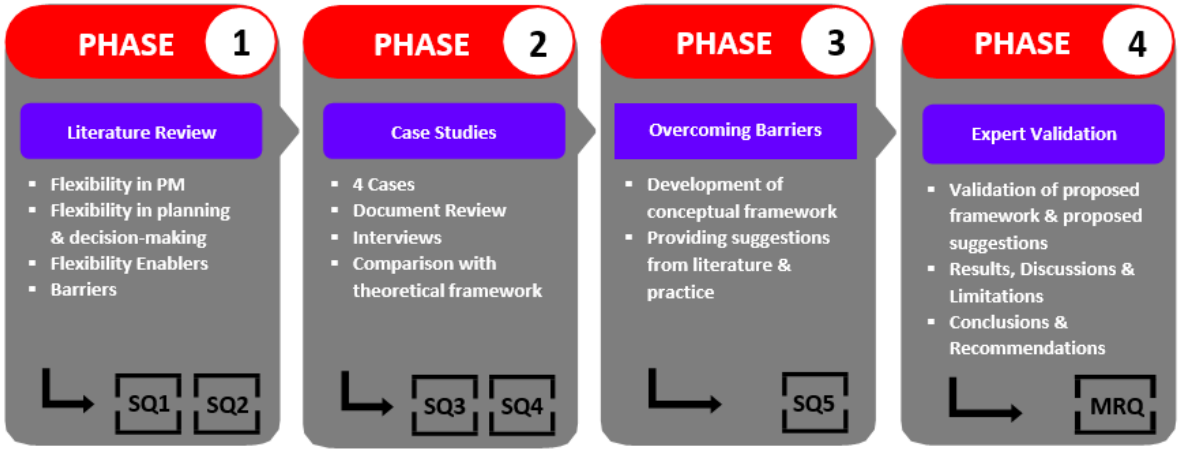


Figure 1.1: *Research Methodology*

The characteristic of this research is exploratory in nature, as could be seen from the formulation of the main research question which starts from 'How', as suggested by (Yin, 2014). The research has been conducted in four phases and follows a case study methodology.

The first phase, which is the starting point of the research is the literature review that lays the foundation of the research. The literature review focuses on the following aspects:

1. Defining the concept of flexibility in project management.
2. Defining the concept of flexibility in terms of project planning (and scheduling) and decision making.
3. The enablers that contribute towards achieving flexibility in terms of planning and decision-making.
4. The barriers in the incorporation of these enablers.

The literature review performed in the first step helps to answer sub-research question 1 of the research. With steps 2 and 3 of the literature review, sub-research question 2 has been answered. In step 4, the barriers in the incorporation of the five enablers have been identified from the literature, which theoretically addresses sub-research question 4. The first phase develops a better understanding of the research topic and research context.

The second phase of this research consists of a case study approach. The aim of this phase is to investigate whether the flexibility enablers are recognized by the practitioners and the ways in which the flexibility enablers are adopted in practice. This gives a clear understanding and provides a link between theory and practice on how flexible practices are currently being implemented in practice in the construction industry. A selection of four cases has provided with exposure to different project types. The case studies will additionally be complemented with interviews to gather a broader viewpoint of the professionals who are adopting flexible practices and their perspective on it. This phase includes the analysis of case studies and its results, which provides answers to sub research question 3. Subsequently, further complementing step 4 from phase 1, the second phase helps to identify the barriers in the implementation of flexibility enablers in practice, thereby answering the sub-research question 4.

The third phase consists of developing a conceptual framework and proposing suggestions to overcome the identified barriers based on the literature and that observed in practice. This phase provides an answer to sub-research question 5. The fourth and final phase of the research consists of expert validation of the proposed framework, followed by the validation of the recommended measures to overcome the identified barriers. It focuses on results followed by providing suggestions and general conclusions of the research, thereby answering the main research question. Moreover, the limitations of research have been provided, followed by the recommendations for the company and further research.

1.12. Research Outline

The thesis report consists of eight main chapters. The following figure illustrates the outline of the thesis report.

Figure 1.2: *Research Outline (Own illustration)*

2

Literature Review

With Project Manager at the HollandPTC Project (Source: AT Osborne ©)

Chapter 2: LITERATURE REVIEW

This chapter contains a literature review, forming the base for the current research. It has been performed in four sections. The first section highlights the topic of project management and recent developments in project management. The second section addresses the literature on flexibility in project management. The third section describes flexibility in terms of project planning and decision-making processes, and provides the factors enabling flexibility in the construction industry. Lastly, it contains a section on barriers in the incorporation of the flexibility enablers. The chapter corresponds to answering the sub-research questions 1 and 2 of this research. It also states what shall be explored further in this thesis.

2.1. Project Management & Recent Developments in Project Management

The term "Project Management" has been established in the 1950s and widely used, both in theory and in practice, in a variety of fields like business, software, construction, heavy-engineering and defense and many others. It entails a set of guidelines and principles on how a particular project can be managed. The Project Management Institute (2013) defined project management as *"the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements."* Several other knowledge bodies and institutes like APM, IPMA, ISO21500:2012 have described it in similar terms.

Project management has been evolving from the well-known Gantt Charts and mathematical project scheduling models like CPM and PERT to current modern project management methods like PRINCE2 and Agile, project management has vastly developed to adapt to the changing project requirements and the project environment (Morris, 2011). The following figure depicts the historical timeline of project management from its early 1910s to the latest practices used today:

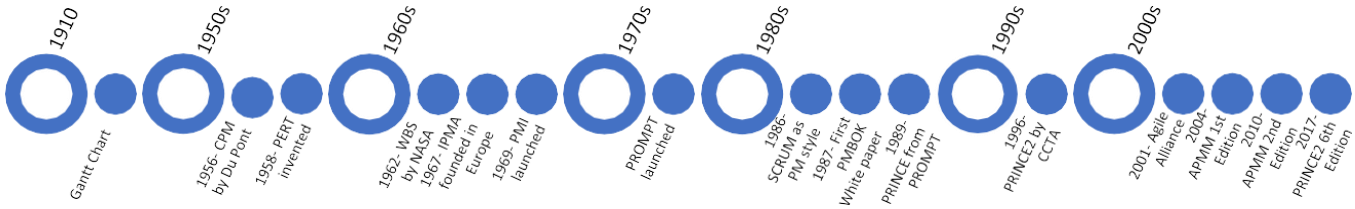


Figure 2.1: *Evolution of Project Management (Own illustration)*

The conventional or traditional project management (TPM), as we know it today, follows a linear and sequential cycle divided into a number of distinct phases, viz., initiation, planning, executing, controlling and monitoring, and closing. It is heavily dependent on tools like the Gantt chart, Work Breakdown Structure (WBS), CPM and PERT (Nicholas & Steyn, 2017). These tools aid in achieving the pre-determined constraints for project development, which are cost, time and quality, also known as the 'iron triangle.' The traditional approach is characterized by pre-planned activities and control methods, thereby focusing on extensive front-end planning (Koppenjan, Veeneman, Voort, & Leijten,

2011). Due to its deliberate planning and rigid control practices, it is also often referred to as "plan-driven" approach (Jalali & Wohlin, 2012) and "control-focus" approach (Karrbom-Gustavsson & Hallin, 2014). The key in this approach is that it assumes a project and its tasks to be sequential and predictable, considering it easier for preparing a detailed plan and following that plan without assuming any further changes in scope (Spundak, 2014; Collyer et al., 2010; Saynisch, 2010).

It is observed that projects in general, not alone in the construction industry, have shown a progressive rise in complexity and uncertainties, as it now consists of a higher number of tasks, more collaboration and sudden changes. These changes are certainly inevitable because of the unpredictable and dynamic changes within the project and the project environment (Wysocki, 2007; Eriksson, Larsson, & Pesamaa, 2017; Sun & Meng, 2009). Many authors argue that due to the linearity and hierarchy followed in the TPM, it does not adequately deal with all the complexities and dynamism in current projects and its project environment (Shahu, Pundir, & Ganapathy, 2012; Karrbom-Gustavsson & Hallin, 2014; Pollack, 2007). The limitations of this approach to manage complex and dynamic projects often besets these projects with heavy cost and time overruns, thereby leading to poor performance (Eriksson, Larsson, & Pesamaa, 2017; Collyer et al., 2010; Cantarelli, van Wee, Molin, & Flyvbjerg, 2012). The more complex a project grows the more changes eventuate in them and the more it becomes necessary to adopt a management style based on flexibility and collaboration and non-rigid practices. It is thus necessary for TPM methodology to switch from its rigid, control practices towards the practices having a more flexible approach, that embrace change and evolve in the direction of 'prepare and commit' approach, as stated in several literature (Bosch-Rekveldt, 2011; Geraldi, Maylor, & Williams, 2011; Koppenjan, Veeneman, Voort, & Leijten, 2011), which would be able to deal with the nature of today's projects.

Since the early 1990s, the research in the field of project management has argued that a paradigm shift is necessary from the TPM towards developing modern methods of project management. The established components of traditional methodology like the WBS, Gantt charts, organization, etc. are necessary building blocks for managing the projects in an organized manner. These tools shall always prevail. However, it is necessary to build upon the practices and processes of traditional methodology to adapt according to the project requirements, without affecting the project performance. The research in project management was then focused on developing methodologies which would prove to be more flexible in nature, which further led to the development of Agile project management methodology, with the creation of the Agile manifesto in the year 2001 (Manifesto for Agile Software Development, 2001), which is an umbrella term for methods focusing on iteration in planning, keeping decisions open, adapting according to project requirements than following pre-planned activities and most importantly, the methods that complement with embracing change and increased collaboration (Nwobodo-Anyadiegu & Tapuwanashe, 2018). Agile project management methodologies are so far proven to be the most flexible project management methodologies, which has seen its success in the software, production and manufacturing industries (Stare, 2013). However, its implementation in the construction industry is limited (Owen, Koskela, Henrich, & Codinhoto, 2006).

The construction industry being a traditional industry, the approach of flexible project management is still embryonic. A lot of research is being done in the direction of implementing flexible and agile practices into the construction industry and also developing the existing traditional practices, for example, updating the PRINCE2 (PRojects IN Controlled Environment) methodology to evolve more towards agile (Axelos, 2015). To summarize, there has been a wide development in project management, but in order to deal with a changing project environment, a change is essential- a change from the traditional approach towards a more flexible approach. The projects today thus call for 'flexibility in project management'- a theme which is explained in the next section.

2.2. What is Flexibility in Project Management?

The growing complexities in the projects demanded developments in project management in the direction of increasing flexibility. The need for flexibility in project management has been widely emphasized by not only the researchers but also the practitioners. As a result, several researchers have researched different aspects of flexibility and have set up different perspectives on flexibility that help enhance the current project management practices. This section will put forth the literature on different concepts of flexibility in various disciplines of project management.

Flexibility in project management is now seen to emerge as a response to the constantly changing environment, but flexibility in project management is not a new concept (Sushil, 2015). Different authors have provided different definitions of flexibility, few of which have been summarized in the table below:

Sr. No.	Definition of Flexibility	Focus/Domain	Reference
1	*"the capability to adjust the project to prospective consequences of uncertain circumstances within the context of the project."*	*General project management*	(Husby, 1999)
2	*"degree to which an organization possesses a variety of actual and potential procedures, and the rapidity by which it can implement these procedures, in order to increase the control capability of the management and improve the controllability of the organization and the environment"*	*Organizational*	(Leeuw & Volberda, 1996)
3	*"ability to respond effectively and efficiently to changing circumstances"*	*Process*	(Schmenner & Tatikonda, 2005)
4	*"an absorber of environmental uncertainty and variability"*	*Operations*	(Paslwaski & Karlowski, 2016)
5	*"ability to change or react with little penalty in time, effort, cost, or performance"*	*General project management*	(Sushil, 2015)
6	*"capability to implement changes in the business process type and instances by changing only those parts that need to be changed and keeping other parts stable"*	*Business Process*	(Regev & Schmidt, 2006)

Table 2.1: *Different definitions of flexibility*

Its discourse in engineering context first emerged in the manufacturing section during the 1950s (Nurdiani, Borstler, & Fricker, 2017), which at first led to lack of clarity, as a result of which a few authors proposed to focus on a single aspect of flexibility and exhibit it further in different ways. One such early research on the concept of single aspect of flexibility was done by Leeuw & Volberda (1996) wherein the connotation of flexibility is determined in terms of organizational flexibility. Literature in project management suggests the need to achieve organizational flexibility by developing flexible project-oriented organizations that are contingent on temporary and flexible project teams, which can thereby maintain a balance between efficiency and flexibility (Sun, Zhu, & Sun, 2018; Cattani et al., 2011; Leybourne & Sainter, 2012; Klein, Biesenthal, & Dehlin, 2014).

Another aspect of flexibility in project management was based on using a flexibility approach to deal with effects of uncertainty in planning (Sager, 1990) and has provided various approaches to planning.

He has also defined other terminologies like robustness, resilience and stability as being closely related to flexibility. Kreiner (1995) and Karlsen (1998) have discussed flexibility as a response to environmental uncertainty, as project and project management are often challenged due to uncertainty, thereby creating 'drifting environments', which can occur as a result of changes in a project context, changes due to stakeholders' desires and other unknown specifications. With regards to dealing with uncertainty, real option paradigm- a concept derived from finance (Ranjbar-Bourani, Hajizadeh, & Gaza, 2019), states that uncertainty tends to increase the value of a project, if flexibility is preserved and commitment of resources is not rigid. Flexibility in terms of real options is often quantified in monetary terms and it is an established term for reacting to dynamic changes in heavy industrial and energy infrastructure projects (Ajah & Herder, 2005). The real option perspectives aid in incorporating flexibility into the conceptual design phase of the infrastructure and hospital projects, by evaluating the decision-making based on cost valuations (Kauppinen & Siddiqui, 2018; Wang & Neufville, 2005).

Exploring further on flexibility, few researchers have stated flexibility in terms of decision making and proposed different methods to achieve it. Mandelbaum & Buzacott (1990) proposed a model using decision theory and provided insights measuring flexibility by keeping alternatives as a measure of flexibility after the initial decision has been made. Likewise, Olsson (2006) has proposed three strategies by which flexibility in decision process can be achieved. First, "Late locking" of project concepts, specifications and organisations, which is regarded as one of the success criteria for large engineering projects (Cantarelli, Flyvbjerg, van Wee, & Molin, 2010). Second, "Continuous step-by-step locking", which is regarded as making commitments in succession and can be achieved by using stage-gate models (Cooper R. , 2008). Third, "Contingency planning", which is regarded as developing a set of alternative plans in addition to defining a set of base plans, of which the former can be used in case of failure of the latter.

Literature suggests two approaches to flexibility in project management- 'Process flexibility' and 'Product flexibility'. Process flexibility is "adaptability to decision making" in order to respond or react to uncertainty, while Product flexibility is "adaptability in the use of project deliverables". According to Olsson (2006), these two approaches interact in a project, but there lies a huge difference from the managerial perspective. He characterized the flexibility in process and product as high and low and identified several strategies for different environments. The model proposed by him is as shown below, which can be adapted based on various circumstances:

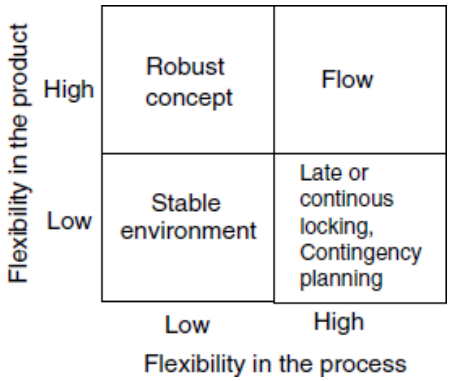


Figure 2.2: *Flexibility in the product and the decision process (Olsson, 2006)*

As shown in the figure above, when flexibility in product and process both is low, a project assumes a stable environment, which indicated that project concept and project management are slightly conducive towards adjustments within the estimated project time frame. The situation that has low

flexibility in product and high flexibility in process follows the principle that the final decisions can be postponed. These two situations generally occur for hospital real estate projects (Olsson, 2006).

Adapting to changing circumstances and environment, the evolution in project management led to the advent of new project management approaches that are more flexible in nature, known as agile project management. First developed in the software industry, it emerged as a methodology which can adapt to specific needs of the project, leading to more interactive managerial approaches, which appeared to be in contrast with the traditional practices. Advent of agile project management gave recognition to other principle-based methods like Scrum, Lean, Extreme programming, Kanban, Adaptive Software Development (ASD), which were then considered under one umbrella term- 'agile' (Highsmith, 2011). Agile project management is based on an iterative and incremental approach, like iterative planning and short delivery iterations, accompanied by increased communication and collaboration, continuous learning and more efficient decision making. It emphasizes four cornerstones viz., (1) change acceptance, (2) team focus, (3) customer focus and (4) product quality, with the goals to create flexibility and encouraging possibilities to adapt to changes (Heeager et al., 2016). Looking at the success of agile project management in the software industry, there was a switch from traditional to agile method, which also flourished in other sectors like manufacturing, production and lately even construction. Its management style has proven to be the most flexible project management methodology (Paslwaski & Karlowski, 2016; Sushil, 2015), as a result, the researchers are trying to identify the practices from agile methodology that can be successfully implemented into more traditional industries such as construction. This research attempts to identify certain practices from agile that can aid in the implementation of flexible practices in the construction industry.

In this section, a brief description of the concept of flexibility and its meaning in different areas in literature was extracted. It discussed organizational flexibility, planning flexibility, decision-making flexibility, process flexibility, product flexibility, and flexibility in terms of agile project management. As mentioned, flexibility is a very broad concept and focusing on all aspects of flexibility will be out of scope for this thesis. Hence, considering the starting point of the research, the definition of flexibility for this research is: "*the ability to deal with the project dynamics"* (Jalali Sohi, 2018). Further, based on the exploratory interviews in section 1.3 it was identified that the term referred to as 'flexibility' by the practitioners was often regarded as 'flexibility in process', directing towards "*implementing and achieving flexibility in terms of planning and decision-making, by having an ability to define and change or alter when certain tasks should be realized and by having an ability to make changes to the initially fixed decisions*." Therefore, in the context of the construction industry, this thesis focuses on the flexibility in process in terms of planning and decision-making process which will be explained in the next section. It is based on the starting point of the research as mentioned previously, where the focus is on the "WHEN" category of enablers as mentioned in section 1.5.

2.3. Flexibility in terms of the 'WHEN' category

In order to narrow down the scope of research, it was decided to focus on one of the five categories of flexibility enablers from the research of Jalali Sohi (2018). Based on the exploratory interviews, the 'WHEN' category of flexibility enablers was chosen as mentioned in section 1.3. The flexibility in terms of the 'WHEN' category refers to the ability to define and change when the tasks should be realized. It comprises changing the plans and schedules and also the decision taken prior with respect to the previous tasks in order to cope with the changing requirements of the project (Geraldi, 2008; Jalali Sohi, 2018). This section will discuss the concept of flexibility in terms of planning and decision-making

processes in alignment with the WHEN category of enablers and further discuss the five enablers of the WHEN category. An attempt is made to identify and investigate in literature if an addition can be made to the WHEN category of enablers.

Ever since the formal recognition of the term 'project management', project planning and scheduling have been regarded as the cornerstone tasks in engineering projects. While 'planning' is defined as the process which defines the methods of completing a project within a specific timeframe using defined stages and designated resources "by defining the project objectives, identifying what needs to be delivered, when and how it will be delivered, how much will it cost and who will carry it out" (APM, 2019); 'scheduling' is a complementary process to planning that can be defined as the process of "describing all the work necessary to deliver the project on time and with success" (TW Project Staff, 2019). Ackoff (1970) in his research has linked the planning process to decision-making and has defined planning as "a decision-making process performed in advance of action which endeavors to design a desired future and effective ways of bringing it about."

In the construction management processes, the process of planning serves as an essential thread in the entire project. The construction industry uses formal planning and control mechanisms like traditional Gantt Chart, Line-of-Balance, CPM and PERT, modern LPS (Last Planner System) and CCPM (Critical Chain Project Management) (Nasseri, Widen, & Aulin, 2013) in managing the projects and any deviation from these plans is certainly not accepted. Although these tools and methods have proven to be successful, but as projects today are becoming more complex and often there is high uncertainty associated with projects, the use of planning and scheduling methods in their current manner does not always guarantee project success. This uncertainty is also associated with the projects due to absence of complete and accurate information for making decisions at the onset of the planning process (Li, 2008). Most authors have agreed to this and have proposed a shift from currently adopted rigid and formal planning and scheduling process towards a flexible planning and scheduling processes that has the capability to adapt to new and changing situations and is based on making decisions not upfront, but sequentially over episodes (Olsson, 2011).

The interpretation of flexibility in planning and decision-making processes which had a negative connotation in the 1960s and 1970s, has now shifted to a more positive one (Tasan-Kok, 2008; Gielen & Tasan-Kok, 2010), especially after the advent of agile project management methodology. Adopting flexibility in project planning and scheduling does not mean developing new techniques for project schedule or not using the current tools and methods. It means aligning the project plans and schedules and adapting it to meet the project priorities and project requirements to cope with the changes and uncertainty in the business environment (Mahmoud-Jouini, Midler, & Garel, 2004). Flexibility in planning and scheduling can also be achieved by making the plans and schedules flexible, as quoted in Sager (1990) by ensuring the following (taking the following two measures of):

(1) Not rigidly prescribing to a definite step in a schedule when such a step depends on circumstances which would be understood only at a later time;
(2) Not deciding upon an earlier stage that would unnecessarily limit the spectrum of future possibilities.

According to him, a plan or decision can be flexible only when a number of options are kept open. He has also regarded flexibility in planning as adjustability and preservation of opportunities. The possibilities of making adjustments can be achieved by adopting to agile iterative planning approach in which the plans can be reviewed and adjusted depending on the changing project requirements (Drury-Grogan, 2014). According to Lavikka et al. (2019), process flexibility in terms of decision making

can also be achieved by scheduling the decisions to suit the needs of decision-makers and construction processes.

There is a basic dilemma in project planning and scheduling which states that – "*the importance of decisions is at the highest at the same time as the available information is at its lowest*" (Mikkelsen & Riis, 2007). This dilemma can be reduced or avoided by increasing the available knowledge about the project. In this regard, flexibility in terms of project planning and decision-making can be achieved by postponing the irreversible decisions in the front-end phase in addition to collecting more information. The postponing of decisions, in certain literature is referred to as 'locking the decisions at a later stage' or 'late locking' as suggested by (Miller & Lessard, 2001), while in others it is referred to as 'deciding at last responsible moment' as suggested by Ballard & Howell (2003); both of which consider it as an explorative and iterative front-end process.

Additionally, Jalali Sohi (2018) in his research has identified five enablers that facilitate in achieving flexibility in terms of planning and decision-making process, which he has defined as the ability to define and change the time constraints for different tasks and has characterized it under "WHEN" category. The identified enablers that help in the implementation of flexibility in terms of project planning and decision-making, which are as follows:

1. Iterative planning
2. Iterative delivery
3. Short feedback loop
4. Late locking
5. Continuous locking.

The description of these enablers and the context in which it can be put to practice or can be implemented will be described in the next section. The ability to incorporate or implement flexibility in the process, with or without the enablers is influenced by two aspects- first is the ability of the organization or the project management team to be flexible and the next is the commitment of the organization or the project management team to be flexible (Olsson & Hansen, 2010). In simpler terms, the former is regarded as 'actual flexibility', while the latter as 'planned flexibility'. Actual flexibility in a project and project management processes occur when flexibility is incorporated due to requirements in the process in order to cope with the project circumstances. Planned flexibility in a project and project management processes occur when flexibility is incorporated due to the pre-planned activities or decisions, for example, 'it is stated in the business case'. Whether the enablers are applied as actual flexibility or as planned flexibility will be investigated further in the research using a case study methodology.

2.4. The Five Enablers

In this section, the five enablers of the WHEN category will be discussed, viz. iterative planning, iterative delivery, short feedback loops, late locking and continuous locking. These five enablers are grouped into two categories- the planning-based enablers and the decision-based enablers as shown in the following figure:

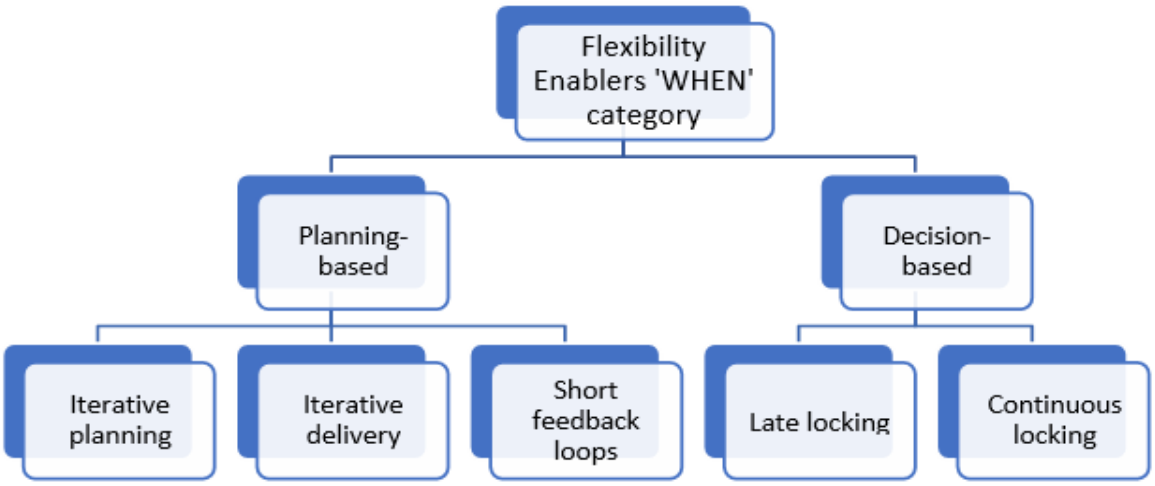


Figure 2.3: *Classification of Flexibility enablers (Own illustration)*

2.4.1. Iterative Planning, Iterative Delivery & Short Feedback Loops:

The limitations of traditional project management approach to meet the changing demands of projects in today's dynamic environment led to the development and evolution of the agile project management methodology. Agile project management is highly characterized by its iterative and incremental planning process and short cycles of feedback loops for its business processes and activities, with an aim to provide services and/or products in a flexible and interactive manner. Due to its ability to tackle changes and dynamics in projects, researchers argue that the agile management and some practices from agile are crucial for project's success in the 21st century (Stare, 2013). A lot of research has examined the application of agile methodology in industries other than the IT and have concluded that a few of the agile approaches, can be successfully applied to the processes of other industries. The agile approaches of iterative and incremental planning and shorter feedback loops have gained impact in not only the IT sector but also in other areas of project management in the manufacturing, production and research-based sector (Turner, 2014). However, the construction industry has still seen a limited application of these approaches. The traces of agile that are currently visible in literature and in practice in the construction industry direct towards the application of Scrum in the early project stages. This section discusses the iterative nature of agile management used in the software industry in the context of its iterative planning, iterative delivery approach and short feedback loops, which are the enablers of flexibility in project management and further specifying its implications in the construction industry.

An iterative process is the basis of agile methodology which emphasizes on developing software using a continuous and repetitive cycle (iterative) and in a lesser amount of time (incremental). Every project is divided into a number of iterations, where an iteration refers to a (short) period in which the team must design, implement, test and deliver a particular product increment, for example, a particular subpart of the entire project. This is in contrast to the traditional methodology which depends on a single delivery, with all functionalities delivered all together at once (Al-Zubaidi et al., 2018). It is observed that agile teams refrain from identifying the entire project requirements up front, and hence, it is a common practice in industries using agile methodology to plan for iteration, irrespective of the project size, nature and scope. There is usually a format set for undertaking an iteration and an iterative planning which will be explained subsequently.

Prior to starting the iteration and iteration planning, it is important to specify and prioritize the goals and issues from the clients' point of view as it is essential to carry out the planning activity for a large project based on priority, which usually is assigned by the project manager in consultation with the project team (Ganesh, 2016).The prioritization is generally done by selection of the objectives and issues from the product backlog. A product backlog is a list of things/activities/tasks/issues with their description, quantity or value, that needs to be done within a project. This product backlog is maintained by the project team working in an agile setting. It is the responsibility of the project team to define the iteration goals prior to the beginning of the iteration planning cycle, by taking into consideration the factors like: (a) the iteration goal should align with the project goal; (b) the iteration goal must be defined based on the team's capability to complete that goal (Al-Zubaidi, 2018). Once the iteration goal is defined, it goes to the next phase of iterative planning, where the major planning and decision-making is carried out. The following figure depicts the generic iteration model showing iterative planning and delivery:

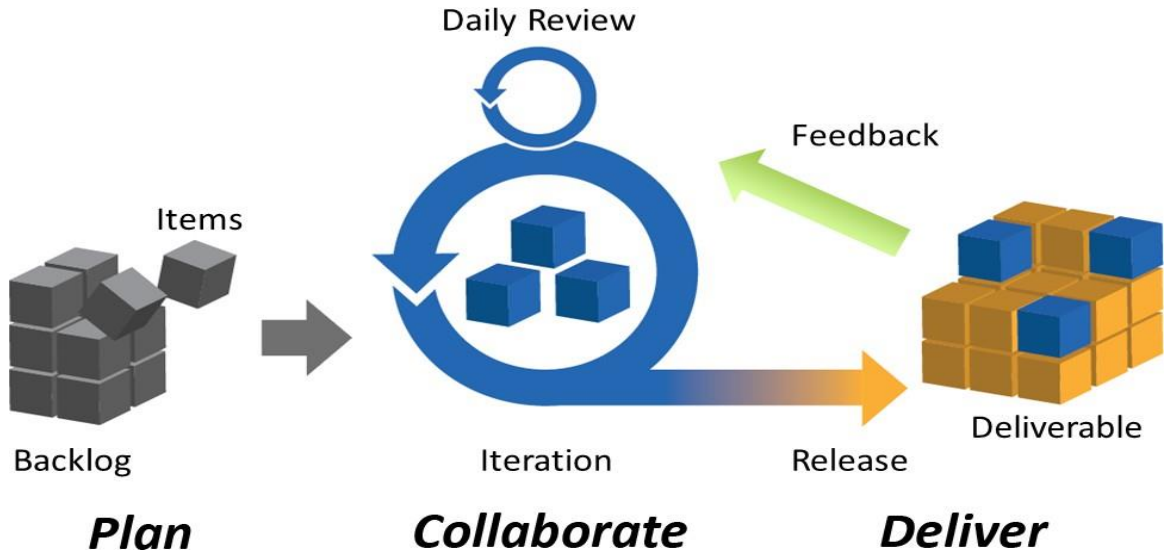


Figure 2.4: *Agile Iteration Model, (Planbox, 2012)*

In an iterative planning approach, every iteration goes through different phases in which the planning and decision-making is conducted with the involvement of various team members. It begins with an iteration planning meeting and concludes with an iteration retrospective meeting as shown in the figure below:

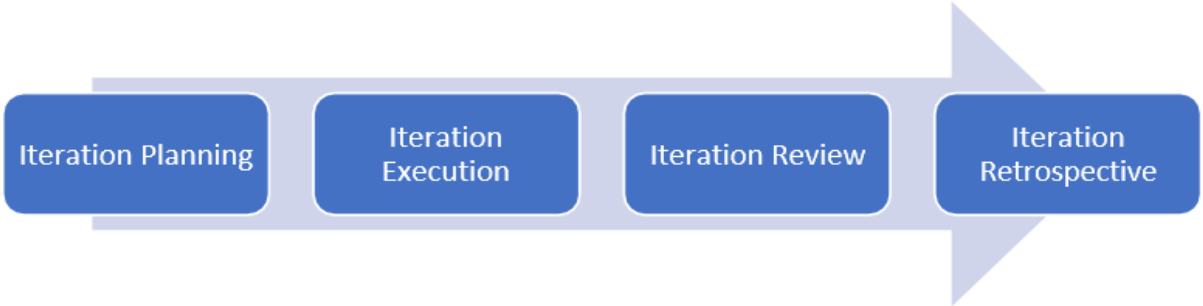


Figure 2.5: *Planning and Decision-Making phases in an iteration (Own illustration)*

The above-mentioned phases of an iteration planning approach with its ideal requirement of members and timespan are explained as follows:

1. **Iteration Planning:** This step marks the beginning of each iteration in development and it consists of planning, deciding and dividing a set of tasks or activities or specific set of work that must be undertaken by an agile team in the forthcoming iteration. The presence of project owner, team leader and team members are expected in this meeting and this meeting should last for one to three hours (Drury et al., 2012; Schwaber & Sutherland, 2017).
2. **Iteration Execution:** In the second phase, the project team works on developing the product or completing the iteration goals and activities/tasks decided during iteration planning, and solving the issues prioritized during the iteration planning. The development and testing of the design and product are done in this phase. The project leader and the project team are completely responsible for activities in the iteration execution. There is no specific time duration specified for this phase, but it can vary from one to four weeks depending on the project complexity (Drury, et al., 2012; Schwaber & Sutherland, 2017).
3. **Iteration Review:** The focus of iteration review is to discuss and review the work done and delivered by the project team during the iteration execution and compare the progress and commitment since the beginning of an iteration and to the actual delivery at the end of the iteration. In this phase, the project team must deliver its product demo or the tentative design. This phase is often referred to as a part of iterative delivery. The Iteration review is to be conducted amongst the team leader and team members with the presence of necessary stakeholders. It consists of obtaining feedback from the stakeholders, which should be incorporated in the next iteration by using short feedback loops that help in reviewing and sharing their experience, thereby leading to knowledge sharing and learning from experience. The ideal time for an iteration review meeting is thirty minutes to two hours (Drury, et al., 2012; Schwaber & Sutherland, 2017).
4. **Iteration Retrospective:** This phase concludes an iteration planning cycle of a particular iteration in which usually a brain storming session is conducted. This phase is often referred to as a part of iterative delivery. It includes sharing of team member's experience during an iteration and specifying the activities that need improvement and the activities that still need to be provided with a solution. Here, the team members also reflect upon working together and evaluating their work for future potential. They also discuss the iteration goals and issues from the product backlog that needs to be prioritized for the upcoming iteration. For this phase, it is expected that all the team members, team leader, project/product owner and responsible stakeholders show their presence. There is no ideal time-duration mentioned for this phase (Ganesh, 2016; Schwaber & Sutherland, 2017).

The Agile team, consisting of five to nine members, follow such an iterative planning pattern characterized by iterative delivery. The iterative planning process continues until the final product is delivered. Due to its continuous and iterative nature, the iterative planning and iterative delivery approaches enable the project teams to adapt and respond to the changing requirements quickly as they deliver working products after every iteration, unlike the traditional approach where the final product is only available to the users at the end. Its main aim lies in satisfying the clients, stakeholders, customers and other related parties through early and continuous delivery of work that provides business value. This iterative-based focus increases the level of interaction within a multidisciplinary team working together for product development, thus enhancing the collaboration and making it flexible for the team members to make decisions by sharing the decision-making process, where all team members can contribute to the decisions taken (Drury & O'Dwyer, 2012), while ensuring the continuous involvement of the clients and different stakeholders.

In order to enable and enhance the collaboration between the project team and other related parties, agile methodology emphasizes on short feedback loops. In simple terms, feedback loops can be

defined as the mechanisms used for validating and receiving feedback either positive or negative about the development process that can be immediately fed back into it (Watson, 2017). Incorporation of feedback loops within the iteration cycles enables tailoring and monitoring the performance of each member in the team, their interaction, teamwork and progress so that the change and dynamics can be addressed in a better way.

Feedback loops are considered to be the driving factors of the agile methodology and its use can be seen in almost every agile framework, like Scrum, Kanban and XP to name a few. A daily sprint or daily standup in itself is a feedback loop and such feedback loops can be injected into any/all phase(s) of an iteration to increase the agility. In an iteration model, a feedback loop is considered to be a part of the iteration review phase, but it is possible to inject it in any of the 4 phases of the iteration model (Pollentier, 2018). A short feedback loop also helps to improve the team productivity, as the shorter the feedback loops, the more there is opportunity to increase productivity of an individual's performance or the entire project team or the process. These feedback loops attempt continuous reevaluation of the development path towards the desired project goals on the basis of the feedback received in each loop, that are usually addressed during the process and are incorporated in the project by the project teams. Incorporating shorter feedback loops enables the team to have increased collaborative, coordinated and committed deliverables in each iteration and also encourages proactive and positive attitude and shared ownerships within the team, thereby improving the performance and flexibility towards uncertainties and unpredictability faced in the projects. Researchers in the construction industry have been trying to explore and develop practices not only to incorporate short feedback loops but also to adapt to the processes of iterative planning and iterative delivery.

Iteration Model in the construction industry:

Traditionally, all the construction projects are managed using the waterfall approach which follows a sequential process of forecasting all the activities prior to the start of the project with an aim to make a detailed project plan and execute that plan without any deviations, which usually takes up significant resources as well as long time durations (Streule et al., 2016). However, as the project progresses ahead in time there are often changes and deviations from the original project goals/requirements that required the plans and decisions to be adjusted accordingly, which in the process often leads to delay and cost overruns (Flyvberg, 2011). In order to counter this, few researchers have thus proposed to adopt iterative-based agile methodology also in the construction industry (Demir & Theis, 2016).

In an attempt to better understand the construction planning process, researchers Heesom & Mahdjoubi (2004) and Akinsola et al. (2000) have identified it as an iterative process than regarding it to be a linear or procedural process. Moreover, due to absence of complete and accurate information, the pre-planning phase involves an iterative way of working for achieving the objective. It is also evident that both the software and the construction industry consist of a design phase during which the project requirements need to be defined, wherein the commonality lies in its cyclic and repetitive character. Similar to the software industry, the design phase in the construction industry is also iterative in nature as during this phase the design team is highly interactive and evaluates the impact of change on design, thereby leading to iterations in plans. However, most often this has been done in an unstructured manner due to lack of availability of suitable methods (Mujumdar & Maheswari, 2017). Due to this character of the construction industry in its design phase, literature has suggested the application of an iteration model. According to Owen et al. (2006) and Olsson (2006), this approach results in frequent value delivery for the clients in the design phase but is considered undesirable for the execution phase. However, by effectively using short term planning and system analysis,

construction companies can attempt to utilize an iterative planning approach also in the execution and commissioning phase (Li, 2008). This has so far not been supported by enough literature.

Very few researchers have explored the application of an iterative model in the construction sector (Jalali Sohi, 2018). Incorporating iterative planning, iterative delivery and short feedback loops in the construction industry, especially in the design phase can help the project team to be flexible to incorporate changes even before the final delivery, thereby saving both cost and time. Also, it will provide the stakeholders with a clear idea of the development of projects since they would be involved in the iterations. As these enablers lead to increased collaboration and continuous learning, the efficiency in planning and decision-making can be increased (Mujumdar & Maheswari, 2017). However, with the growing complexities in construction projects, it is important to plan these iteration cycles carefully. Researchers are exploring the ways in which this method can be made suitable to the construction industry. Prior to this, it is necessary to investigate if this method and these three enablers have been recognized and applied by practitioners in the construction industry. On the other hand, if this method and enablers are not applied, it is important to acknowledge the barriers and challenges that occur in its implementation and make an attempt to search for resolving it.

2.4.2. Late locking & Continuous locking:

The second type of enablers under the WHEN category is based on flexibility in terms of the decision-making process. One way of implementing flexibility in project management is by implementing flexible approaches in the decision-making process in order to adapt to changing project requirements. As mentioned previously, Olsson (2006) in his research states: "*Flexibility in decision process is based on an approach where decisions and commitments in the projects are made sequentially over episodes."* Three methods were provided in his research as strategies to achieve flexibility in decision-making process, viz., (1) late locking or locking at last responsible moment, (2) continuous locking and, (3) contingency planning. Out of these three strategies, the first and the second strategy were classified under the 'WHEN' category of flexibility enablers, which deals with implementing flexibility in terms of project scheduling in the research of Jalali Sohi (2018). The third strategy 'contingency planning' was identified as an additional enabler to the WHEN category. However, 'contingency planning' has already been classified in the research of Jalali Sohi (2018) under the 'HOW' category of flexibility enablers and hence in this research it will not be added as an additional enabler to the WHEN category.

The 'WHEN' category enablers being the starting point of this research, this section will introduce the concept of 'locking' or 'lock-in' in decision process and the method by which it can be implemented in the projects. The term "locking" refers to escalation in the commitment of decision-makers towards certain course of action. It is also recognized in the literature as 'entanglement,' 'entrapment', 'sunk cost effect', 'knee-deep in the big muddy' effect and 'too much invested to quit' effect (Cantarelli, Flyvbjerg, van Wee, & Molin, 2010). Locking can take a form of institutional locking or technical locking; the latter is generally observed in the construction industry. In the construction industry, locking can be used in two contexts:

1. *Locking at decision-making level:* It occurs before the decision to build;
2. *Locking at project level:* It occurs after decision to build.

Most commonly, it is used in the former situation and can be defined as "*the over-commitment of decision-makers to an ineffective course of action"* (Cantarelli, Flyvbjerg, van Wee, & Molin, 2010). Moreover, the locking that occurs at the decision-making level and at the project level can be either a

conscious locking or an unconscious locking. When the decision-makers have the tendency to justify their decisions than critically evaluating them and have the possibility to reverse their decisions, it is regarded as a conscious locking. In contrast to this, when the decision-makers do not foresee a possibility of changing the situation, it is regarded as unconscious locking. The concept of locking is also classified as 'intentional locking' and 'unintentional locking' which highlights the influence of social and political factors on the decision-maker (Walby, 2003). In context of this thesis, the application of locking will be limited to locking at decision-making level and at the project level.

Although locking has been researched by applying different lenses like economical, technical, political and psychological, due to changing dynamics and ever-increasing complexities in projects, locking is often considered to have a negative influence on project performance. It leads to an early commitment to a formal decision in the decision-making process that cannot be changed later, thereby restricting flexibility. However, it need not necessarily be negative as it could also prove to be advantageous with regards to certain decisions in order to limit delays. This is dependent on two drivers of locking, viz., inflexibility and closure of alternatives. These two drivers influence the process of locking as the decision-makers make certain decisions within an inflexible and incomplete (not including all alternatives) decision-making process. In the large and complex projects, it is observed that due to locking, the "real decision to build" is finalized much earlier in the decision-making process, thus making the process rigid. As a result, the cost estimated during this phase of the project is lower than the cost estimated at the later stages in the decision-making process after the constantly changing project requirements are defined during those (later) stages. Thus, this inflexible nature of early locking makes it difficult to manage cost overruns and often result in an inefficient decision-making (Cantarelli, Flyvbjerg, van Wee, & Molin, 2010).

Although locking is characterized by its inflexible nature, the decision-making process influenced by locking can be made flexible if it is applied late in the process, i.e. by applying the enabler of late locking and/or applied continuously using iterations, i.e., by applying continuous locking (Olsson, 2006). This is also facilitated by clearly identifying if it is a 'formal decision to build' or a 'real decision to build'. In order to make the locking entail flexibility in project management and make precise distinction between formal and real decision to build, review stages can be introduced in the decision-making phases. The discussion about the review stages or the so-called stage gate model is provided in the Appendix B. In these review stages, the possible alternatives can be analyzed and evaluated and if an agreement still cannot be reached with the available information then such decisions can be kept for locking at later moments or for evaluation and locking at the next review stage. The use of review stages or the stage gate model is a traditional practice, but it can be applied to evaluate and choose the decisions during the decision-making process that can be kept open for locking at the later moments (Jalali Sohi, 2018). By doing so, the decision-makers will have time to find additional information and ways to make the best possible decision for the project, thereby enhancing the flexibility in decision-making process.

There is limited research available on using review stages specifically for implementing the enablers of late locking and continuous locking in the construction industry (Shiferaw, 2013). Also, there is lack of information on the methods that can be used to incorporate late locking and continuous locking in practice in the construction industry. This research aims to identify whether these enablers are incorporated in practice. It will also investigate if the flexibility in locking occurs at decision-making level or project level. Additionally, the barriers and challenges that occur in its identification and implementation will be investigated.

2.5. Barriers in incorporating WHEN category enablers

Despite the fact that different researchers have suggested incorporating flexibility and its enablers in project management, there is limited literature available on how it can be enabled in practice. Researchers have agreed that there are a lot of barriers and challenges in our ability to implement flexibility and its enablers, that need to be tackled or overcome in order to enhance flexibility in practice. Following this, it is important to identify the challenges faced by the practitioners in their daily project management practices which prevent or resist them from implementing the flexibility enablers in practice. The aim of this section is to identify the barriers to implement the flexibility enablers from the existing literature. Considering the scope of the research, the challenges were researched and identified for the chosen five flexibility enablers- iterative planning, iterative delivery, short feedback loops, late locking and continuous locking. It was found that different researchers have addressed different barriers identified for either one or all five enablers.

A systematic literature review was undertaken to identify the challenges for incorporating the five enablers. The review consists of barriers encountered in recognition of the enablers as well as its implementation. The keywords included- “barriers”, “challenges”, “difficulties”, “prevent”, in addition to the AND operation with keywords- “flexibility”, “flexible”, “Iteration”, “iterative”, “late locking”, “agile”, “iterative delivery”, “scrum”. A combination of search string was used but it was kept limited to the enablers of flexibility in terms of planning and decision-making. The search was limited to recent years, i.e. from 2010 onwards. A total of 12 research papers were found, which highlighted and focused on various challenges for different enablers. Several barriers in identification and implementation of the WHEN category of flexibility enablers were found from the literature. The identified challenges were divided into five clusters- lack of awareness/ methodologies, change resistance, organizational behavior, management processes and miscellaneous, which were partially adopted from the research by Dikert et al. (2016). The clusters act as themes which makes it easier to classify and address each of the identified barriers under one of the five clusters, which is elaborated in the following table 2.2. The five clusters of barriers are explained as follows:

1. **CLUSTER 1- Lack of awareness/ methodologies:** A common challenge observed in the iteration process (iterative planning, iterative delivery and short feedback loops) and the locking process (late locking and continuous locking) was that its implementation turned out to be difficult due to little understanding of these enablers and/or inadequate experience with these enablers (Dikert, Paasivaara, & Lassenius, 2016). Also, in the context of construction industry there are not many methodologies available using which these enablers can be easily adopted in projects. Also, the current ‘flexible’ genre in literature is highly prescriptive and conceptual, with investigation of many dimensions still lacking. As a result of which the project teams fail to identify these enablers and have low motivation in applying it in the project (Miller G., 2013). The barriers that occur due to these reasons have been classified under cluster 1, as mentioned in table 2.2.

2. **CLUSTER 2- Change resistance:** In most cases, resistance to flexibility enablers is simple: People don’t like change. Most of these flexibility enablers come along with change and this change can be in the form of changes in plan/ schedule, decisions and also strategies and organizations. For example, using iterations in planning can often lead to making changes to original plans and timelines for the project and similarly using continuous locking, can affect certain decisions which otherwise would have been fixed at early stages. It is a common behavior that people are unwilling to embrace changes unless there are advantages or good

reasons for them and changes are perceived effortlessly, especially when it is a new way of working the consequences of which the people are unaware of (Dikert, Paasivaara, & Lassenius, 2016). The barriers that occur due to this factor is classified under cluster 2, as shown in table 2.2.

3. **CLUSTER 3- Organizational Behavior:** The barriers that occur as a result of organizational behavior during implementing flexibility and agility has recently received much attention from researchers and practitioners (Leeuw & Volberda, 1996). According to them, an organization must be considered as a controlled system which can become adrift if these enablers are implemented without their control as most of the organizations do not have a high level of flexibility to shift to these processes due to their traditional way of working. As a result, there are often conflicts between the team members and lack of trust and active participation in the process of incorporating these enablers. In line with cluster 1, the organizations often experience a planning fallacy which fails to give desirable results. The barriers identified from literature due to these reasons are classified under cluster 3.

4. **CLUSTER 4- Management Processes:** Incorporating any of these five flexibility enablers might have long-term implications for the projects and project processes for which the support of management is necessary as it requires a radical change in the planning processes as well as in decision-making processes (Shukla et al., 2019). In addition to this, lack of clear methodologies can create technical inconsistencies as well as transformational challenges from sequential planning and scheduling methods to iterative model. The barriers that occur in this transformation have been classified under the cluster 4, as mentioned in table 2.2.

5. **CLUSTER 5- Miscellaneous:** Certain barriers in the process of implementing the flexibility enablers occur as a result of scope changes, risk bearing, and various other reasons which are not identified in any of the above four clusters, have been classified under cluster 5.

The table illustrates the challenges identified from the literature and has classified these challenges into above mentioned five clusters of barriers. The first column lists the identified barriers and challenges and the first row lists the authors; the works of whom have been explored. The list of authors has been organized chronologically based on the year of publication. As different authors have addressed the barriers for different enablers, a numbering system has been adopted to address the five enablers. The numbers in each cell represent the flexibility enablers that encounter the barrier or difficulty listed alongside in the first column and found from the literature mentioned in its respective column. The numbering system adopted for the five enablers in the research follows- ‘1’ for Iterative planning; ‘2’ for Iterative delivery; ‘3’ for Short feedback loops; ‘4’ for Late locking; and ‘5’ for Continuous locking.

AUTHORS / BARRIERS	(Cantarelli et al., 2010)	(Drury, 2012)	(Han, 2013)	(Inayat et al., 2014)	(Padmanabhuni, 2015)	(Dikert et al., 2016)	(Gregory et al., 2016)	(Gustavsson, 2016)	(Hohl et al., 2016)	(Moreil, 2017)	(van Kralingen, 2017)	(Verret, 2018)
1. Lack of awareness/ Lack of methodologies												
1. Lack of understanding of these enablers			1,2,3, 4,5			1,2,3, 4,5	1,2,3	1,2,3, 4,5				1,2,3
2. Lack of guidance/ methodologies from theory to implement these enablers	4,5		1,2,3, 4,5		1,2,3, 4,5	1,2,3, 4,5	1,2,3					1,2,3
3. Insufficient training and coaching					1,2,3, 4,5	1,2,3, 4,5						
4. Lack of qualified members (who are aware of these enablers)							1,2,3	1,2,3, 4,5			1,2,3	1,2,3
5. Failure to explore alternatives	4,5					1,2,3, 4,5						
2. Change resistance												
6. Tendency of team members to stick to initial plans and decisions								1,2,3, 4,5		1,2	1,2,3	
7. Team members unwilling to accept changes as old commitments need to be kept	4,5	4,5	5	1,2,3, 4,5		1,2,3, 4,5		1,2,3, 4,5		1,2		
8. Organizations resistant to adopt these enablers out of fear of consequences	4,5				1,2,3	1,2,3, 4,5	1,2,3, 4,5		1,2,4, 5			1,2,4, 5
9. Contractual requirements/ Fixed price contracts do not allow for changes				**1,4,5**								
10. Skepticism towards new way of working		4,5				1,2,3, 4,5					1,2,3	
3. Organizational Behaviour												
11. No initiation from the project members to adapt to flexibility enablers						1,2,3, 4,5	1,3		1,2,4, 5	1,2		
12. Lack of trust from stakeholders	4,5	4,5			1,2,3, 4,5			1,4,5			1,2,3	
13. Lack of people collaboration and active participation					2,3	1,2,3, 4,5	1,2,3					
14. Fear of conflicts between project teams and stakeholders							1,2,4			1,2		
15. Keeping old bureaucracy	4,5			1,2,3, 4,5		1,2,3, 4,5			1,2,4, 5			
16. Planning fallacy and optimism bias	4,5											
4. Management Processes												
17. Transferring bulky traditional PM practices into fast paced iterations		1,2				1,2,3		1		1,2	1,2,3	
18. Dependency on project managers to assign tasks		1,2								2		
19. Tracking issues & confusion if iterations and decision-changes not formally documented			1,4,5							1,2		1,2,4, 5

20. Implementation of iterations in plans can be difficult for employees			1			1,2		1		1,2	1	
21. Lack of management support					1,2,3, 4,5			1,2,3, 4,5			1,2	
22. Poor interfaces between design and construction and improper coordination					2							
23. Over scoping and rework				1,4,5								
24. Unable to estimate time and budget	4,5			4,5								1,4,5
25. Unwillingness to put more efforts	4,5	1,2, 3							1,2,3, 4,5			1,2,3, 4,5
26. Technical inconsistency						1,2,4, 5						
5. Miscellaneous												
27. Resistance to scope creep								1,3,4, 5				
28. Inadequate requirement verification												1,2,3, 4,5
29. Political vulnerability	4,5											
30. Risk on non-predictability	4,5											

Table 2.2: *Barriers in identification and implementation of enablers*

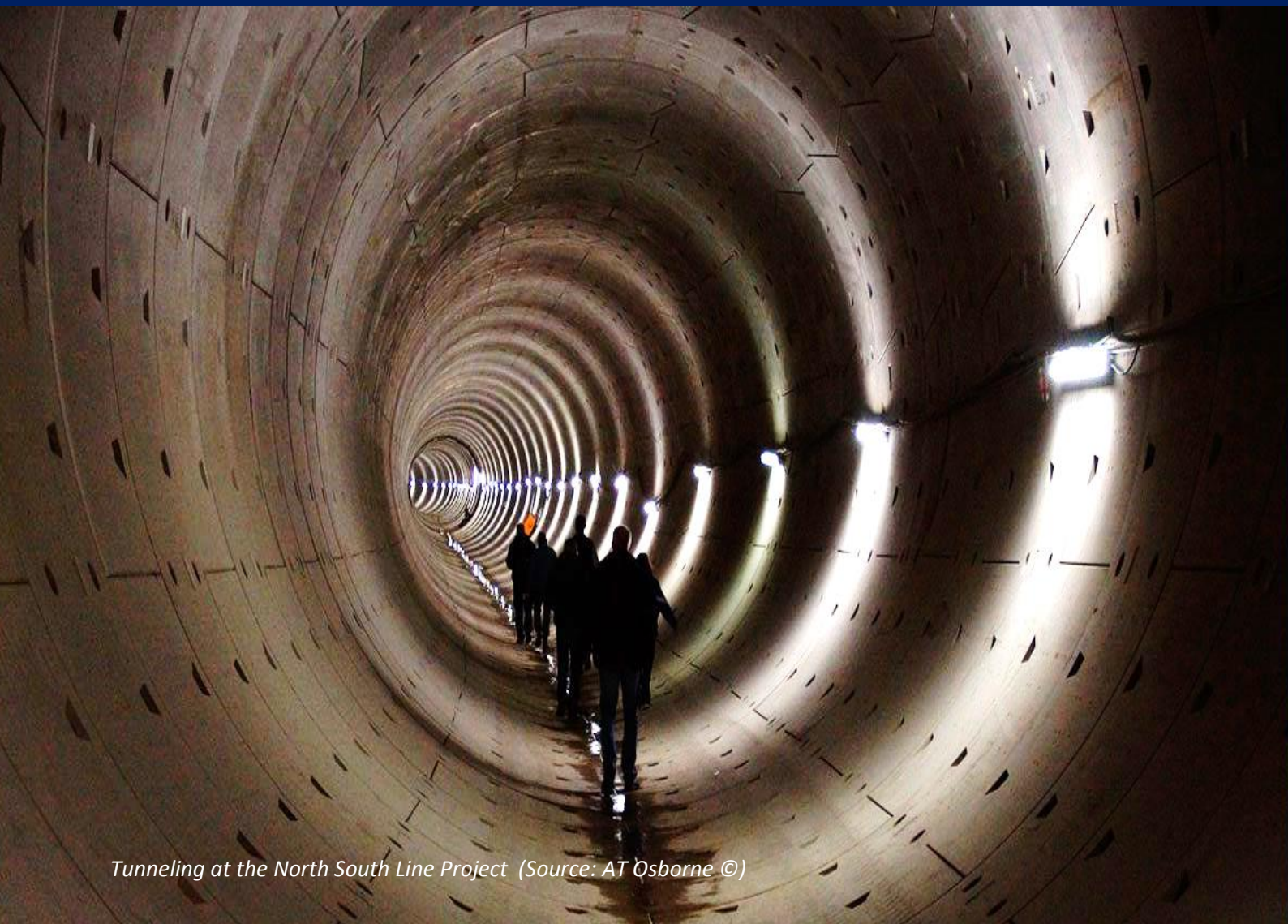
2.6. Conclusion

The concept of flexibility in project management is broad and several researchers are trying to explore different methods for achieving flexibility. This section has provided different definitions of flexibility and has highlighted the concepts of implementing flexibility in terms of organizational flexibility, planning flexibility, decision-making flexibility, product flexibility, process flexibility and flexibility in terms of agile methodology. In order to focus on a specific aspect of flexibility and to limit the research, the emphasis was given to investigating flexibility in terms of project planning and decision- making. Flexibility in this regard is often reflected upon the possibilities for (1) making the project plans and schedules adjustable, and (2) postponing the decisions that tend to be irreversible. It was identified from the literature that the former could be achieved using an iterative planning approach while the latter by influencing the decisions using locking. Although limited literature is available on achieving flexibility in planning and decision-making, five enablers were identified that facilitate its implementation. These five enablers being iterative planning, iterative delivery, short feedback loops, late locking and continuous locking. Additionally, this section has also researched about the challenges and difficulties that have been faced in the identification and incorporation of these enablers that prevent facilitating flexibility. Every identified barrier has been classified under one of the five clusters, thus developing a theoretical framework for the barriers.

Altogether, the literature review has described the concept of flexibility in project management and flexibility in terms of planning and decision-making and has also analyzed five enablers that by implementing them in the project management practices, can help achieve flexibility. This chapter has provided answers to sub-research questions 1 and 2 of this research. Furthermore, the five enablers will be applied in the research in order to investigate whether these enablers are identified by the practitioners and further study their application in the construction industry for implementing flexibility. The research will also investigate if the barriers identified from the literature review also occur in practice, which if we could overcome them, could stimulate flexibility in project management.

3

Research Methodology



Tunneling at the North South Line Project (Source: AT Osborne ©)

Chapter 3: RESEARCH METHODOLOGY

The literature review identified the possibilities for the implementation of flexibility enablers for achieving flexibility in terms of planning and decision-making in the construction industry. Due to the scarce literature available on the implementation of flexibility enablers in the construction industry and the unavailability of practical evidence of implementation of the enablers in practice, it was necessary to investigate how the identified possibilities are being incorporated and dealt with in practice. Thus, a case study methodology was chosen as it is the most suitable approach to explore the application of these enablers in practice. Additionally, the formulation of the main research question with "how" leads to adopting to the case study approach (Yin, 2014).

The theoretical framework also provided a list of barriers that hamper the implementation of the five enablers. To enhance the implementation of flexibility enablers, it was important to investigate if these theoretically identified barriers also appear in practice in the construction projects. This gives another reason to explore the current practice, thereby making case study methodology a suitable approach for this research. It allowed the author to identify the most commonly occurring barriers which would be used in the next phase of the research. In the next phase, the suggestions to overcome the identified barriers will be proposed based on literature and on case studies. In consideration with the identified barriers and proposed suggestions to overcome them, a conceptual framework has been proposed. The last step of the research consists of conducting expert interviews to validate the proposed suggestions and the conceptual framework.

In this section, the research methodology will be explained. It consists of the case-study setup, case selection criteria, document review, interviewees selection and interview set-up and expert validation.

3.1. Case-study Set Up

This research is exploratory in nature which identifies and analyses the application of the flexibility enablers and also the barriers in its application, it was necessary to determine the overall design for performing the case studies. After the selection of a specific design for performing case studies, its selection criteria, document review and interview protocol will be explained.

Yin (2014) has suggested four designs for a case study methodology, viz., single case- single unit of analysis, single case- multiple unit of analysis, multiple cases- single unit of analysis, and multiple cases- multiple unit of analysis. These four designs were evaluated to choose an appropriate case study methodology, that led to selection of the fourth type of design, i.e. multiple cases- multiple units of analysis. The reasons for this are as follows:

1. Multiple cases will provide a broad perspective and extensive explanations on the way in which the enablers are identified and put in practice as compared to a single case in which there would be a limitation in its identification and implementation. Using a multiple case approach will help to understand the differences and similarities between the cases with respect to the incorporation of enablers.
2. As there are two different aspects to be determined in practice- the incorporation of enablers and the barriers that occur in its incorporation in practice, case analyses would be used for these two different factors.

After selecting the case study design, the case selection criteria were defined which is explained in the next section.

3.1.1. Case-study Selection Criteria

A combined approach will be used for performing the case study methodology, consisting of document review and interviews. The selection was based on factors like current state of project, departments (sector), interviewees roles and availability. Due to the interest of the company in performing this research in both infrastructure and healthcare real estate construction projects, the cases shall be chosen from both departments. A total of four case studies, two from each department respectively is suitable for the research. As flexibility is little known at AT Osborne, it took quite an effort to find appropriate case studies. The case study selection was based on the following criteria:

1. *Completion & Delivery:* It was necessary to focus on projects which were in the same life-cycle phase. Hence, all the four cases selected were completed and delivered recently within the span of 1-2 years, i.e. in 2018 and/or 2019.
2. *Role of AT Osborne:* As the research has been conducted in a consultancy firm, it was important to identify the role of the firm and the project activities undertaken by them for the selected cases. For the chosen cases, the role of AT Osborne was as an advisory group and it extended its project management expertise. In all the four cases, AT Osborne had a major role in helping clients with planning and decision-making process, which is an important criterion as the enablers focus on planning and decision-making.
3. *Availability:* The availability of actors actively involved in the project management roles, who drive the planning and scheduling processes and influenced decision-making processes was necessary as these actors will be able to extend suitable discussion.
4. *Location:* As the research focuses on facilitating flexibility in the project management practices, the consideration of project location is important. This is because cultural changes vary with the location which has an influence on the project management practices (Hofstede, Hofstede, & Minkov, 2010). Hence, the projects located in the Netherlands were chosen.

Based on the specified selection criteria, initially a total of seven projects- four from infrastructure and three from healthcare real estate, qualified the criteria. But due to lack of availability of employees and permission denial by the client firms, the selection had to be finalized for two projects from each domain. The two finalized projects from infrastructure domain are the North South line metro project in Amsterdam and the Uithoflijn light rail project in Utrecht; and the two finalized projects from healthcare real estate domain are the hospital HollandPTC project in Delft and the Imaging Center project in Amsterdam. The following table shows the projects used for case studies based on the case selection criteria:

Project Name	Uithoflijn	North South line	HollandPTC	Imaging Center
Start Year	2012	2003	2009	2010
Completion/Delivery Year	2019	2018	2018	2019
Role of AT Osborne	Project Management & Process Management	Project Management, Implementation Management	Project Management	Project Management
Location	Utrecht	Amsterdam	Delft	Amsterdam

Table 3.1: *Case Selection Criteria*

3.1.2. Document Review

After selection of these four cases, a combined approach was applied. It consisted of document review and interviews. Before conducting the interviews, it was necessary to have background information of the chosen projects. It helped to verify the responses provided by the interviewees. The main idea was to avoid misinterpretation of facts in the responses provided by the interviewees and investigate if the application of certain enablers were stated in the business case or in the applied project management methodology. For each project, documents like project summary, project business case, evaluation reports, quarterly review reports and planning documents were reviewed. Few documents were obtained from AT Osborne while other few documents were obtained from the client company. Certain review documents of the Uithoflijn projects were not shared for the study due to its involvement with other parallel projects (for example, the Utrecht station area). Due to the confidentiality of these documents, only certain information can be used in this thesis. The document review, especially the evaluation reports gave an overall perspective of the way in which the project management processes (based on the five enablers) were undertaken. An attempt was made to identify the difficulties the project management teams faced in the implementation of the enablers.

3.1.3. Interviewees Selection

The interviews were the main source of data gathering for this research. It thus became important to wisely select the respondents for the interview. The selection of interviewees was done parallel to the document review. The respondents were approached to be a part of the interview based on their roles and responsibilities in the project and project management, and those who influenced the planning and decision-making processes by their positions in the project teams and their active involvement. AT Osborne had provided its project management expertise in majority of the projects, thus the first point of contact for each project was with AT Osborne project managers. This resulted in the first point of contact made directly either with the Project Manager or the Project Director. They were first asked if they were interested in participating in the interview and in this research. If there was unavailability of project managers from AT Osborne, the second point of contact was the Project Manager and/or Project Director from the client company. Thus, for every project the Project Manager or the Project Director was the first chosen interviewee.

The Project Managers and/or the Project Directors were informed about the aim to conduct three interviews per case study and were asked to advise two other interviewees based on their roles and responsibilities. They advised two to three employees for their projects, who were further approached for participating in the interviews. The interview request was accepted by the employees and this resulted in selecting three interviewees per case study, thereby making a set of twelve interviewees for the research. This set was a mix of employees from AT Osborne, the client company and the contractor company, the functions of whom will be discussed in the data analysis section.

3.1.4. Interview Set up

In the exploratory interviews a protocol was followed for conducting the interviews that proved to be beneficial for the process. Similarly, for case studies, an interview protocol was developed for every interview. An important point to be mentioned is- initially it was planned to conduct face-to-face interviews with all the interviewees. But due to the outbreak of COVID and the current work-from-

home situation, all the interviews were conducted online, using Skype video calls, Microsoft Teams and Zoom video calls, as per the convenience of the interviewees. This arrangement was readily accepted by all the interviewees, but this situation led to rescheduling eight of the twelve interviews. The duration of every interview varied from 50-75 minutes. Most of the interviews were conducted in English, except two which had to be conducted in Dutch. The interviews were recorded and transcribed and further sent to the interviewees for their approval. In order to ease the interview process and limit to the duration to 60 minutes, because video calling applications like Zoom have a time limit of only 60 minutes, certain questions were asked by preparing a survey questionnaire. At first, the questions asked in the survey questionnaire were a part of interview protocol but due to the new arrangements of conducting interviews it became easier to use a survey questionnaire. It consisted of questions based on the identification of enablers by the interviewees and the phases in which they had applied. Additionally, the survey also asked for the personal information of the interviewee and their designation and roles in the project. The survey questionnaire is provided in Appendix C2. This survey was sent to the interviewees at least five days prior to the interviews.

3.1.5. Interview Protocol

A semi-structured approach was followed for interviews. The interviews being the main source of data gathering, it was necessary to obtain reliable data. As following a case study protocol ensures gathering reliable data (Yin, 2014), a case study protocol was prepared and adapted for every interview. The interview protocol is attached in Appendix C1.

The first part of the protocol consisted of the general introduction of the interviewee and the interviewer and the introduction to the research topic. The introduction to the topic was kept concise as this information was already provided to the interviewees in the interview writeup. Following this, questions were asked on their opinion on flexibility in project management in the construction industry. It served to provide information to the extent to which the interviewees were familiar with this concept and their perception. As the survey questionnaire already provided answers on identification of enablers by the interviewees, these questions were not repeated during the interview, rather the interviews were focused on the application of these enablers in practice and the difficulties they face in its application.

The second part of the protocol consisted of questions on the enablers of iterative planning, iterative delivery and short feedback loops- enablers for flexibility in terms of planning. Questions based on application of each of the enablers and the challenges in its application were asked. Subsequently, information collected from the case documents was also verified and cross-checked. Following this part, the next part consisted of questions on the enablers of late locking and continuous locking- enablers for flexibility in terms of decision-making. Similar to part two, questions based on application of each of the enablers, challenges in its application and methods to overcome those were asked. These two parts provided with the main data required for this research and an in-depth understanding of how these five enablers have been acknowledged and incorporated in the construction industry and the challenges in its application.

The final part questioned the reasons why these enablers have not been used widely in construction industry. An alternate questionnaire was prepared for the interviewees who in survey would have answered that they fail to recognize either of the five mentioned enablers.

3.2. Data Analysis

After the data collection from document review and interviews, a qualitative analysis was performed. First an in-depth analysis was done for each case prior to comparing it with other cases. This consisted of intra-case analysis per case with an aim to understand the application of flexibility enablers by the practitioners and to identify the difficulties the practitioners face in its application. Subsequently, a cross-case analysis was performed to understand the similarity and differences in incorporating the five enablers in infrastructure and healthcare real estate sectors. The data analysis also consisted of identifying the barriers that occur in the implementation of flexibility enablers. A link was developed between the results obtained from case studies and the theoretical framework based on the occurrence of barriers. The case study approach addressed multiple barriers from which selection had to be made on the most commonly occurring barriers in the case studies in order to propose suggestions for overcoming them, which will be explained in detail in section 5.1.

3.3. Expert Validation

After identifying the most commonly occurring barriers from case studies, the last phase of the research consisted of developing a conceptual framework to stimulate the implementation of the flexibility enablers by proposing suggestions to overcome the barriers that occur in the incorporation of the enablers. The proposed suggestions were obtained from the literature in addition to those observed from the case studies which were applied by the practitioners. In order to validate the proposed framework for its applicability and workability, and to validate the proposed suggestions for each barrier, an expert validation session was setup. The expert validation was done by conducting four expert interviews. The panel consisted of experts in project management with expertise in flexible project management. The research was first explained to the experts along with its results in a joint presentation presented to the company. The discussion was focused on discussing the proposed suggestions and validating the framework, which will be explained in detail in chapter 6 of the thesis.

4

Case Study Results & Analysis

The Amsterdam UMC Imaging Center Project (Source: Wiegerinck ©)

Chapter 4: CASE STUDY RESULTS & ANALYSIS

This chapter contains the results of the case study conducted on two projects each from the infrastructure and the healthcare real-estate sector. The goal is to investigate the identification and implementation of the five flexibility enablers as well as the occurrence of barriers in these projects. The analysis of case studies will explain if the five enablers are recognized in practice and to what extent the practitioners apply these enablers. It will provide with an in-depth explanation of the practitioners' perspectives on identification and implementation of these five enablers. Subsequently, the barriers to the application of these enablers will be identified in each of the case studies and a link is provided with the theoretical framework. Following this, a cross-case analysis has been performed to analyze the similarities and differences in implementing the enablers in two different construction sectors- infrastructure and healthcare real estate. The cross-case analysis also provides with identifying the most commonly occurring barriers in all the four cases that have been addressed in the next phase of the research.

This chapter is constructed as follows. The first section consists of the respondent characteristics. Section 4.2 presents the intra-case analysis and the results of all four cases. The general setup of this section includes the project description, identification and incorporation of flexibility enablers, the identified barriers and findings from each case. In section 4.3, the results of the cross-case analysis for similarities and differences observed in infrastructure and healthcare real estate projects have been presented for the implementation of enablers and identification of barriers. Lastly, section 4.4 presents the results of the cross-case analysis for identification and occurrence of observed barriers. It should be noted that throughout this chapter, the numbering system adopted for flexibility enablers follows:- '1' for Iterative planning; '2' for Iterative delivery; '3' for Short feedback loops; '4' for Late locking; and '5' for Continuous locking.

4.1. Respondent Characteristics

As mentioned in section 3.1.3, a total of twelve interviewees participated in this study, with three interviewees per case study. The list of interviewees is provided in the Appendix C3. The following table presents the characteristics of the interviewees along with the assigned code for the interviewees:

Case	Code	Project Role	Company/Organization	Years of experience
1. Uithoflijn Project	1.1	Project Director	Mott MacDonald	>25
	1.2	Project Planner	Gemeente Utrecht- Project organization (POUHL)	17
	1.3	Program Manager	AT Osborne	>25
2. North South line Project	2.1	Commissioning Manager	AT Osborne	>10
	2.2	Project Director	AT Osborne	31
	2.3	Project Leader	AT Osborne (current)	>7
3. HollandPTC Project	3.1	Project Manager	AT Osborne	17
	3.2	Building Manager	HollandPTC	15
	3.3	Project Manager	J.P. van Eesteren	>20
4. Imaging Center Project	4.1	Project Leader	PTG Advies	30
	4.2	Project Manager	PM² Bouwadviseurs	18
	4.3	Building Supervisor	Adviesbureau J. Vriesema	40

Table 4.1: *Respondent Characteristics*

4.2. Case Study- Results & Analysis

In this section, the results and analysis of four case studies have been provided separately. The results and analysis of each case study begin with a brief description of the case. It is followed by section 'Identification and Incorporation of Flexibility Enablers.' It consists of a table that presents the results on the identification and incorporation of enablers by the practitioners in various project phases. These results were obtained from the survey questionnaire, which was sent to the interviewees before conducting the interviews, as mentioned in section 3.1.4. Following this, detailed analysis and results of how these enablers were implemented in practice have been provided, as obtained from the interviews and case documents. In the next sub-section, the results of barriers identified in practice for the incorporation of the enablers have been presented in a tabular format. The detailed analysis of this part has been provided in Appendix D. Lastly, it reflects on findings from the case studies.

4.2.1. Results & Analysis Case I- Uithoflijn Project:

4.2.1.1. Project Description:

The Uithoflijn project is a light-rail infrastructure project located in the Utrecht province of the Netherlands, with an objective to accommodate the growth in the number of travelers (≈ 45.000) between the Utrecht Central station and the knowledge center De Uithof. This project is undertaken by the municipality of Utrecht and BRU (now the province of Utrecht) as a subset of the "Tram 5" network in the Utrecht region. The total tram route covers a distance of 8 km with nine halts.

The decision to realize this project was agreed in 2011, which further got its administrative approval on June 20, 2012. The Uithoflijn Project Organization (POUHL) was set up in 2012 on behalf of the Utrecht Region Board and the municipality of Utrecht to realize this project, with a division of POUHL between, the Station Area Project Organization (POS)- responsible for substructure and superstructure of the station area and the PO & Municipality and Utrecht province- responsible for preparation and realization of tram infrastructure, acquisitions, management and maintenance. These two parties were the main decision-makers for this project. The role of AT Osborne in this project was to provide support in the integral exploration to realize a working tram transport system. It facilitated the administrative and project management processes on behalf of a dynamic task force- consisting of the municipality of Utrecht, the province of Utrecht, the Uithoflijn Project Organization (POUHL) and the contractor combination (BAM Combination Uithoflijn Utrecht). There were seven different major contract types ranging from Design & Build, DBFM and EPC.

Based on the management agreement, it was announced that the tram will be operational from the first quarter of 2018 with an estimated total budget of € 425 million. However, with several complexities involved, the Uithoflijn project was operational from December 2019 with the final project budget of € 510,2 million. This time and cost overruns were due to certain complexities faced in the project due to the addition of extra scope and later during the testing period of the tram lines. The realization of this project was complex due to simultaneous ongoing works of several adjacent projects in its vicinity, which required being flexible in its planning and decision-making processes in order to adapt to the changing environments, also in consideration with other parallel projects.

4.2.1.2. Identification & Incorporation of Flexibility Enablers:

Based on the interviews, survey and case documents, the following table shows the results obtained on the identification and incorporation of five flexibility enablers in the Uithoflijn project.

Enablers	Attributes	Interviewees		
		1.1	1.2	1.3
1. Iterative planning	Enabler Identified	✓	✓	✓
	Enabler Implemented (in phases)	A, B, C, D	C	C
2. Iterative delivery	Enabler Identified	✓	✓	-
	Enabler Implemented (in phases)	A, B, D	D	-
3. Short feedback loops	Enabler Identified	✓	✓	✓
	Enabler Implemented (in phases)	A, B, C, D	B, C	C
4. Late locking	Enabler Identified	-	-	-
	Enabler Implemented (in phases)	C	C	-
5. Continuous locking	Enabler Identified	-	-	-
	Enabler Implemented (in phases)	-	-	-

Table 4.2: *Identification of enablers- Case 1*

*(**Notation:** 'A'-Conception phase; 'B'- Design and planning phase; 'C'- Execution phase; 'D'- Project closeout phase)*

The practice/method using which these enablers have been implemented is explained as follows:

1. Iterative Planning:

This enabler was identified and implemented by all the interviewees in this project, primarily in the execution phase. Due to several parallel projects running simultaneously in the Utrecht region, a need arose to be flexible in project planning and scheduling. Hence, the project management team decided to prepare two versions of project plans for the Uithoflijn project in late 2016, one of which was for internal use while the other was submitted to the external stakeholders (e.g. politicians); which otherwise would have led to delay in the project. Iterative planning was an approach used for the internal project plan, as mentioned by one of the interviewees who stated- "*We asked everybody to be flexible in this internal plan and adjust the plans as per requirement but make no changes to the plan versions submitted to the stakeholders*." In this internal planning version, the project was divided into sub-projects and each project had its own milestones to be achieved. The plan and schedule for each of these sub-projects were planned and reviewed and the iteration loops were conducted on a quarterly basis, during which the schedule was adjusted, and changes were accommodated. In comparison to the literature, this process follows the iterative planning enabler as mentioned in the literature review section 2.4.1 that follows the step of planning, executing and reviewing. The project manager and the project planner were responsible for conducting these iterations loops every quarter. This process was acknowledged as iterative planning which was complemented by using a tool- time chainage diagram (explained in Appendix G). It was different from that used in execution phase in traditional approach as here the iterations were conducted on a timely basis and monitored regularly. This process enabled flexibility in the planning process of the execution phase as mentioned by interviewee, who stated- "*This provided room for flexibility to make changes to the plan and schedule to achieve the set milestones."* As the execution was not undertaking at the same time for entire project, iterative planning was possible to be used for this case. Based on the interview responses, there was an intentional application of this enabler, thereby an attempt of planned flexibility in the execution phase of the Uithoflijn project.

2. Iterative Delivery:

Iterative delivery was identified and implemented by two of the three interviewees in this project. All the interviewees regarded the WBS method to iterative delivery. However, WBS is a standard practice in the construction industry that cannot be regarded as iterative delivery. The third interviewee was unfamiliar with the term 'iterative delivery.' From the interview responses two of the examples were acknowledged as the process of iterative delivery. The first was observed in the design and planning phase, where the preliminary design and detailed design for the part of tram-line at Utrecht Central station area was undertaken and delivered using iterative delivery method, where the design was submitted, adjusted for correction and corrections were incorporated, along with continuous reviewing and retrospection of the design as mentioned in literature review section 2.4.1. Although the duration of these iterations was longer (quarterly and half-yearly), application of iterative delivery granted flexibility in the design and planning process of the station area, as stated by two of the interviewees. The second process in which iterative delivery was incorporated was in the project closeout phase for testing and validation of light-rail/tram signaling systems. The signaling systems were executed and delivered, and the tram lines were tested with coaches. In case of any errors, these systems were reviewed and delivered again till the time it is fixed and fit for final delivery. Also, the project team used probabilistic analysis to check if these deliveries were made on time. "*Using iterative delivery in this phase is a common practice in testing and validation of coaches and signal systems that aids in ensuring successful final delivery"*- as stated by interviewee 1.1. It can be stated that the incorporation of iterative delivery was intentional in this project in the project closeout phase, thereby an attempt of planned flexibility. As there is no mention about specific application of iterative delivery in the design and planning phase, it cannot be concluded if it was intentional or unintentional, thereby an attempt of actual flexibility.

3. Short Feedback Loop:

This enabler was most distinctly identified and implemented in the Uithoflijn project as compared to the others. The short feedback loops were conducted for a variety of purposes in the Uithoflijn project. Interviewees resembled this enabler to the progress review meetings, regular review meetings, and also update meetings; during which the progress was discussed, plans were discussed, schedules were updated, and problems/issues were discussed. Each meeting group consisted of different participants. For example, certain feedback loops were attended only by the project management group, while in certain feedback loops the participants consisted of stakeholders as well as contractors. The duration of these meetings lasted from 45-60 minutes. The business case and the project plan of the Uithoflijn project mentioned the intervals for conducting these loops. In addition to these meetings, all the three interviewees also identified the daily stand up meetings conducted by the contractor which had a duration of 15-20 minutes. But none of the interviewees identified and mentioned this process as Scrum. Moreover, there was no specific technique or method developed/used for conducting short feedback loops. Thus, it can be concluded that there was no explicit use of agile elements like Scrum in the Uithoflijn project, but the implementation of feedback meetings similar to the short feedback loops granted flexibility in the process as the project team could discuss and take immediate required actions; which was an attempt of planned flexibility.

4. Late locking:

Late locking was not identified by any of the three interviewees. One interviewee responded- "I thought about this enabler but not sure if it fits with knowledge of late locking. But one of the key things that we did for late locking was the commencement date of start of service." The commencement date of tram operations was considered as an example of late locking for the

Uithoflijn project. There were two dates announced- a formal date of commencement (which was announced to public) and the actual date of commencement (for internal purpose), of which the latter was a decision taken at the later moment. This example was mentioned by two interviewees. In this case late locking of decision had to be done as interviewees were forced to do so by the project board and project organizations during the course of the process due to certain reasons (which remain disclosed). This provided a room for flexibility in deciding the start date of operation which was not fixed until the project closeout phase. This was also confirmed in the case documents and it was identified that the implementation of late locking in the context of the Uithoflijn project occurred at the project level and not at the decision-making level, as the late locking occurred after the decision to build. In conclusion, the implementation of the late locking enabler was unintentional, thereby an attempt of actual flexibility and not planned flexibility.

5. Continuous locking:

This enabler was not identified by any of the three interviewees. As this enabler was not identified, its application could not be traced in the Uithoflijn project. The case documents also did not support its application. Although continuous locking was unidentified by the interviewees for the Uithoflijn project, one of the three interviewees identified the application of this enabler in other subway metro project during his past experience. In that project, the enabler was applied in the design phase of the project using the tool called Stage gate model. A stage gate model is a traditional tool that enables the implementation of continuous locking in the project. As there was no application of continuous locking, it cannot be concluded if it occurred on the decision-making level or the project level. Also, it cannot be concluded if this enabler emerged out as planned flexibility or actual flexibility.

4.2.1.3. Identified Barriers in incorporation of Flexibility Enablers:

Based on the interview responses and case documents, the barriers/challenges faced by the practitioners in the identification and implementation of these enablers were identified. These barriers were compared with the barriers listed in the theoretical framework for the five enablers. The following table mentions only those barriers which were identified from the literature and occurred in practice in the Uithoflijn project for different enablers. A detailed analysis of the barriers has been provided in Appendix D1.

Barrier	Enablers				
	1	2	3	4	5
Lack of understanding of these enablers		✓		✓	✓
Lack of guidance/methodologies from theory to implement these enablers		✓		✓	✓
Team members unwilling to accept changes as old commitments need to be kept	✓	✓			
Organizations resistant to adopt these enablers out of fear of consequences		✓		✓	✓
Contractual requirements/Fixed price contracts do not allow for changes	✓				
Skepticism towards new way of working	✓	✓			
Lack of trust from stakeholders				✓	✓
Lack of people collaboration and active participation	✓		✓		
Implementation of iterations in plans can be difficult for employees	✓	✓			
Lack of management support	✓			✓	
Over scoping and rework		✓	✓	✓	✓
Unable to estimate time and budget	✓	✓			
Unwillingness to put more efforts		✓			
Political vulnerability	✓				
Notion that it can lead to additional delay and cost expense (Not found in literature)		✓		✓	

Unacceptable by a few contractors (Not found in literature)	✓	✓			
Difficulty to decide and prioritize between different deliveries (Not found in literature)		✓			
Management of expectations is difficult (Not found in literature)				✓	
Notion that certain enablers cannot be applied to construction industry (Not found in literature)				✓	✓

Table 4.3: *Identified Barriers- Case 1*

*(**Notation:** '1'- Iterative Planning; '2'- Iterative Delivery; '3'- Short Feedback Loops; '4'- Late Locking; '5'- Continuous Locking)*

4.2.1.4. Findings from Case I- Uithoflijn Project:

From the results of this case study analysis, the following findings were noted:

1. In this case, flexibility in process was interpreted as flexibility in terms of planning process. The practitioners felt the need to be flexible in their planning and scheduling processes, mainly because of several parallel projects running alongside the Uithoflijn project.
2. The enablers of iterative planning, iterative delivery and short feedback loops were intentionally implemented in this project and occurred as an attempt of planned flexibility, while late locking occurred as an attempt of actual flexibility.
3. There were no evidences for identification or implementation of continuous locking in this case.
4. The practitioners were unfamiliar with the terms late locking and continuous locking. One of the practitioners was also unfamiliar with the term iterative delivery. Major reason for this was the lack of awareness and lack of methodologies to implement these enablers in context of construction projects.
5. In order to avoid delay in progress and to be flexible with planning and scheduling, two different plans were made, of which one followed the approach of iterative planning. It was observed that this approach was successfully utilized in this project and can be used in other similar projects that need to be flexible in its planning and scheduling. Iterative planning allowed the project team to make iterations in plan and adjust their milestones and achieve them within the set time constraints, thus enabling them to complete the project within the fixed timeline.
6. Testing and installations of tram systems using iterative delivery ensured rightful delivery of tram systems that ensured no further delay, which otherwise using the traditional approach of one-time delivery could have led to problems with system integration of tram systems.
7. The technique of time chainage diagram complemented the iterative planning process and the method of probabilistic analysis was used to track the timely deliveries of coaches, which complemented the iterative delivery process.
8. Many barriers from the theoretical framework were identified in practice for different enablers, mostly for iterative planning and iterative delivery as shown in table 4.3 and discussed in Appendix D1. Most of these barriers occurred due to unawareness of methods used to implement these enablers (cluster 1) and resistance to changes from traditional way to a new way of working (cluster 2).
9. The barriers 'management of expectation', 'notion that it can lead to additional delay and cost expense,' 'difficulty to decide and prioritize between different deliveries' and 'notion that certain enablers cannot be applied to construction industry' were not found in the literature but its occurrences were identified and occurred in the context of this case.
10. The practitioners did not attempt to resolve all the barriers listed in the table 4.3 but some of the barriers for enablers like iterative planning and iterative delivery were successfully resolved by organizing joint knowledge sessions to acknowledge project teams about these enablers, providing examples of other projects, conducting pilot testing and encouraging the project teams; as described in detail in Appendices D1.1 and D1.2.

4.2.2. Results & Analysis Case II- North South Line Project:

4.2.2.1. Project Description:

Widely regarded as one of the most challenging infrastructure projects in Dutch history, the North South Line metro project was a recent fifth addition to the existing 4-lines metro system in Amsterdam. With a total distance of 9.7 km, of which 7 km runs underground, it connects Amsterdam North to Amsterdam South in 16 minutes. Consisting of eight stations, of which 5 are subsurface stations, it carries around 120,000 passengers per day. This project has been controversial for about 40 years right from its conception until halfway through the execution phase. Initially, the project was expected to be completed in 2011-2012, which got delayed to July 22nd, 2018 with a total cost of € 3,1 billion, which is three times more than the initial estimated cost. The entire project was divided into different stages, viz., planning, design and preparation of tender documents; civil works; architectural finishing and installations; IT systems installation, integrations tests and trial runs; which was managed by multiple actors at several stages. The main stakeholders were Gemeente Amsterdam, Stadsregio Amsterdam (SRA), GVB Transport and Dienst Metro. The governance between the stakeholders was initially not established. Further, the main contractors during the construction phase were Max Bogl, Strukton, Saturn and Heijmans, while the main contractors for installations and testing systems were VIA, Alstom, Thales and Siemens. AT Osborne has played a leading role in the NSL organization and has been involved in the NSL project for over ten years, providing its expertise in the Quality & Organization, Project Management Departments, Contract Management, System integration and Implementation management.

Initially, the NSL project was prepared, organized, planned and controlled in a conventional way, which focused on detailed contracts, tight scope control, detailed planning and WBS and cost control, narrow front-end loading and top-down communication. There were approximately 15 main contracts, mainly DB and DBM. No specific project management methodology was used for managing this complex project. Due to its overall conventional strategy, most of which was left unexplored and undefined, the project suffered great delays, budget overruns, contractual disputes and interface issues, due to which the project was put on hold in 2008. As a result, there was a need for clear and strategic vision, alignment of actors and joint adaptation to complexity, which thereby needed the actors, contracts and project processes to shift from conventional to flexible practices and implement flexibility in this project in order to deal with the complexities faced by this project and deliver it.

4.2.2.2. Identification & Incorporation of Flexibility Enablers:

Based on the interviews, survey and case documents, the following table shows the results obtained on the identification and incorporation of the five flexibility enablers in the NSL project.

Enablers	Attributes	Interviewees		
		2.1	2.2	2.3
1. Iterative planning	Enabler Identified	✓	✓	✓
	Enabler Implemented (in phases)	C	C	C
2. Iterative delivery	Enabler Identified	✓	✓	✓
	Enabler Implemented (in phases)	C, D	C, D	C, D
3. Short feedback loops	Enabler Identified	✓	✓	✓
	Enabler Implemented (in phases)	C, D	C, D	C
4. Late locking	Enabler Identified	✓	✓	-
	Enabler Implemented (in phases)	C	C	-
5. Continuous locking	Enabler Identified	-	-	-
	Enabler Implemented (in phases)	-	-	-

Table 4.4: *Identification of enablers- Case 2*

*(**Notation:** 'A'-Conception phase; 'B'- Design and planning phase; 'C'- Execution phase; 'D'- Project closeout phase)*

The practice/method using which these enablers have been implemented is explained as follows:

1. Iterative Planning:

The iterative planning or the 'integral planning' as the interviewees mentioned was identified and implemented by all the three interviewees. The concept of integral planning was given priority in this project, mainly in the execution phase. The project was divided into several sub-projects that were executed parallelly, which led to scheduling challenges in the project. The planning team tried to make the process similar to the agile elements like iteration loops, where the plans and schedules were updated on a quarterly basis during execution to adapt to changes and integrate new scope. These plans were reviewed and retrospected and based on their importance/urgency the next iteration meeting was scheduled. The planning team made use of visualization tools to analyze and communicate the schedule within the project team. For smaller milestones, the iteration in planning was undertaken bi-weekly to keep the process flexible. The changes from these iterations were escalated to the steering groups, who made decisions to adopt these changes. Interviewee 2.1 mentioned- "*It was a good practice to have certain regular points in schedule that you review regularly and bi-weekly as we can be flexible in adjusting the schedule without hampering the set milestones and also if some major issues happen, this approach allowed us to change our planning than enforcing the teams to follow the previous plans."* Based on the case documents, there appears to be a sound approach for iterations made to using the integral planning approach during the execution phase, as reported by the planning team. The integral planning approach implemented in this case is comparable with the iterative planning approach mentioned in the literature review section 2.4.1. The traces of agile elements of iteration loops were identified in this project that enabled flexibility, the approach of which was different than traditionally managed projects in execution phases. Based on the interview responses and case documents, there was an intentional application of this enabler, thereby an attempt of planned flexibility in incorporating this enabler.

2. Iterative Delivery:

The enabler of iterative delivery formed the base of this project and "*was the major concept used in the project,*" as stated by interviewees 2.1 and 2.2. Iterative delivery was identified and implemented distinctly in the execution and project close out phases using the concept of 'release management', in which the entire project was not delivered at once but in small deliveries in iterations. This corresponds to the technical part and the working metro system line. The project was divided into smaller subprojects and smaller milestones, and every smaller part was released step by step with each release being a step closer towards the final milestone. A robust system integration process was used where each delivery was planned, executed, tested and validated, with each cycle being evaluated and adapted as a result of planning. These releases were evaluated by the internal project management team on a monthly basis and by the steering group on a quarterly basis. The work focused around the robust system engineering techniques and established management processes. The explanation of release management in context of this case is provided in the appendix F. It was observed that flexibility was achieved in terms of planning and scheduling along with continuous improvement as stated by interviewee 2.2- "*The work was divided in time and there was learning throughout the process as you use what you learn from the previous release and improve it for next releases. It is more like a cycle where people evaluate and also make technical adaption as a result of planning which increased flexibility in this process."* Implementation of release management approach for infrastructure projects is not a common approach, which was still applied successfully in this project. One of the reasons identified in implementation of this enabler was due to the contractual flexibility available in the contracts, that allowed the project teams to adapt to changes during these

iterations. In conclusion, iterative delivery has seen intentional implementation in the NSL project and was an attempt of planned flexibility in order to overcome the complexities faced in this project.

3. Short Feedback Loop:

This enabler was identified and implemented by all the interviewees majorly during the execution phase and to a certain extent in the project close out phase. But their acknowledgment towards this enabler was widely different. There were monthly progress meetings, review meetings, steering groups meeting conducted after a certain interval, which were identified by the interviewees as a short feedback loops and also mentioned in the case documents. In these meetings, the plan and schedules were reviewed, and decisions made were escalated to the project board. Each meeting consisted of different participant groups, based on the level of importance and issue of discussion. These meetings were conducted for a duration of 20-60 minutes depending on the urgency of the issue. For this project, the meetings that had the most resemblance with the short feedback loops were the Reflective meetings conducted by the project director himself. In this meeting, feedback sessions were conducted to provide feedback on each delivery or release, based on which the further plans were reviewed. There was no specific format or tool or technique adopted to conduct these feedback loops. However, the interviewees identified the use of Scrum meetings by a few contractor firms. The presence of agile element can be traced in conducting the progress meetings and the reflective meetings. Thus, there was an intentional use of short feedback loop in the NSL project which occurred as an attempt of planned flexibility.

4. Late locking:

Late locking was identified by two of the three interviewees, but they were unsure if their idea of late locking resembled to the actual process/definition of late locking. Both the interviewees provided examples of late locking in a similar context which were also confirmed from the case documents. Two instances for late locking were mentioned. The first instance where late locking was considered to be applied was for the commencement date of operations of the metro line. The initial date announced was bypassed, and the new date to be announced was not set until more progress level and information was achieved. It was decided in 2016 to set the commencement date to July 22, 2018, which was a year and half after the announcement date, and so the interviewees regarded this as an example of late locking. The second instance referred to as late locking were based on decisions on testing of metro signaling systems and number of metros required for testing the line. The decisions of certain signaling systems have still not been fixed due to changing technological requirements and integration challenges. All these decisions were taken in consensus with the steering board and project team. There was no tool or technique implemented for keeping these decisions for late locking and it was neither decided to keep these decisions for late locking. It can be said that in this project, late locking occurred at the project level and not on the decision-making level, as the late locking occurred after the decision to build. Thus, in the NSL project there was an unintentional application of late locking, thereby making its incorporation as an attempt of actual flexibility in decision-making process.

5. Continuous locking:

For this case there was a difficulty to trace the implementation of continuous locking as it was not recognized by any of the three interviewees. Based on the responses, it could be stated that the interviewees had no prior knowledge of continuous locking and they were unable to distinguish between late locking and continuous locking. Also, in the case documents no decisions were found to be fixed using continuous locking approach. Thus, there was no incorporation of continuous locking in the NSL project.

4.2.2.3. Identified Barriers in incorporation of Flexibility Enablers:

Based on the interview responses and case documents, the barriers/challenges faced by the practitioners in the identification and implementation of these enablers were identified. The following table mentions only those barriers which were identified from the literature and occurred in practice in the North South Line project for different enablers. A detailed analysis of the barriers will be provided in Appendix D2.

Barrier	Enablers				
	1	2	3	4	5
Lack of understanding of these enablers		✓		✓	✓
Lack of guidance/methodologies from theory to implement these enablers		✓		✓	✓
Insufficient training and coaching		✓		✓	
Team members unwilling to accept changes as old commitments need to be kept	✓	✓			
Organizations resistant to adopt these enablers out of fear of consequences		✓			
Skepticism towards new way of working		✓			
Lack of trust from stakeholders		✓		✓	
Lack of people collaboration and active participation			✓		
Planning fallacy and optimism bias	✓	✓			
Implementation of iterations in plans can be difficult for employees	✓				
Poor interfaces between design and construction and improper coordination	✓	✓			
Over scoping and rework	✓	✓	✓		
Unwillingness to put more efforts		✓	✓		
Political vulnerability	✓	✓		✓	
Notion that it can lead to additional delay and cost expense (Not found in literature)	✓				
Unacceptable by a few contractors (Not found in literature)	✓	✓		✓	✓
Notion that certain enablers cannot be applied to construction industry (Not found in literature)		✓			✓

Table 4.5: *Identified Barriers- Case 2*

*(**Notation:** '1'- Iterative Planning; '2'- Iterative Delivery; '3'- Short Feedback Loops; '4'- Late Locking; '5'- Continuous Locking)*

4.2.2.4. Findings from Case II- North South Line Project:

From the results of this case study analysis, the following findings were noted:

1. In this case, flexibility in process was interpreted as flexibility in planning and scheduling. The practitioners recognized the need to be flexible in their planning processes in order to cope with the growing complexities and to ensure timely delivery of this project (without causing any further delay in this project).
2. Iterative planning, iterative delivery and short feedback loop had intentional implementation while there was an unintentional implementation of late locking. Continuous locking was not recognized and incorporated in the context of the NSL project.
3. The practitioners were unfamiliar with the term continuous locking and to a certain extent late locking. None of the practitioners from this case was aware of these enablers in the context of infrastructure projects as in infrastructure projects all decisions need to be taken and conveyed to the involved authorities and stakeholders prior to the construction processes.
4. The approach of integral planning resembled the enabler of iterative planning that granted flexibility in making alterations to the plans and schedules at regular intervals with regular

retrospections. Using this approach made it possible to adjust the scope and accommodate the required changes in an iterative manner. As this approach had a successful application in this project, it can be applied to other infrastructure projects where there is a need to achieve flexibility in their plans and schedules in order to accommodate changes occurring dynamically.

5. The enabler of iterative delivery formed the basis of this project, which was incorporated using a concept of release management. It is an uncommon practice identified in the infrastructure projects which proved to be successful in the NSL case. It made the process flexible than that compared to traditional processes, as the division of projects into different releases and delivery of different releases offered flexibility in deciding in what ways each part must delivered and what should be changed in following releases. This offered possibility to learn from the previous releases and improve the process to achieve the end results.
6. A lot of barriers were recognized for incorporation of iterative planning and iterative delivery as shown in table 4.5 and discussed in Appendix D2. As release management was most adopted flexibility enabler as compared to the other enablers, it can be seen that the interviewees mentioned most of the identified barriers in the context of release management, which mainly occurred due to lack of understanding these methods (cluster 1), resistance towards adopting a different way of working that was new to such type of projects (cluster 2) and lack of proper managerial practices in adopting the new method of release management (cluster 3).
7. Three additional barriers were found from practice, viz. 'notion that it can lead to additional delay and cost expense', 'unacceptable by a few contractors' and 'notion that certain enablers cannot be applied to construction industry', as discussed in Appendix D2.
8. Although the practitioners did not attempt to resolve all the barriers, they were able to overcome some of the barriers by creating awareness by conducting regular training and workshops on release management and providing insights on application of these enablers from software industries. Pilot testing was also conducted for intermediate releases in collaboration with the contractors, which encouraged the people to use these enablers and gained their acceptance; as described in detail in Appendices D2.1 and D2.2.

4.2.3. Results & Analysis Case III- HollandPTC Project:

4.2.3.1. Project Description:

The HollandPTC project is regarded as the first of its kind project in the Netherlands. It is unique because it is the first proton therapy center in the Netherlands and one of the fewest proton therapy centers in the world. It is located on the TU Delft campus and next to the Reactor Institute in Delft. The proton therapy is a new irradiation technology used first time in the Netherlands, which added to the complexity of this project in its realization phase and commission phase. The conception phase for this project began in the year 2009, and the construction began in 2015. The project was delivered in late 2017 and officially opened in the year 2018. The total project cost was approximately € 108,75 million. This project was a joint venture of the Erasmus Medical Centre, the Leiden University Medical Centre and TU Delft, who were the main stakeholders. The focus of the clients was to deliver a sustainable building and adopting a flexible design process. In order to achieve, it was necessary to adapt to flexible practices in the HollandPTC project.

AT Osborne provided its project management expertise right from its front-end phases to its delivery. The PRINCE2 project management methodology was adopted to manage the HollandPTC project. It provided flexibility in terms of decision-making process more than the planning process. It did not provide flexibility in terms of organizational level; hence the changes made to decisions first had to be escalated to the steering group and the project board. The contract type was traditional, which offered flexibility in planning and decision-making phases in the conception and design phase until the contractor was on board, thereafter, implementing flexibility up to a certain level in the execution phase. The project had a vision of Motion Consult, where success was regarded as a combination of three factors- clearly defined project and team results, project processes, interactions and dynamics; which was complementary in implementing flexibility enablers in this project.

4.2.3.2. Identification & Incorporation of Flexibility Enablers:

Based on the interviews, survey and case documents, the following table shows the results obtained on the identification and incorporation of the five flexibility enablers in the HollandPTC project.

Enablers	Attributes	Interviewees		
		3.1	3.2	3.3
1. Iterative planning	Enabler Identified	✓	✓	✓
	Enabler Implemented (in phases)	B, C	C	C
2. Iterative delivery	Enabler Identified	-	-	-
	Enabler Implemented (in phases)	D	-	-
3. Short feedback loops	Enabler Identified	✓	✓	✓
	Enabler Implemented (in phases)	B, C, D	B, C, D	C, D
4. Late locking	Enabler Identified	✓	✓	✓
	Enabler Implemented (in phases)	B, C	B, C	C
5. Continuous locking	Enabler Identified	✓	✓	-
	Enabler Implemented (in phases)	C	C	-

Table 4.6: *Identification of enablers- Case 3*

*(**Notation:** 'A'-Conception phase; 'B'- Design and planning phase; 'C'- Execution phase; 'D'- Project closeout phase)*

The practice/method using which these enablers have been implemented is explained as follows:

1. Iterative Planning:

Iterative planning was recognized and implemented in practice in this case in the design phase and execution phase. There were two instances identified where this enabler was used. First in the design and planning phase, where iterations were made for the detailed design of the hospital building. However, in this phase it was done quarterly and major reason to apply iterative planning was due to the specification adopted for hospital building, which was Type C, instead of the required Type B specification. Furthermore, in the design phase the project had to be reduced by 25% as one of the four partners had left the project, due to which there were changes made in the design, which was another reason for implementing iterative planning that enabled flexibility in planning. Here, the iterations were conducted quarterly. The second instance where iterative planning was observed was in the execution phase during the installation of medical machinery and equipment. As mentioned by one of the interviewees- "*Due to inexperience with proton equipment a lot of changes occurred and the users wanted certain things differently so we had to always keep changing our plans and schedules based on the user requirement for which we followed iterative approach you can say similar to agile in software for delivering these changes."* The iterations in this phase were conducted and performed monthly in consultation with contractors and in these iterations, changes were made in the plans and schedules based on the project requirement and project progress, which were further reviewed, based on which the decision for next iterations were made; thereby following the process of iterative planning as defined in section 2.4.1. The interviewees mentioned that implementing this enabler emerged during the process which granted flexibility in planning processes. Its application was not planned or mentioned in the business case. Thus, there was an unintentional application of iterative planning in this case, thereby an attempt of actual flexibility in the design as well as the execution phase in the HollandPTC project.

2. Iterative Delivery:

All the interviewees had difficulty in identifying this enabler in the context of construction industry. One of the interviewees stated- "*This enabler was the most difficult to identify. I am not certain to use this in building projects."* Two interviewees acknowledged the application of this enabler in the software industry during which they compared the WBS used in the project to iterative delivery approach. Interviewee 3.1 provided an analogy to the process of testing and validation of medical equipment, where certain equipment (like hot cells, oxygen chamber) were installed, tested, reviewed and delivered. However, he was unsure if these processes could be considered as application of iterative delivery. There were no other examples or instances mentioned in the interviews or identified in the documents that traced the implementation of iterative delivery. Due to its unclear recognition, it can thus be stated that this enabler was not implemented in the HollandPTC project.

3. Short Feedback Loop:

This enabler was most easily acknowledged by all the interviewees and they stated that it was implemented as a result of PRINCE2 methodology used in this project which mentioned the application of short feedback loops at regular intervals in the business case. This enabler was implemented in the design phase, execution phase as well as project closeout phase. Short feedback loops were conducted for various purposes, like monitoring the plans and schedules, monitoring progress and reviewing the iterations made in iterative planning. Conducting "*short feedback loops in this project was introduced by the project manager to manage several parallel teams and project works simultaneously, and keep the project team updated with the ongoing works*" as stated by interviewee 3.2, who further mentioned that the project manager had a strong influence on this meetings who delegated the responsibilities to different team leaders and team members for

conducting these loops, with the project manager being the endpoint of responsibility. For the contractor firm, short feedback loops were also conducted as stand-up meetings on a daily basis in the execution phase for a duration of 15-20 minutes. It was observed that there was no theoretical model or method used for conducting these meetings. But these feedback loops resembled to the Scrum meetings and daily stand-ups as used in the agile project management methodology. Thus, it can be said that there was an implicit use of agile elements in this project and an intentional incorporation of this enabler, thereby making it an attempt of planned flexibility in this case.

4. Late locking:

Late locking was distinctly identified and deliberately incorporated in the design and planning and execution phases for the decision-making processes for fixing the decisions based on the selection and acquiring of medical devices like MRI, CT Scans and Cyclotrons. Decisions for internal arrangement of building spaces for some laboratories were also kept for late locking. The former is an example of flexibility in the decision process, while the latter is an example of flexibility in building design, and hence the latter can be discarded as it is not in the scope of this thesis. It was implemented for postponing the decisions further ahead in time in order to acquire the latest medical equipment, thus providing room for flexibility in decision-making. Other reasons to implement late locking was- because HollandPTC was the first proton therapy center in Holland, it required different permits and more training and supervision to obtain these permits. "*There was lack of available information at the start of the project about this heavy medical equipment*," as a result of which it was wise to keep the decisions on medical equipment for late locking. These decisions were made in the early project stages before the decision to build, due to which the late locking applied was at the 'decision-making level' and not at the 'project level.' As stated by interviewees 3.1 and 3.2, "*it is a common practice to use late locking as an enabler in the hospital projects*." However, no tool or technique complemented using late locking as it was done merely by consensus. In conclusion, it can be stated that the enabler of late locking was intentionally used in the HollandPTC project, and it was an attempt of planned flexibility.

5. Continuous locking:

This enabler was acknowledged by interviewees 3.1 and 3.2, but they stated that there was a fine line of distinction between late locking and continuous locking. Two instances were observed as phenomena of continuous locking from the responses of interviewees 3.1 and 3.2 which was in a similar context to late locking. It was implemented for decisions on installations of equipment like hot cell and the irradiation equipment for PT (proton) equipment. The decisions had to be locked continuously based on the test results of these equipment, their specification and the laboratory requirements. However, they were skeptical if decisions kept for identified as continuous locking were incorporated as late locking or continuous locking. They considered "*continuous locking as a normal process in planning and decision making, most often used for decisions based on critical path planning,"* as stated by interviewee 3.2. Furthermore, no tool or technique was incorporated in its application. As enough traces of decisions for continuous locking were not found in the case documents and there were no concrete responses by the interviewees, it cannot be concluded if its application was an attempt of planned flexibility or actual flexibility.

4.2.3.3. Identified Barriers in incorporation of Flexibility Enablers:

Based on interview responses and case documents, the barriers/challenges faced by the practitioners in the identification and implementation of these enablers were identified. The following table mentions only those barriers which were identified from the literature and occurred in practice in the HollandPTC project for different enablers. A detailed analysis of the barriers will be provided in Appendix D3.

Barrier	Enablers				
	1	2	3	4	5
Lack of understanding of these enablers		✓			✓
Lack of guidance/methodologies from theory to implement these enablers	✓	✓			
Tendency of team members to stick to initial plans and decisions changes	✓				
Team members unwilling to accept changes as old commitments need to be kept	✓				
Organizations resistant to adopt these enablers out of fear of consequences	✓	✓			
Skepticism towards new way of working	✓	✓			
No initiation from the project members to adapt to flexibility enablers	✓	✓	✓		
Lack of trust from stakeholders				✓	✓
Lack of people collaboration and active participation	✓		✓		
Fear of conflicts between project teams and stakeholders				✓	
Dependency on project managers to assign tasks	✓				
Implementation of iterations in plans can be difficult for employees	✓				
Lack of management support		✓			
Unable to estimate time and budget		✓		✓	✓
Unwillingness to put more efforts	✓	✓			
Notion that it can lead to additional delay and cost expense (Not found in literature)	✓	✓			✓
Unacceptable by a few contractors (Not found in literature)	✓			✓	
Notion that certain enablers cannot be applied to construction industry (Not found in literature)		✓			
Requirement of constant risk monitoring (Not found in literature)				✓	✓

Table 4.7: *Identified Barriers- Case 3*

*(**Notation:** '1'- Iterative Planning; '2'- Iterative Delivery; '3'- Short Feedback Loops; '4'- Late Locking; '5'- Continuous Locking)*

4.2.3.4. Findings from Case III- HollandPTC Project:

From the results of this case study analysis, the following findings were noted:

1. In this case, flexibility in terms of decision-making was given more importance than in terms of planning, as the practitioners recognized the need to be flexible in their decision-making processes due to unavailability of required information in the early project phases.
2. The enablers of iterative planning, short feedback loop and late locking were intentionally implemented in this case and occurred as an attempt of planned flexibility. The incorporation of continuous locking was unclear.
3. The practitioners were unfamiliar with the concept of applying iterative delivery in hospital building projects as they lacked the awareness and the methods used to apply it in practice.
4. The application of iterative planning in the design phase led to continuous improvement in the designs and plans, thereby adapting to new circumstances and meeting the client's demands. This is a clear contrast to the conservative and rather inflexible way most hospital building projects in the construction industry are managed today. As this approach was successfully

implemented in this project, it can be implemented in other similar projects in its design phases.

5. The enabler of late locking was observed to be a common practice in hospital building projects although it had lesser recognition as an enabler that implements a flexible decision-making process. The practitioners must recognize the application of late locking and attempt to develop tools to incorporate it or attempt to implement it using the stage-gate model which is a tool known for the process of late locking.
6. No new/specific tools or techniques were used for the implementation of enablers.
7. Barriers mentioned in the literature were identified in the implementation of enablers in this project as shown in table 4.7 and discussed in Appendix D3. It was observed that most of the barriers occurred due to a lack of awareness (cluster 1) and organizational behavior that is more inclined towards the traditional way of working (cluster 3).
8. The additional barriers found in practice were 'notion that it can lead to additional delay and cost expense,' 'unacceptable by a few contractors', 'notion that certain enablers cannot be applied to construction industry' and 'requirement of constant risk monitoring.'
9. Due to the traditional way of working, it was observed that not more emphasis was given to overcome the barriers that occurred in implementing flexible enablers. However, the project manager as well as the management encouraged the project teams to implement enablers like short feedback loops and late locking, which helped overcome barriers related to managerial processes and organization behavior (clusters 3 and 4), as described in detail in Appendix D3.1.

4.2.4. Results & Analysis Case IV- Imaging Centre Project:

4.2.4.1. Project Description:

The Amsterdam UMC's Imaging Center project is located in the VU Campus in Amsterdam. This hospital project was built as a center for medical imaging, research and radiopharmacy. It houses a large amount of and diverse, high-quality and high-tech medical equipment that are used for imaging centers, production, clinical care, preclinical and clinical research and for academics and industry. The Imaging Center project is the pioneering project in the Netherlands in which a hospital building has brought together three important components- radiological research, clinical research and isotope production, for the first time, in a compact structure. This new building will include the Tracer Center Amsterdam, BV Cyclotron VU and the Laser Lab. The project began in 2010-2011 and was delivered in 2019, with a total budget of around €43 million, with a cost overrun of €10,1 million. The main stakeholders were Amsterdam UMC, Laser Center VU, BV Cyclotron, the VU, the consortium De Beeldbouwers VOF- a joint venture of Ballast Nedam and ULC Group. This hospital building marks the beginning of redesign of the VU campus with an aim to realize and deliver a building with three main components- synergy, flexibility and sustainability; in which the role of AT Osborne was to provide their project management expertise in the front end project phases and to provide project management expertise in the relocation of the BV Cyclotron to the Imaging Center project for the entire project. No specific project management methodology was adopted in this project. Also, it was a traditional contract that allowed for more flexibility in the design phase until the contractor was onboard than that compared to the execution phase. This case focused on enhancing the factors of cooperation and communication by adopting a flexible design approach, which required the project organization to adopt flexible practices.

4.2.4.2. Identification & Incorporation of Flexibility Enablers:

Based on the interviews, survey and case documents, the following table shows the results obtained on the identification and incorporation of the five flexibility enablers in the Imaging Centre project.

Enablers	Attributes	Interviewees		
		4.1	4.2	4.3
1. Iterative planning	Enabler Identified	✓	✓	-
	Enabler Implemented (in phases)	B, C	B, C	-
2. Iterative delivery	Enabler Identified	-	-	-
	Enabler Implemented (in phases)	-	-	-
3. Short feedback loops	Enabler Identified	✓	✓	✓
	Enabler Implemented (in phases)	C	C	C, D
4. Late locking	Enabler Identified	✓	✓	✓
	Enabler Implemented (in phases)	C	B, C	C
5. Continuous locking	Enabler Identified	-	✓	✓
	Enabler Implemented (in phases)	-	C	C

Table 4.8: *Identification of enablers- Case 4*

*(**Notation:** 'A'-Conception phase; 'B'- Design and planning phase; 'C'- Execution phase; 'D'- Project closeout phase)*

The practice/method using which these enablers have been implemented is explained as follows:

1. Iterative Planning:

Iterative planning was identified and incorporated by two interviewees in the design and execution

phases. Both the interviewees provided similar examples of its application. Firstly, during the design phase, during which the design of the hospital building was completed using iterative planning process "*in order to achieve the aim of synergy, flexibility and sustainability*." In this phase, the iterations were conducted quarterly, and the plans were reviewed for further changes and changes were accommodated as per requirements before the final submission of detailed designs and plans. The second instance of iterative planning was identified in the execution phase. As the contractor was not involved in the design phase because of the traditional contract, the contractor recognized some errors with the design during the early execution phase. A change in design was necessary, and these changes in design during the later project phases were delivered iteratively by the project team. These iterations were performed on a bi-weekly basis in consultation with the contractor. Although this provided flexibility in the process, but the interviewees were unsure if this practice resembled the iterative planning approach. The approach of iterative planning was not similar to that mentioned in the literature review section 2.4.1, as it involved only reviewing the designs for its suitability. Thus, there was an unintentional implementation of iterative planning in this case, thereby an attempt of actual flexibility.

2. Iterative Delivery:

There was no acknowledgment of this enabler in this case. All the interviewees had an opinion that this enabler cannot be incorporated for building projects. Interviewee 4.3 compared this enabler with WBS used in construction projects and it should be used in hospital building projects as it can add to complexities. Interviewee 4.1 stated- "*this enabler was not implemented in this project because it was a technical building and they did not want a room for mistake*." In this case, it was observed that the project was managed using traditional practices, where the interviewees opposed the process of iterative delivery. Even the case documents did not register any instances on the application of this enabler. Based on interview responses and case documents, it can be stated that there was no incorporation of iterative delivery in this project.

3. Short Feedback Loop:

Short feedback loop was identified as an enabler by all three interviewees distinctly in the execution phase. All three interviewees acknowledged the daily stand-ups used by the contractor firm, which also included few members from client teams. These daily stand-ups were conducted for a duration of 15-20 minutes. Interviewee 4.3 implemented short feedback loop in the close out phase and mentioned that he was responsible for conducting short feedback loop (meeting) every week during last phases to discuss the results of validation and commissioning of medical equipment. These loops were conducted for a duration of 30-45 minutes and was attended by the clients and contractors. Interviewees 4.2 and 4.3 stated that these meetings resembled the Scrum meetings from the IT sector. The interviewees also mentioned about the meetings which were conducted for reviews and consultation, but these meetings were not conducted regularly, but as per requirement. Although there was an implicit use of agile element in this case, it was observed that this enabler was unintentionally used. Thus, the incorporation of short feedback loop was an attempt of actual flexibility in this case and not planned flexibility.

4. Late locking:

This enabler was identified by all the interviewees and was deliberately implemented in this project in the execution phase. All the interviewees applied it for decisions based on the design of laboratories, selection of heavy medical equipment like CT, MRI and cyclotrons, and installation of hot cells. The decisions were postponed to later moments in the front-end phases and execution phases

which helped them achieve flexibility in the decision-making process, as stated by the interviewee 4.2, but interviewees 4. 1 and 4.3 could identify it only during the execution phase, due to their presence and active role majorly in these phases. The project management team and the client organization actively decided to keep certain decisions open for later moments as they felt the need to have flexibility in the decisions taken because they wanted to procure the latest available technology and they needed enough information and time to procure this important equipment. "*The implementation of this enabler was influenced by the project organization,"* as stated by interviewee 4.3. There was no tool or technique used for implementing this enabler in practice but was based on the experience of the project team responsible for the construction of the hospital building project. These decisions were made in the early project stages before the decision to build, due to which the late locking applied was at 'decision-making level' and not at the 'project level.' Due to its deliberate implementation, it can be stated that there was an intentional application of late locking in this project, thereby making an attempt of planned flexibility.

5. Continuous locking:

The interviewees 4.2 and 4.3 identified and implemented continuous locking in a similar context by providing similar examples from the execution phase. It was incorporated for making decisions based on the timely purchasing of medical inventory (DEXA and mammography), similar to the decisions made for late locking. Although the interviewees identified such decisions as continuously locked, but they were not sure if these decisions can be considered as late locking or continuous locking. It was observed that the interviewees were unable to distinguish between late locking and continuous locking. Hence, even if they provided examples for continuous locking, it cannot be concluded if those decisions could be classified as an example of implementing continuous locking enabler. The application of continuous locking for decisions mentioned by the interviewees was not evident in the case documents, and hence it cannot be confirmed whether this enabler was applied intentionally or unintentionally. Also, it cannot be concluded if the incorporation of this enabler was an attempt of planned flexibility or actual flexibility.

4.2.4.3. Identified Barriers in incorporation of Flexibility Enablers:

Based on the interview responses and case documents, the barriers/challenges faced by the practitioners in the identification and implementation of these enablers were identified. The following table mentions only those barriers which were identified from the literature and occurred in practice in the Imaging Centre project for different enablers. A detailed analysis of the barriers will be provided in Appendix D4.

Barrier	Enablers				
	1	2	3	4	5
Lack of understanding of these enablers	✓	✓			
Lack of guidance/methodologies from theory to implement these enablers	✓	✓	✓	✓	✓
Insufficient training and coaching		✓			
Lack of qualified members (who are aware of these enablers)	✓	✓		✓	
Tendency of team members to stick to initial plans and decisions changes	✓				
Team members unwilling to accept changes as old commitments need to be kept	✓	✓			
Organizations resistant to adopt these enablers out of fear of consequences	✓	✓			
Skepticism towards new way of working	✓	✓			
No initiation from the project members to adapt to flexibility enablers			✓		
Lack of trust from stakeholders				✓	

Lack of people collaboration and active participation			✓		
Dependency on project managers to assign tasks			✓		
Lack of management support			✓		
Unable to estimate time and budget				✓	
Unwillingness to put more efforts	✓	✓			
Notion that it can lead to additional delay and cost expense (Not found in literature)	✓	✓		✓	
Unacceptable by a few contractors (Not found in literature)				✓	
Notion that certain enablers cannot be applied to construction industry (Not found in literature)		✓			

Table 4.9: *Identified Barriers- Case 4*

(**Notation: '**1'- Iterative Planning; '2'- Iterative Delivery; '3'- Short Feedback Loops; '4'- Late Locking; '5'- Continuous Locking)

4.2.4.4. Findings from Case IV- Imaging Centre Project:

From the results of this case study analysis, the following findings were noted:

1. Flexibility in this case was interpreted in terms of decision-making process.
2. The enabler of late locking was the only enabler that was intentionally implemented. The enablers- iterative planning, short feedback loop and continuous locking was implemented unintentionally. Iterative delivery was not incorporated in this project.
3. The practitioners were unfamiliar with the term iterative delivery in the context of hospital building projects, mainly due to lack of awareness in construction and resistance to change and adopt a new way of working. The practitioners were also not fully aware of the concept of iterative planning in construction context but were aware of agile elements in iterative planning.
4. Although iterative planning was incorporated in this project, the need for its application arose in order to achieve flexibility in design process. Using bi-weekly iterations, it was possible to review the plans regularly and be flexible in its planning.
5. The enabler late locking was familiar to all practitioners and was incorporated by them in several other projects. Hence, based on their experience, they applied it also for the Imaging Center project. This enabler provided flexibility in decision-making process as it enabled postponing the decisions until more information was obtained for required heavy medical equipment.
6. No new/specific tools or techniques were used for the implementation of these enablers.
7. The common barrier identified for all 5 enablers was 'lack of guidance from theory to implement these enablers.' Most of the practitioners mentioned that they would only implement these enablers in practice if they have proper guidelines and techniques to apply it (cluster 1). It is further discussed in Appendix D4.
8. Additional barriers found in practice were- 'notion that it can lead to additional cost and delay', 'unacceptable by a few contractors', and 'notion that certain enablers cannot be applied to construction industry.'
9. In this project, it was observed that the practitioners did not attempt to overcome the identified barriers that occurred while incorporating the flexibility enablers. All three respondents followed a traditional approach in project management due to which they were hesitant in implementing the enablers without proper methodologies and hence overlooked the barriers that occurred in its application and preferred to continue using the traditional approach in practice.

4.3. Cross-case Analysis

This section presents the analyses of all the case studies together. Firstly, it will discuss the similarities and differences in the incorporation of the flexibility enablers in practice between the infrastructure sector and the healthcare real estate sector. Secondly, it will establish a link between the barriers found in the theoretical framework and that found in practice, which were investigated in the document review and interviews.

4.3.1. Results- Incorporation of Flexibility Enablers:

In the following table, an overview of the enablers incorporated in the four cases is stated, along with the tools/techniques used to incorporate these enablers, followed by the discussion on similarities and differences observed in their incorporation. Based on the findings of per case analysis, the aim is to acknowledge the incorporation of the five enablers in two different construction sectors and identify whether they are implemented in a similar manner or differently. This section aims to provide an answer to sub-research question 3 of the research.

Enablers	Application	Case 1	Case 2	Case 3	Case 4
1. Iterative planning	Planned flexibility (in phase)	C	C		-
	Actual flexibility (in phase)	-	-	B, C	B, C
	Tools/Techniques	Similar to literature; Time-chainage diagram	Integral planning	Similar to literature	-
2. Iterative delivery	Planned flexibility	D	C, D	-	-
	Actual flexibility	-	-	-	-
	Tools/Techniques	Similar to literature; Probabilistic analysis	Release management	-	-
3. Short feedback loops	Planned flexibility	B, C	C, D	B, C, D	-
	Actual flexibility	-	-	-	C
	Tools/Techniques	Progress meetings, Review meetings, Daily stand-ups	Reflective meetings, Scrum, review meetings	Daily stand-ups, Review meetings, Progress meetings	Daily stand-ups, Scrum
4. Late locking	Planned flexibility	-	-	B, C	C
	Actual flexibility	C	C	-	-
	Tools/Techniques	-	-	Collaborative Consensus	Consensus
5. Continuous locking	Planned flexibility	-	-	-	-
	Actual flexibility	-	-	C	C
	Tools/Techniques	Stated Stage-Gate model	-	-	-

Table 4.10: *Results- Incorporation of flexibility enablers*

*(**Notation:** 'A'-Conception phase; 'B'- Design and planning phase; 'C'- Execution phase; 'D'- Project closeout phase)*

4.3.1.1. Similarities in incorporation of enablers between two sectors:

This section provides a discussion on similarities observed in the implementation of flexibility enablers for the cases from infrastructure and healthcare real estate sectors.

1. Iterative Planning:

The method of incorporation of this enabler in both infrastructure and one healthcare project had similar approach as mentioned in the literature. In these cases, the iteration planning loop followed the process of planning, executing (here executing refers to addition/changes in scope) and reviewing. Every iteration loop was conducted at monthly and/or quarterly intervals.

2. Iterative Delivery:

In both the sectors, iterative delivery to a certain extent was referred to as the WBS method, which however cannot be considered as an approach of iterative delivery.

3. Short Feedback Loop:

a) In both sectors, short feedback loops were conducted in the form of progress meetings, review meetings, and daily stand-ups. Elements of Scrum were identified in few cases. In both the sectors, the daily stand-ups were conducted by the contractor firm for a duration of 15-20 minutes, while the other feedback meetings lasted for 30-60 minutes. It was mainly used in the execution phase.

b) The enabler of short feedback loop provided flexibility in all these cases by enhancing interactions between different project teams and keeps the project team updated about the project activities, changes and progress, which also made it easier to adopt certain changes and take quick decisions.

4. Late locking:

Although late locking was not recognized well in the infrastructure sector, one point of similarity where late locking was observed based on decisions on testing and validations of systems *(Coaches and signaling system in case of infrastructure and medical equipment in case of healthcare).*

5. Continuous locking:

As this enabler was not implemented in the infrastructure sector, no point of similarity was observed.

4.3.1.2. Differences in incorporation of enablers between two sectors:

This section provides a discussion on differences observed in the incorporation of flexibility enablers for the cases from infrastructure and healthcare real estate sectors.

1. Iterative Planning:

a) Though the method of incorporation of iterative planning was found to be similar in infrastructure and healthcare projects, its incorporation is more common in the execution phase for infrastructure projects and design phase for healthcare real-estate projects. New methods were found in infrastructure cases as a complement to this enabler, viz., time-chainage diagram and integral planning.

b) The analogy of iterative planning to the infrastructure project can be compared to the rolling wave planning in project management. It can also be compared to the process of progressive elaboration which is an iterative process in project management that helps project teams make project plans with clear and additional details at the later project stages.

c) The implementation of this enabler has been increasing in healthcare real estate projects to gain flexibility in terms of design spaces and enabling rapid changes in the planning process.

2. Iterative Delivery:

a) This enabler was found to be implemented only in the infrastructure sector, where it was incorporated for the testing, installations and validations of metro/trams. Here, the systems were executed, tested and delivered iteratively, with each iteration conducted monthly as well as quarterly, thereby granting flexibility in its commissioning phase.

b) It was a continuous learning process which was facilitated using techniques of release management (*uncommon technique applied to infrastructure projects)* and probabilistic analysis that enabled a flexible delivery process than that compared to the traditional approach.

3. Short Feedback Loop:

Although this enabler was implemented in a similar fashion in both infrastructure and healthcare real estate sectors, it was observed that Short feedback loop has been used in almost every infrastructure project, although it might not be acknowledged as an enabler of flexibility in every project, than that compared to the healthcare projects, where it is dependent on the adopted project management methodology and the project managers.

4. Late locking:

a) The incorporation of late locking is a common practice in healthcare real estate projects than compared to the infrastructure projects and was also most distinctly identified in the former.

b) There was no specific method used for implementing late locking in both sectors. In the healthcare sector, the decisions to be kept for late locking were merely done by collaborative consensus between the steering board and the project team.

c) It was observed that the project owners favor the enabler of late locking in healthcare construction projects as they have to take into account the changing demands that may result from rapidly changing technology, changes in regulations, and changes in treatment methods, which create the need for flexibility. Thus, late locking is adopted in order to ensure that the most up to date solutions are employed, and the building can adapt to changing demands.

d) On the other hand, late locking is not considered as an efficient enabler in case of infrastructure projects. As there is the involvement of many stakeholders, the incorporation of late locking loses their confidence in the project. Although using late locking, flexibility can be achieved, and decisions can be altered after more information is available; it might result in other difficulties like cost overruns or time overruns.

5. Continuous locking:

a) This enabler was identified by practitioners in the healthcare domain but was stated to be unacceptable by practitioners in the infrastructure domain.

b) Also, in the healthcare domain, although certain decisions were identified to be taken using continuous locking, but the practitioners failed to provide a clear distinction between late locking and continuous locking. Decisions based on installations of smaller equipment were kept for continuous locking, but this enabler was also applied using collaborative consensus and not using a specific tool or technique.

4.4. Barriers

This section establishes a link between the barriers found in the theoretical framework and that found in practice, which were investigated in the document review and interviews. Table 4.11 mentioned below lists the barriers mentioned in theory (table 2.2) and those identified in practice in the case study for different enablers as obtained from case study analysis (tables 4.3, 4.5, 4.7 and 4.9). The highlighted cells under each project represent the presence or occurrence of barriers in that specific case. The numbers inside each cell represent the flexibility enablers which encountered the listed barrier in that specific case; which follows:- '1' for Iterative planning; '2' for Iterative delivery; '3' for Short feedback loops; '4' for Late locking; and '5' for Continuous locking. *(For example, the first highlighted cell in yellow under Uithoflijn project with numbers 2, 4, 5 represents that the occurrence of barrier 'lack of guidance/methodologies from theory to implement these enablers' was identified for the enablers '2'- Iterative delivery, '4'- Late locking and '5'- Continuous locking, for the Uithoflijn project).* This table helps to obtain a general overview of barriers that occurred most commonly in all the cases for different enablers as well as those which have occurred in single cases. As all the barriers found in the literature for different enablers were not identified in practice, the cells representing such barriers are not highlighted. Also, certain barriers were only found from practice (and not found in literature) are mentioned under 'Additional Barriers'.

Barriers from the theoretical framework	Barriers identified in practice			
	Uithoflijn Project	North South Line Project	Holland PTC Project	Imaging Centre Project
I. Lack of awareness/ Lack of methodologies				
1. Lack of understanding of these enablers	2,4,5	2,4,5	2,5	1,2
2. Lack of guidance/methodologies from theory to implement these enablers	2,4,5	2,4,5	1,2	1,2,3,4,5
3. Insufficient training and coaching		2,4		2
4. Lack of qualified members (who are aware of these enablers)				1,2,4
5. Failure to explore alternatives				
II. Change resistance				
6. Tendency of team members to stick to initial plans and decisions			1	1
7. Team members unwilling to accept changes as old commitments need to be kept	1,2	1,2	1	1,2
8. Organizations resistant to adopt these enablers out of fear of consequences	2,4,5	2	1,2	1,2
9. Contractual requirements/Fixed price contracts do not allow for changes	1			
10. Skepticism towards new way of working	1,2	2	1,2	1,2
III. Organizational Behavior				
11. No initiation from the project members to adapt to flexibility enablers			1,2,3	3
12. Lack of trust from stakeholders	4,5	2,4	4,5	4
13. Lack of people collaboration and active participation	1,3	3	1,3	3
14. Fear of conflicts between project teams and stakeholders			4	
15. Keeping old bureaucracy				
16. Planning fallacy and optimism bias		1,2		

IV. Management Processes				
17. Transferring bulky traditional PM practices into fast paced iterations				
18. Dependency on project managers to assign tasks			1	3
19. Tracking issues and confusion if iterations and decision-changes not formally documented				
20. Implementation of iterations in plans can be difficult for employees	1,2	1	1	
21. Lack of management support	1,4		2	3
22. Poor interfaces between design and construction and improper coordination		1,2		
23. Over scoping and rework	2,3,4,5	1,2,3		
24. Unable to estimate time and budget	1,2		2,4,5	4
25. Unwillingness to put more efforts	2	2,3	1,2	1,2
26. Technical inconsistency				
V. Miscellaneous				
27. Scope Creep				
28. Inadequate requirement verification				
29. Political vulnerability	1	1,2,4		
30. Risk on non-predictability				
VI. Additional barriers (Found in practice)				
31. Notion that it can lead to additional delay and cost expense	2,4	1	1,2,5	1,2,4
32. Unacceptable by a few contractors	1,2	1,2,4,5	1,4	4
33. Difficulty to decide and prioritize between different deliveries (iterative delivery)	2			
34. Management of expectations is difficult	4			
35. Notion that certain enablers cannot be applied to construction industry	4,5	2,5	2	2
36. Requirement of constant risk monitoring			4,5	

Table 4.11: *Results- Identified Barriers*

(***Notation:*** *'1'- Iterative Planning; '2'- Iterative Delivery; '3'- Short Feedback Loops; '4'- Late Locking; '5'- Continuous Locking)*

As seen from the table above, different barriers from the literature were identified in different cases for each of the five enablers based on the case study analysis. This table provides an answer to sub-research question 4.

The additional barriers found in practice can be classified under the cluster of barriers based on the context in which it occurred. In this way, the theoretical framework can be updated with these additional barriers found in practice. From the table above, barrier 32- 'Unacceptable by a few contractors' can be classified under cluster II- Change resistance; barriers 31- 'Notion that it can lead to additional delay and cost expense,' 33- 'Difficulty to decide and prioritize between different deliveries,' and 36- 'Requirement of constant risk monitoring' can be classified under cluster IV- Management process; barriers 34- 'Management of expectation is difficult' and 35- 'Notion that certain enablers cannot be applied to construction industry' can be classified under cluster III- Organizational Behavior.

Based on the case study analysis, a total of eleven barriers were observed most commonly in all four case studies and were mentioned by all the twelve interviewees for one or all five enablers. Thus, the major barriers that occur in the implementation of the flexibility enablers in practice are as follows:

Code	Barrier (Most commonly occurring)	Clus -ter	Identified for enabler
B1	**Lack of understanding of these enablers**	I	Iterative planning, Iterative delivery, Late locking, Continuous locking
B2	**Lack of guidance/methodologies from theory to implement these enablers**	I	Iterative planning, Iterative delivery, Short feedback loops, Late locking, Continuous locking
B3	**Skepticism towards new way of working**	II	Iterative planning, Iterative delivery
B4	**Organizations resistant to adopt these enablers out of fear of consequences**	II	Iterative planning, Iterative delivery, Late locking, Continuous locking
B5	**Team members unwilling to accept changes as old commitments need to be kept**	II	Iterative planning, Iterative delivery
B6	**Unacceptable by a few contractors**	II	Iterative planning, Iterative delivery, Late locking, Continuous locking
B7	**Lack of trust from stakeholders**	III	Iterative delivery, Late locking, Continuous locking
B8	**Lack of people collaboration and active participation**	III	Iterative planning, Short feedback loops
B9	**Unwillingness to put more efforts**	IV	Iterative planning, Iterative delivery, Short feedback loops
B10	**Notion that it can lead to additional delay and cost expense**	IV	Iterative planning, Iterative delivery, Late locking, Continuous locking
B11	**Notion that certain enablers cannot be applied to construction industry**	III	Iterative delivery, Late locking, Continuous locking

Table 4.12: *Most commonly occurring barriers*

From the cross-case analysis, it was observed that barriers under the same cluster usually occurred together and in a similar context for various enablers (as mentioned in Appendix D). Further, to address the clusters of barriers, from table 4.12, the following can be stated:

- Barriers B1 and B2 under cluster I- 'Lack of awareness/methodologies' were identified mostly for enablers iterative planning, iterative delivery, late locking and continuous locking because these enablers are still not properly established in the context of construction industry due to which it lacks methods and techniques to apply these enablers in practice. The barrier B2 was also identified for enabler short feedback loops to a certain extent because there were no well-defined methods found to implement short feedback loops (as Scrum was not adopted in all projects). As observed from cases, there was no specific or well-defined method used in any case to implement iterative planning, late locking and continuous locking. Moreover, the release management (iterative delivery) method was used first time in an infrastructure project. Although it had successful implementation in case 2, at present it has no widespread application in the construction sector, due to which it lacks awareness in this sector.
- Barriers under cluster II- 'Change Resistance' (B3-B6) occurred for enablers iterative planning, iterative delivery, late locking and continuous locking (as mentioned in Appendix D) because the project managers and team members in the construction industry are restricted to a flexible mindset due to the attitude "this is how it always has been done." It was observed that most of the project team members did not want to change from their traditional way of working towards adopting flexible practices (e.g., using time chainage diagram in case 1 or

iterative planning in case 4), which resisted implementation of flexibility enablers, thereby leading to the occurrence of barriers identified in this cluster.

- Barriers under cluster III- 'Organizational Behavior' (B7, B8, B11) and cluster IV- 'Management Processes' (B9, B10) have been found to occur for all five enablers under a different context (as mentioned in Appendix D). To implement flexibility enablers and change from the traditional way of working requires a mindset with greater room for adjustment to the specific circumstances for the project in order to adapt to changing goals, for example, willingness to conduct and manage timely iterations and adjust plans and decisions accordingly, put additional efforts for its review and retrospections and increase in collaboration. The project members often considered such activities as processes that lead to unnecessary addition to cost and time. Due to traditional nature of construction projects (chosen for case studies), continuous iterations and adjustments in plans and schedules as well as keeping the decisions open for later moments while implementing the enablers led to lack of confidence and trust amongst the project members and the stakeholders (as mentioned in Appendix D); which further led to the occurrence of barriers as listed under clusters III and IV.

In conclusion, although the practitioners felt the need to implement flexibility enablers in practice and a few attempted to implement them, the results of cross-case analysis have shown the presence and occurrence of multiple barriers in practice for the implementation of the five flexibility enablers. Thus, it is important to overcome these barriers to facilitate the implementation of these enablers. As the next step of this research is focused on overcoming these barriers, it would be difficult to focus on all the barriers found in practice which will largely increase the scope of this research. Therefore, the next step of the research will focus on resolving the above mentioned most commonly occurring barriers (and as mentioned by the interviewees) found from the cross-case analysis, as listed above.

5

Development of Framework & Overcoming the Barriers

Photo taken during the first test run of the light rail Uithoflijn Project (Source: POUHL, Gemeente Utrecht ©)

Chapter 5: DEVELOPMENT OF FRAMEWORK & OVERCOMING THE BARRIERS

After identifying the barriers that occur in implementation of flexibility enablers and prioritizing the most commonly occurring barriers from case analysis, in this chapter a framework is developed in an attempt to resolve these barriers to stimulate the incorporation of flexibility enablers. Following this, the suggestions for overcoming these barriers as proposed in the framework are explained in detail based on the literature and from practice as observed in the case studies.

5.1. Development of Framework

A conceptual framework is developed with the aim of stimulating the implementation of flexibility enablers in WHEN category by proposing the suggestions in order to overcome the identified barriers in its implementation. This section explains the development of the proposed framework.

In consideration to the increasing need to implement flexible practices in the construction industry in order to cope with the growing complexities in the projects, it is essential to address the existence of such practices and acknowledge the practitioners in the construction industry about these flexible practices, which fall short in this traditional industry. In order to bring the change in the current way of working, i.e., from a traditional approach to a flexible approach, following a step by step approach that will first address and acknowledge the flexible practices (here, enablers) and make them explicit would be beneficial and convenient for the practitioners (Kotter, 1996) in stimulating its incorporation. Further, it is important to address the barriers that prevent the implementation of enablers, which mostly occurred due to lack of awareness and methods and resistance to change to a new way of working, as identified from case studies. Efforts must be taken to resolve these barriers in order to stimulate the implementation of flexibility enablers in construction projects. In consideration to this, a step by step approach is proposed in the form of a conceptual framework.

As it was observed from case analysis that for all enablers the barriers under same cluster were usually found to occur together, hence the suggestions have been proposed based on the cluster of barriers which could be applicable to minimize or overcome barriers along with other barriers present in a particular cluster from the theoretical framework that hamper the incorporation of flexibility enablers. In the framework, focus has been given to lay down the suggestions for clusters 1-4 as the most commonly occurring barriers for different enablers in the cases were identified from these clusters, as shown in table 4.12. Based on the context in which the barriers under different clusters occurred for the five enablers, it was decided to structure the framework into three layers. By doing so, it will be more tangible to use the framework to identify the barriers from each layer for various enablers and apply suitable suggestions. The formation of three layers in the framework is explained as follows:

Formation of Layer 1:

Construction projects are sometimes required to implement changes in their traditional way of working to a more flexible approach in order to cope with the growing complexities in projects and successfully deliver it. However, it lacks awareness of practices (and enablers) that can implement flexibility. As observed in case 2, to overcome the complexities in that project, the enabler of iterative

delivery (release management) was incorporated, which in the first place was unknown to the team members and was different as compared to the traditional practices implemented in other infrastructure projects. On the one hand, this method was successfully incorporated in case 2, on the other hand, even after its successful incorporation it lacks awareness in the construction industry and has not been used in other projects. Similarly, the enabler of late locking, which was incorporated in healthcare real estate domain was not known in the infrastructure domain. Moreover, as concluded from case study analysis, the project members are unaware of the methods to implement the enablers as there are no specific methods to implement the enablers prescribed for construction sector. Therefore, in order to make the enablers explicit, incorporate it and achieve flexibility in construction projects, it is first important to address the barriers occurring under cluster 1- 'Lack of awareness by awareness about these enablers.' This results in step 1 of this framework- **"AWARENESS"** which addresses cluster 1 and corresponds to overcoming its barriers B1- 'Lack of understanding the enablers' and B2- 'Lack of guidance/methodologies to implement the enablers,' which can be done by S1-'Create awareness about the flexibility enablers,' S2-'Provide training and workshops on application of these enablers' and S3-'Provide training to the management.' Thus, layer 1 of the framework addresses cluster 1 and comprises of step 1- "AWARENESS" that recommends suggestions S1, S2 and S3 to overcome barriers B1 and B2.

Formation of Layer 2:

When the project managers and team members from the case studies attempted to implement flexible practices, it led to major changes in how their previously used traditional project management approach was executed. For example, continuously improving the plans and schedules by conducting iterations (iterative planning) than following a single plan for the entire project *(cases 1, 2, 3)*; dividing projects into smaller parts and delivering those parts iteratively until it adapts to the unique project circumstances (iterative delivery) than delivering entire project all at once *(case 2)*; postponing the decisions to be made (late locking and continuous locking) and not fixing those decisions in the early project phases *(cases 3, 4)*. This change in the way of working was unacceptable to the team members as they were unsure of the way the enablers work and the consequences it would have on the project. Thus, a 'resistance to change' (cluster 2) was identified leading to occurrence to barriers like B3- 'Skepticism towards new way of working', B4- 'Organizations resistant to adopt these enablers out of fear of consequences', B5- 'Team members unwilling to accept changes as old commitments need to be kept' and B6- 'Unacceptable by contractors.' According to Kotter's 8-Steps of Change Management, it is important to know how to acknowledge and manage this change- in this case, from traditional to a flexible way of working (Kotter, 1996) that occurs due to implementing the enablers, which can be done by understanding how it has been done in other projects and the advantages other projects had after applying these enablers. This results in step 2 of the framework- **"INSIGHTS"** that attempts to overcome the barriers under cluster 2- Change resistance, which can be done by S4- 'Sharing positive insights from other projects on implementing the enablers,' S5- 'Concentrating on advantages of enablers,' S6- 'Start with pilot testing using enablers to gain acceptance,' S7- 'Keeping changes transparent' and S8- 'Ensure management support in adopting enablers.' Thus, layer 2 of the framework addresses cluster 2 and comprises of step 2- 'INSIGHTS' that recommends suggestions S4, S5, S6, S7 and S8 to overcome barriers B3, B4, B5 and B6.

Formation of Layer 3:

In accordance with the argument made above- incorporating the five enablers come along with changes in the way of working, these changes are generally organizational changes and/or changes in the management processes. In the case studies, these changes led to barriers identified under cluster

3- 'Organizational Behavior,' viz., B7- 'Lack of trust from stakeholders,' B8- 'Lack of people collaboration and active participation' and B11- 'Notion that certain enablers cannot be applied to construction industry;' and cluster 4- 'Management Processes,' viz., B9- 'Unwillingness to put more efforts' and B10- 'Notion that it can lead to additional delay and cost expenses.' According to Kotter's 8-Steps of Change Management, to cope with the organizational behavior and management processes in the process of establishing new ways of working, it is important to motivate people to take actions, coordinate and align their actions, and establish desired set of outcomes (Kotter, 1996). Similarly, as implementing the flexibility enablers is new to the construction industry, importance should be given to motivate people to put them in practice, the need for which has been now felt by the practitioners. This results in step 3 of the framework- **"ENCOURAGE"** that attempts to overcome the barriers under clusters 3 and 4, which can be done by S9- 'Encourage management and teams to adopt these enablers,' S10- 'Create alignment towards common goal,' S11- 'Provide estimations from pilot testing' and S12- 'Show strong commitment towards the process of applying the enablers.' Thus, layer 3 of the framework addresses clusters 3 and 4 and comprises of step 3- "ENCOURAGE" that recommends suggestions S9, S10, S11 and S12 to overcome barriers B7, B8, B9, B10 and B11.

After acknowledging the barriers in three layers and making efforts to follow the steps of Awareness, Insight, Encourage further allows to proceed to the final step of **'IMPLEMENT'**-ing the suggestions and flexibility enablers in practice. These steps also allow the framework to be used in any sector of the construction industry and in any phase of the project. The suggestions laid in each layer would be explained in detail in the section 5.2.

The framework is proposed to be a linear model following the steps of **A**wareness, **I**nsights, **E**ncourage and **I**mplement (**AIEI** framework), following which the incorporation of flexibility enablers can be facilitated. The main goal of the proposed framework is to make the enablers explicit in practice and enable its incorporation by overcoming the barriers that occur due to its implicit/no application. It is recommended to adopt the framework starting from step 1 and applying the suggestions in layer 1,and following steps 2 and 3 to step 4. Nevertheless, the formation of layers also enables to skip the layer 1 and proceed with step 2 by applying suggestions from layer 2. The flexibility is provided because if in a particular case the practitioners are aware of these enablers and there are barriers identified from cluster 2, then the suggestions from layer 2 can be adopted directly than following the linear model again starting from step 1, i.e. we can skip the step 1 and apply the framework from step 2 followed by steps 3 and 4.

The proposed framework for overcoming the barriers to implement flexibility enablers is portrayed, as shown in figure 5.1:

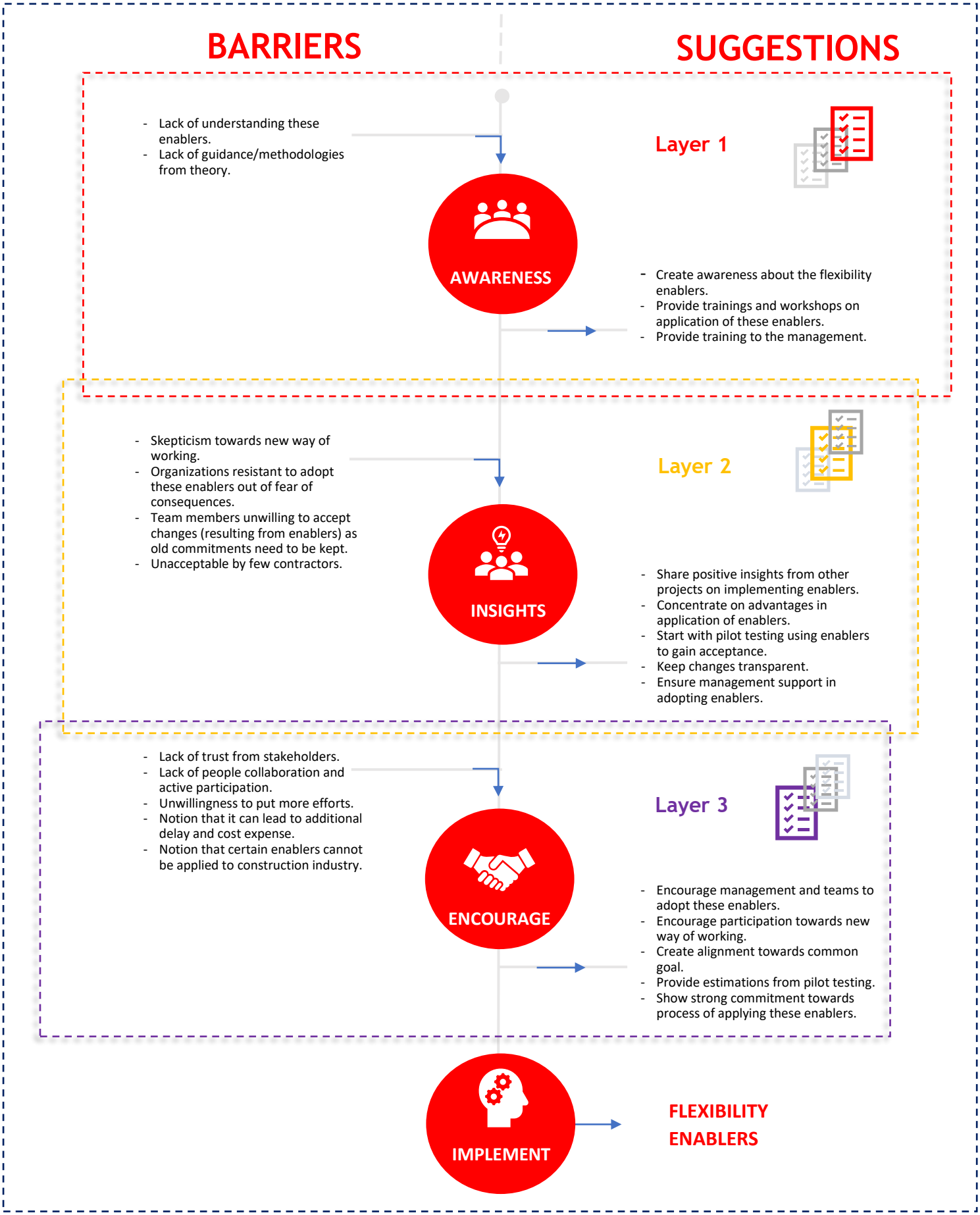


Figure 5.1: *AIEI Framework for suggestions to overcome the barriers identified in implementing WHEN- category flexibility enablers*

5.2. Overcoming the barriers

In this section, the proposed suggestions to overcome the identified barriers as listed in the framework have been explained. It explains how the proposed suggestions relate to the steps in the framework and how the respective suggestions are applicable to overcome the barriers from each layer in order to facilitate the incorporation of enablers to achieve flexibility. The suggestions are sought from literature as well as practice from other industries where the five enablers were applied to enable flexibility in project. Observations were made from the case studies based on the manner in which the practitioners (if) attempted to overcome the identified barriers, which were compared with the proposed suggestions. It is done in order to ensure whether the proposed suggestions from literature are also successfully incorporated by the industries in practice.

5.2.1. Suggestions in Layer 1- for Cluster 'Lack of awareness/ lack of methodologies'

Of the eleven prioritized barriers, two barriers that fall under this cluster are- ***B1- Lack of understanding of flexibility enablers*** and ***B2- Lack of guidance/methodologies from theory to implement these enablers***. These barriers were identified for all five enablers and hence the proposed suggestions are recommended for all the enablers. The proposed suggestions to overcome these barriers are as follows:

S1- Create awareness about the flexibility enablers:

The practitioners have felt an increasing need to implement flexible practices, but as observed from exploratory interviews as well as the case studies, they lack awareness about such practices. Hence, to make projects flexible by incorporating the enablers, developing a sense of awareness and sense of urgency, which first needs attention (Padmanabhuni, 2015), will incline practitioners towards incorporating enablers and encourage them to understand these enablers and try to develop methods to implement them. Sharing experiences of projects where the enablers have been implemented and have added to flexibility can **create awareness** in the organization, thereby resolving barriers identified in this cluster. It can be done using various communication channels like newsletter, marktgroep meetings (in AT Osborne), online discussions and workshops.

S2- Provide training sessions and workshops on application of these enablers:

Literature states that the barriers B1- 'Lack of understanding the enablers' and B2- 'Lack of guidelines/methodologies from theory' can be overcome by providing proper and regular training which can improve the understanding of these enablers and increase the chances of succeeding in incorporating enablers, especially iterative planning, iterative delivery and short feedback loop. As observed in case 2, to make this project flexible and to prevent such barriers, prior to adopting release management (iterative delivery), trainings were conducted for **creating awareness** about this concept and explaining this process, which minimized barriers B1 and B2 in case 2. A few training sessions also focused on topics discussing issues that would arise in this process which further gained confidence in the newly adopted flexible process. This training was only conducted at project level, which is recommended to be also conducted at the organizational level. Conducting workshops on methods of

implementing flexibility enablers in other industries (if not available for construction industry) can also prevent barriers B1 and B2.

S3- Provide training to the management:

From case studies, it was observed in cases 1, 3 and 4 that management failed to acknowledge the enablers. Management not understanding the flexibility enablers would not encourage incorporating them and continue following its traditional practices (Dikert et al., 2016; Inayat et al., 2015), due to which efforts must be made to educate the management in addition to suggestion S2 as in this way the management will also be **aware and informed** about the enablers, thereby overcoming the barriers under cluster 1 and further encouraging a flexible way of working.

5.2.2. Suggestions in Layer 2- for Cluster 'Change Resistance'

The barriers that fall under this cluster are: ***B3- Skepticism towards new way of working, B4- Organizations resistant to adopt these enablers, B5- Team members unwilling to accept changes as old commitments need to be kept and B6- Unacceptable by few contractors***. Although these barriers occurred for enablers iterative planning, iterative delivery, late locking and continuous locking, the proposed suggestions from the framework not only apply to overcome barriers to implement these four enablers but also can be applied for short feedback loops (if such barriers occur for this enabler). Some of the suggestions in this layer closely relate to the Kotter's 8-steps of change management, as mentioned in section 5.1. The proposed suggestions to overcome these types of barriers are as follows:

S4- Share positive insights from other projects on implementing the enablers:

It is observed that incorporating a new method or a new way often has a widespread reach through positive publicity and by making benefits visible (Dikert, et al., 2016; Gregory et al., 2016). Good results obtained in one project by implementing the enablers can develop interest and enthusiasm in team members of other projects to implement them to achieve flexibility in those projects. It can help overcome barriers B3- Skepticism towards new way of working and B4- Organizations resistant to adopt these enablers, which is often created either by misconceptions or reservedness towards flexibility. An instance where B3 and B4 were resolved using S4 was observed in case 1, where the project planner conveyed the project organization (POUHL) to adopt practices like iterative delivery for testing and delivering of coaches and achieved flexibility in project by sharing his positive experiences in application of iterative delivery based on his previous projects. After gaining positive insights shared by the project planner, the POUHL organization agreed to implement iterative delivery for testing and delivering the coaches. Similarly, this suggestion was applied in case 2, where positive insights from software industries were conveyed to project teams in applying short feedback loops and iterative delivery, who were initially resistant to applying new approaches. Furthermore, changes in plans and decisions are prone to occur if there are iterations made in them and there is a postponement of decisions. **Sharing positive insights** from other projects where changes have occurred as a result of implementing enablers can help overcome B5- Team members unwilling to accept changes, as companies will have an exemplar of an applied enabler and its results, and they can make comparisons between usual way and flexible way of working. Doing so can incline the team members towards accepting changes irrespective of the old commitments and allowing them to be

flexible in their planning and decision-making processes. S4 can be done in a formal way (in a training or meeting in addition to S2 and S3) or an informal way (like serious gaming workshops). Moreover, as implementing release management (iterative delivery) successfully led to flexibility in case 2, the insights from this case can be provided to other projects who can apply this enabler to make their processes flexible.

S5- Concentrate on advantages in application of enablers:

Literature suggests that the advantages and principles of enablers like iterative planning and iterative delivery should be emphasized more than the mechanics of its application (Moriel, 2017), which will help project teams to understand these enablers and motivate them to apply it in practice, thus gaining more acceptance (B6) and increasing the willingness to adopt them (B5). The chosen advantages and its **insights** can be provided from the literature or from practice from construction industry or others (Verret, 2018). For example, the advantages of how implementing release management in case 2 or late locking in cases 3 and 4 helped in achieving flexibility and deal with the experienced project complexities if shared with other projects will further encourage application of these enablers in those projects. This suggestion also complements S1- creating awareness and S4- providing insights and can also help in overcoming its associated barriers.

S6- Start with pilot testing using enablers to gain acceptance:

Conducting pilots prior to direct application of enablers can help in evaluating whether its application is suitable for a specific project or organization. It can identify and resolve the potential problems and provide an estimate with the time and costs required for the project (Crossman, 2020). Pilot testing is majorly used to gain acceptance from the management and also the project teams, using which can thus help overcoming barriers B4- Organization resistant to adopt these enablers and B6- Unacceptable by contractors; as the clients, contractors, as well as team members, would get **insights** on the functioning of flexibility enablers and thus gain more acceptance towards incorporating them. According to Kotter (1996), pilot testings will also help to identify and manage the change that will occur in the form of organizational behavior and management processes in implementing flexible practices. If this suggestion is used in combination with S4- sharing positive inisghts it can also help in overcoming B3- skepticism towards new way of working and B5- team members unwilling to accept changes, because achieving positive results from pilot tests will make the managers eager to try implementing the enablers. In the construction industry, it is advisable to conduct pilots on smaller projects or sub-projects to avoid major consequences. The practitioners applied this suggestion in case 2 in order to overcome B4 and B6 as mentioned by the interviewees. In case 2, as release management (iterative delivery) was not a common practice adopted for infrastructure projects, the project board, teams and contractors resisted its implementation. To make this scheme/practice acceptable, pilot testing for release management was performed for an intermediate release (of 2 stations), which further led to approval by the project board, project teams, contractors and sub-contractors. There are a few tools made available by agile promoters for pilot testing of enablers like iterative planning, iterative delivery, scrum and a few tools for pilot testing of enablers like continuous locking using stage-gate models which can be put to practice in different stages of construction projects. Pilot testings further help achieve flexibility in projects as in case if the results of incorporating enablers in the pilots do not have positive outcomes, its method of application can be altered to suit project requirements.

S7- Keep changes transparent:

As mentioned previously under S4- sharing positive insights, application of the flexibility enablers can lead to some changes in the project, which could be in terms of planning, schedules, decisions or nature of working and roles in organization. These changes could have both positive as well as negative outcomes. Enabling transparency of the expected changes and its outcomes is regarded as an important factor for success (Drury, Conboy, & Power, 2012; Kotter, 1996). In addition to this, it is necessary to communicate these changes intensively within the organization in order to reach all the team members and provide **insights and explanations** on how to cope with these changes. Doing so will gain confidence in the team and increase their willingness to adopt these enablers, thereby overcoming B5- Team members unwilling to accept changes (Moriel, 2017). This suggestion was observed in case 2 to overcome B5 where the changes (not disclosed) that occurred and were expected in each iteration or releases were timely reviewed and communicated intensively to various teams and also the contractors prior to the next releases which helped to gain the confidence of project teams to accept changes as a result of the process of implementing iterative delivery (here release management) enabler and also gained acceptance by contractors. The reflective meetings conducted in this case on a regular basis favored this purpose.

S8- Ensure management support in adopting enablers:

In addition to the above suggestions, it is recommended to ensure management support and make it visible to incorporate the flexibility enablers as it is an absolute necessity, especially to motivate team members to adopt the enablers and prevent any kind of reservedness towards the new way of working, i.e. preventing B3- skepticism towards new way of working. Also, if there is enough support from management to adopt these enablers, the team members will show no hesitation towards applying the enablers (Dikert, et al., 2016). Management support can be ensured by S3- providing training to the management on implementing the enablers and S6- using pilot tests and by providing estimations from pilots, which can also prevent barriers B4- organizations resistant to adopt enablers and B5- team members unwilling to accept changes. This suggestion proved to be applicable in case 3 where the project manager gained management support for implementing late locking that enabled flexible decision-making. Initially, late locking came in from the project board, the consequences of which had to be borne by the project manager. By doing so, the project manager was able to incorporate late locking along with the support from the managers, thereby overcoming B3- skepticism towards implementing it in this case. Also, in case 2, more management support was made visible to project teams to encourage teams to adopt the iterative delivery, which facilitated its implementation, thereby making the project flexible.

5.2.3. Suggestions in Layer 3- for Clusters 'Organizational Behavior' & 'Management Processes'

The suggestions for barriers that fall under clusters organizational behavior and management processes are provided under the same section as most of these suggestions are applicable to both the clusters thereby avoiding repetition. The barriers categorized under Organizational Behavior are ***B7- Lack of trust from stakeholders, B8- Lack of people collaboration and active participation and B11- Notion that certain enablers cannot be applied to construction industry***. The barrier categorized under Management Processes are ***B9- Unwillingness to put more efforts*** and ***B10- Notion that it can***

lead to additional delay and cost expense. Most of the barriers from these two clusters occurred for all the five enablers as shown in table 4.12 and hence the proposed suggestions are recommended for all five enablers. Similar to layer 2, some of the suggestions in layer 3 closely relate to the Kotter's 8-steps of change management, as mentioned in section 5.1. The proposed suggestions to overcome these types of barriers are as follows:

S9- Encourage management and teams to adopt these enablers:

Transforming the current way of working and incorporating new ways of working (here from traditional to flexible) requires greater encouragement and coordination in teams (Gustavsson, 2016; Kotter, 1996). Suggestions S4- sharing positive insights and S5- concentrating on advantages in applying the enablers, complement in implementing this suggestion as it will **encourage** the management and teams to use the new flexible methods. In addition to encouraging management and teams, it is important to keep the teams involved and gain their active participation in incorporating the enablers which will develop interest in using these enablers to achieve flexibility in projects. This can help overcome barrier B8- Lack of people collaboration and active participation. Enhancing involvement of team members and encouraging their participation in planning and decision-making in addition to S1- creating awareness will also increase their efforts in the process of implementing enablers, thereby trying to minimize B9- unwillingness to put more efforts. S9- encouraging management and teams to implement enablers, in complement with S6- conducting pilot testings helps in overcoming B11- notion that these enablers cannot be applied to construction industry, as pilot testing are exemplary for incorporating the enablers and understand it's working. This is a common suggestion which must be initiated/pushed forward by the project managers for their project organization. Its application was observed in case 1, where the project director encouraged people to apply time chainage diagram (iterative planning) and tried to engage the project teams, trying to prevent the barriers B8 and B9 from occurring during the implementation of time chainage diagram. The project managers can bring their experiences and new way of working to their own organizations and conduct workshops for encouraging participation towards implementing the enablers, as done by the project director in case 1 in order to achieve flexibility in the planning process. This can also minimize the barriers B11- notion that it cannot be applied to construction industry, B6- unacceptable by contractors and B4- organizations resistant to adopt these enablers.

S10- Create alignment towards common goal:

One of the factors in overcoming barriers like B8- lack of people collaboration, B9- unwillingness to put more efforts, B6- unacceptable by contractors and B5- team members unwilling to accept changes, to incorporate the flexibility enablers is to create an alignment towards the common goal of introducing and creating awareness of new methods (S1) that bring flexibility in construction management practices. It is important that all levels in the organization and in the project speak the same language and are focused towards the same goal (Dikert et al., 2016) that will **encourage** the teams to adopt the enablers for achieving the common goal. In the case of enablers like iterative planning and iterative delivery, focus on achieving a common goal is important to conduct efficient iterations. Alignment can be built by promoting positive stories and experiences (S4) about these enablers, which can encourage teams to implement enablers.

S11- Provide estimations from pilot testing:

As mentioned in S9, the benefits of pilots is that it provides knowledge on the suitability of the process in a project. The estimations obtained from pilots, and its results can serve as valuable learnings which can be shared with the stakeholders and team members who do not accept this flexible way of working (Inayat, 2015). These estimations can also gain trust and confidence from stakeholders and team members and provide certainty to those who are skeptical about incorporating the enablers and further clear their misconceptions about flexibility in project management, thereby trying to overcome barriers like B7- lack of trust from stakeholders, B10- notion that it can lead to additional delay and cost expense and B11- notion that certain enablers cannot be applied to construction industry. Estimations can also be provided using probabilistic analysis techniques, which was used in case 1.

S12- Show strong commitment towards process of applying the enablers:

A change to a new method than the usual way of working inevitably requires a strong commitment, which during the process of implementing the enablers can be put to test. Lack of methodologies and experience in incorporating the enablers can lead to certain issues that can demoralize the project teams as well as organizations (Padmanabhuni, 2015). In this situation, a strong commitment from the management assures the teams that the new process to be adopted must be carried forward. Motivations and commitments from management will also gain acceptance from the stakeholders towards flexibility enablers, thereby overcoming barrier B7- lack of trust from stakeholders and also **encourage** the team members to incorporate the enablers, thereby enhancing their participation and overcoming B8- lack of people collaboration and active participation.

While certain suggestions have been applied for certain barriers in a few cases, the suggestions from S1 to S12 have been proposed in the framework to overcome barriers identified in the case studies in identification and incorporation of the flexibility enablers. Based on the context in which the barriers occurred, the suggestions proposed can be applied in the context of all five enablers with the main objective of making these flexibility enablers explicit in the construction industry and embracing a change in the way of working from a traditional approach to a flexible approach. The following table provides an overview of each barrier and proposed suggestions as presented in the framework. Some of these suggestions were also seen in practice and applied to overcome the barriers, the reference to which has been provided in table 5.1 and explained in Appendix D. The additional suggestions which were identified in practice but have not been included in the framework (because these are similar to the proposed suggestions) are also listed in table 5.1 and represented by SX.

Barriers	Suggestions	Reference to Suggestions applicable to Barriers observed from cases
B1- Lack of understanding of flexibility enablers	S1- Create awareness about the flexibility enablers S2- Provide training sessions and workshops on application of these enablers S3- Provide training to the management	Appendix D2.1
B2- Lack of guidance/methodologies from theory to implement these enablers		Appendix D2.1
B3- Skepticism towards new way of working	S4- Share positive insights from other projects on implementing the enablers S5- Concentrate on advantages in application of enablers S2- Provide training sessions and workshops on application of these enablers	Appendix D1.1; Appendix D2.1; Appendix D3.1
B4- Organizations resistant to adopt these enablers	S6- Start with pilot testing using enablers to gain acceptance S4- Share positive insights from other projects on implementing the enablers S8- Ensure management support in adopting enablers	Appendix D1.1; Appendix D2.1
B5- Team members unwilling to accept changes as old commitments need to be kept	S7- Keep changes transparent S4- Share positive insights from other projects on implementing the enablers S5- Concentrate on advantages in application of enablers S8- Ensure management support in adopting enablers	Appendix D2.1
B6- Unacceptable by few contractors	S10- Create alignment towards common goal S5- Concentrate on advantages in application of enablers S6- Start with pilot testing using enablers to gain acceptance *SX- Enhance active engagement of contractors* *SX- Involve contractors in process of implementing enablers*	Appendix D2.2
B7- Lack of trust from stakeholders	S10- Create alignment towards common goal S11- Provide estimations from pilot testing S12- Show strong commitment towards process of applying the enablers	Appendix D1.1
B8- Lack of people collaboration and active participation	S9- Encourage management and teams to adopt these enablers S10- Create alignment towards common goal	Appendix D1.2
B9- Unwillingness to put more efforts	S9- Encourage management and teams to adopt these enablers S10- Create alignment towards common goal S12- Show strong commitment towards process of applying the enablers S2- Provide training sessions and workshops on application of these enablers	Appendix D1.2
B10- Notion that it can lead to additional delay and cost expense	S11- Provide estimations from pilot testing	Appendix D1.1
B11- Notion that certain enablers cannot be applied to construction industry	S11- Provide estimations from pilot testing S9- Encourage management and teams to adopt these enablers	Appendix D1.1

Table 5.1: *Proposed suggestions*

The proposed suggestions for each barrier, as listed in the framework for overcoming the barriers in order to facilitate the incorporation of flexibility enablers has been explained in this section. The proposed suggestions would be further validated in the expert interviews.

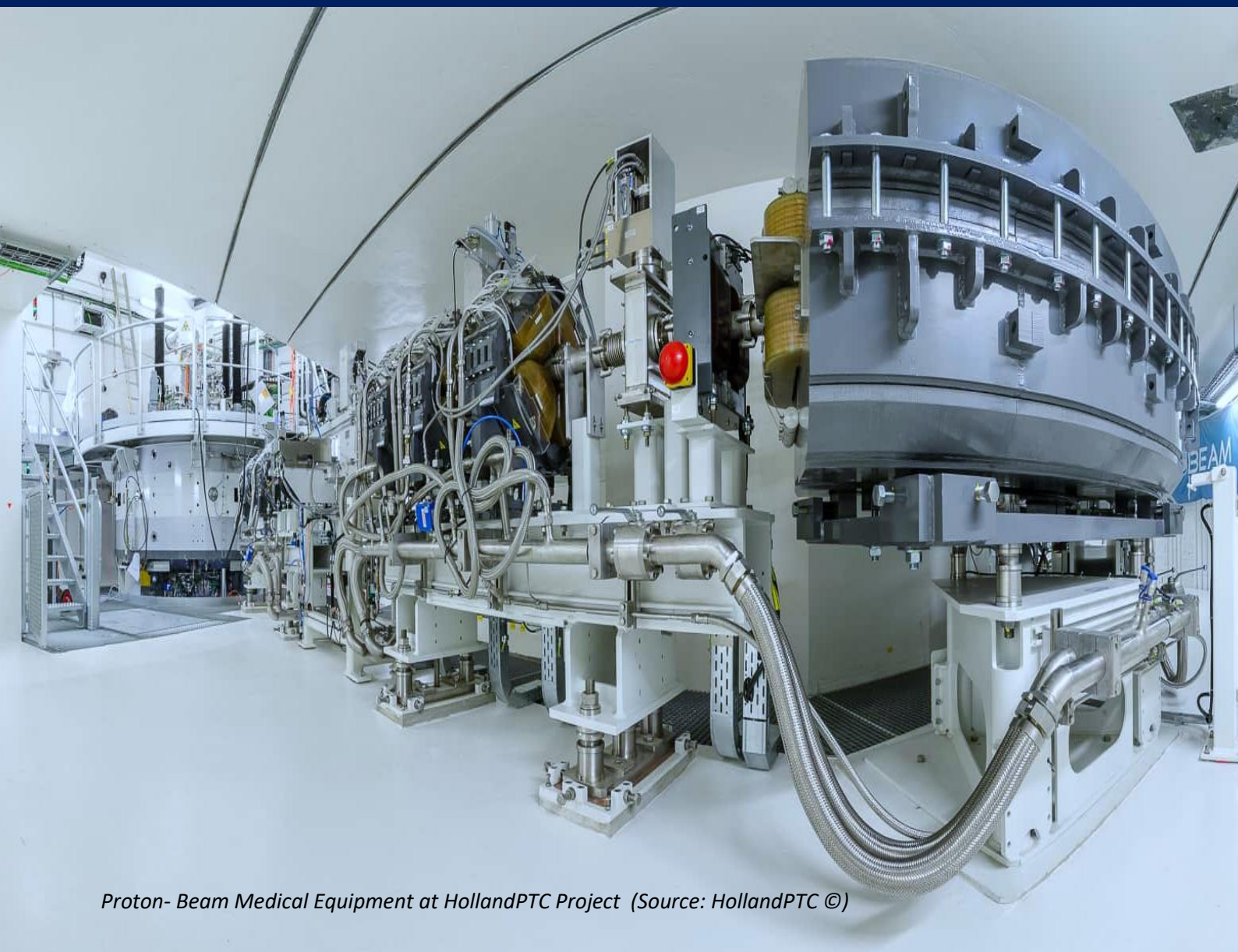
This chapter has thus explained the development of the proposed framework. It has extended the proposed framework for stimulating the implementation of flexibility enablers in practice by overcoming the barriers that occur in its implementation. It has thus proposed the suggestions to overcome the barriers identified from the case study results in the previous chapters. Section 5.2 of

this chapter answers sub-research question 5 of the research. Most of the suggestions proposed in section 5.2, especially for layers 2 and 3 are consistent with Kotter's 8-steps of change management, who has established a framework for how to handle change in the organization's way of working.

With the successful implementation of the four steps from the framework and adopting the proposed suggestions, it can be said that the flexibility enablers will be explicit in the construction industry, using which the projects can be flexibly managed in terms of planning and decision-making. With this framework, the practitioners will not only be aware of the enablers that incorporate flexibility but will also have insights and examples of other projects where these enablers have been implemented, which will further encourage them to implement the enablers and also overcome the barriers that occur in its implementation, thereby achieving flexibility in their practices. The proposed framework and the suggestions will be used to validate for its applicability by the experts in the next chapter.

6

Expert Validation



Proton- Beam Medical Equipment at HollandPTC Project (Source: HollandPTC ©)

Chapter 6: EXPERT VALIDATION

In this chapter, the conceptual framework and the suggestions proposed in the previous chapter have been validated through the experts. Thereafter, the applicability and workability of the developed framework and proposed suggestions shall be discussed. The first section explains the approach of conducting expert validation. Section 6.2 presents the results from the discussion on validating the proposed framework and section 6.3 presents the results from the discussion on validating the proposed suggestions.

6.1. Set-up Expert Validation

The goal of expert validation is twofold. Firstly, to validate the proposed framework. Secondly, to discuss and validate the proposed suggestions for each barrier identified from case studies.

To achieve this goal, four expert interviews were conducted. The participants of expert interviews were the consultants from AT Osborne having expertise in the approach of flexible project management and involved in organizing trainings and workshops for AT Osborne academy and NETLIPSE. Prior to conducting the expert interviews, a presentation was given to the company where the research was explained and results from the case studies were presented. All the chosen experts attended this presentation. Similar to the case study interviews, all the expert interviews were conducted online. During the expert interviews, the proposed framework was presented to the experts and its steps were explained. Open questions were asked on the framework in order to validate it. The duration of this part was around 30-40 minutes. Additionally, table 5.1 from chapter 5 was presented along with it and the proposed suggestions for each barrier were discussed with the experts and validated by them for its applicability. The duration of this section was around 30-40 minutes. The protocol for expert interviews is provided in Appendix E1.

6.2. Discussion on Validation of Proposed Framework

In the first section of expert interviews, open questions were asked to the experts. All the five questions were exclusively asked in the context of applicability and workability of the proposed framework. The questions focused on applicability, workability, clarity, restructuring and recommendations on improving the proposed framework. The answers to these questions will confirm the validity of this conceptual framework in practice based on its application. The questions asked in this section are discussed separately.

1. **Do you think the proposed framework is valid and applicable from both infrastructure and healthcare real estate projects?**

All the four experts agreed that the proposed conceptual framework is valid and applicable for both-the infrastructure and healthcare real estate sectors in stimulating the implementation of flexibility enablers by overcoming the identified challenges in its implementation. Two respondents stated that the framework has followed a logical approach and forms a good basis not only for overcoming the

barriers but also to introduce and incorporate it within the projects and the organizations. One respondent stated, "*The proposed scheme will be stronger if it is provided with the table of suggestions presented along with it as it gives a concrete understanding for all suggestions to be undertaken for particular steps and for barriers in particular layers*." Here, the respondent refers to table 5.1. The author agrees to this comment as the framework does not include specific suggestions for each barrier as provided in table 5.1, but the overview of set of suggestions for barriers classified based on clusters. According to three respondents, following the framework step by step would add to more value towards the final goal of successful implementation of flexibility enablers. But the possibility to skip step 1 and begin with step 2 allows flexibility in application of the framework. Furthermore, formation of three layers helps in quick identifying the barriers and applying suitable suggestion as per the requirement. All the experts also verified the proposition that the framework has been generalized for any domain in the construction industry (i.e., infrastructure, health-care real estate, buildings and industries) and can be used in any project phases. Therefore, this framework has been validated for its applicability and workability in infrastructure and healthcare real estate sectors and can be used in any project phases whereby the barriers are observed on implementing the flexibility enablers.

2. Which steps/suggestions are not clear from the framework?

All the respondents stated that the framework is very clear and easy to understand and implement. Additionally, if provided with table 5.1, it gives even more clarity. One of the respondents did not understand the construction of layers, which on explaining was substantiated by her. To all the experts it was not clear why all the suggestions from table 5.1 were not presented on the framework but was classified in layers as sets of suggestions for each step. The solution mentioned for this issue was to provide the framework along with table 5.1, as mentioned previously. As the layers in the model allow to skip step 1 and start with step 2, one of the respondents questioned if the model provides flexibility to skip step 2 in the process of following steps 1 and 3. However, this would disrupt the linearity and logic in the framework. Instead, it is advised to skip certain suggestions from layer 2 but stick to the linear pattern following the four steps of awareness, insights, encourage and implement. Thus, in total, three points were unclear to the experts, the clarification for which was discussed, as mentioned.

3. What should be changed or restructured from the proposed framework to make it more applicable?

In general, all the respondents mentioned that the framework was clear and will be applicable for both the infrastructure and healthcare sectors. Also, they did not want to change it, but some points of restructuring the framework and adding extra steps were mentioned to make it more effective. One of the experts suggested to add layer 0 before layer 1. This layer 0 can show the step of 'No or little awareness' and the framework can begin from this layer and further continue as proposed. This layer can also include 'developing methodologies for implementing flexibility enablers' as once the methodologies are developed, we can proceed with creating awareness of these new methodologies. Another expert suggested that layer 2 can come before layer 1 for some processes/projects. The reason being the team members would first like to hear some enthusiastic stories about the enablers and receive certain signs from the management that they are willing to incorporate these enablers, after which they prefer to attend the trainings. It was suggested that we could keep layers 1 and 2 interchangeable based on the project requirement and acknowledgment of flexibility enablers by the project team members. This suggestion was accepted and can be implemented in the framework. One

of the experts also suggested to add definitions of the five flexibility enablers on the framework itself as it will be visible while using the framework in practice.

Another respondent suggested to use the four steps iteratively rather than in a linear fashion. This is because the projects last for a long time and it is advisable to use this framework again and again. This framework should not be used only once in the projects, but it will be required to follow the four steps repeatedly. Additionally, throughout the project duration, a lot of team members are stepping out of the project and new people are introduced to the projects. In order to ensure the new members are introduced to this framework, it can be presented iteratively than in a linear way. Also, making the framework iterative would be helpful if two different enablers have to be implemented in two different project phases as different types of barriers would be encountered in each of these phases that would necessitate the use of the framework again. These arguments made by the experts were acknowledged in this research. However, it was decided not to restructure the framework or make any amendments to the framework as suggested by the experts. The reason being it can be adjusted by the practitioners based on the project/organizational requirements as well as knowledge and familiarity of flexibility enablers. These updates will not be developed in this thesis but can be put to practice in the construction sector.

4. Do you think the current working culture of AT Osborne is suitable for implementing this framework?

All the experts agreed that the current working culture of AT Osborne is suitable for implementing this framework. According to the experts, as it is an advisory firm, the consultants from the company can take this framework to various projects they are working on and can thereby integrate this framework also in the client organizations. To do so, they first need to train themselves internally with this framework, understand the technical insights and adopt it, and make it explicit in their projects. This can be done by conducting workshops and developing an implementation strategy and/or a promotional strategy for implementing this framework. All the experts mentioned that in the company there are many project manager and consultants who have been using some of these flexibility enablers (if not all) in their projects. These colleagues can come forward and provide internal training to other members and encourage the use of these enablers, thereby helping to cope with barriers by implementing the proposed suggestions and additional suggestions if any. One of the respondents stated- "*We can keep this framework in our toolbox and promote it in various organizations, including ours*." Thus, based on the above arguments, this framework can be implemented at the company.

5. The suggestions provided in the framework are not new or unknown, then why don't the practitioners use them?

In general, all four experts consider one common reason for not implementing the suggestions for these specific enablers- 'Lack of urgency or sense of urgency.' Firstly, there is no driver for change in the construction industry that will enable the implementation of enablers. As a result, the barriers for its implementation stay in its place due to which there arises no need to implement the proposed suggestions. Due to the traditional nature of the construction industry, people are conservative and do not want to accept the working nature of these enablers explicitly. So, in order to put these suggestions in practice, firstly the management itself should begin with step 1- Awareness as proposed in the framework. This can drive the practitioners to try to implement the enablers as well as overcome the barriers that occur in its application by making use of the proposed suggestions.

6.3. Discussion on Validation of Proposed Suggestions

The second section of expert interviews consisted of discussion on the proposed suggestions. The suggestions were evaluated against each barrier following the sequence as presented in table 5.1. The experts were asked if the proposed suggestions are suitable and applicable to overcome the specific barrier and their comments on the same were noted. The experts were asked whether this approach of evaluating the suggestions for each barrier was preferable to them. All four experts found this approach convenient and they mentioned that using this approach provided them with a concise picture of how the proposed suggestions could be applied for various barriers in context of the flexibility enablers. The following are the results of the expert interviews for this section:

6.3.1. Validating suggestions for barriers B1- Lack of understanding the enablers and B2- Lack of guidance/methodologies from theory to implement the enablers:

From table 5.1, all the suggestions *S1- Create awareness about flexibility enablers, S2- Provide trainings and workshops on application of enablers, S3- Provide training to the management*; proposed for resolving B1 and B2 were accepted by all the experts. According to experts, these enablers should be made more explicit by first preparing the management for adapting it and feeding them with knowledge and then it should be conveyed to the project teams. The sense of urgency for using these enablers and its advantages must be intensively communicated to the management and the project teams during the conducted training.

6.3.2. Validating suggestions for barrier B3- Skepticism towards new way of working:

In general, the experts agreed to the suggestions mentioned. In the context of B3, the proposed set of suggestions, viz*., S4- Sharing positive insights from other projects on implementing enablers, S5- Concentrate on advantages in application of enablers, S2- Provide trainings and workshops*; focus on explaining the 'Why' and 'How' of incorporating enablers and can be applicable to entire cluster 2. One of the experts stated in order to avoid this barrier (B3), the training mentioned in the suggestion should include serious gaming session which will allow involvement of the team members and increase certainty in them towards its application. Suggestion S4 was majorly given importance to for dealing with barriers of this type as positive examples always help to persuade people to follow new methods, especially for enablers like iterative planning and iterative delivery. However, it is important to be careful and considerate while giving examples and insights from other projects as there can be a struggle or conflicts between the two organizations. S4 was applied by two experts who provided insights of implementing release management from NSL project (case 2) in their respective projects.

6.3.3. Validating suggestions for barrier B4- Organizations resistant to adopt these enablers:

The suggestions *S6- Start with pilot testing using enablers to gain acceptance, S4- Share positive insights from other projects on implementing enablers and S8- Ensure management support in adopting enablers*; were considered suitable for barrier B4. In this context, for S6, pilots are safe game which the project teams and organization can try from instincts without major consequences for the

whole project/organization. However, the scope of conducting pilots must be controlled as it will vary for different enablers, i.e., pilots for conducting short feedback loops will requires less efforts and resources than compared to other enablers. It will require more efforts for applying S6 on an organization level than on project level. One of the experts suggested that S6 must be applied by making a separate workflow for a specific enabler and then applied in projects. In context of S8, experts mentioned that this suggestion is a must as it will ease the acceptance by project teams if management is in favor of incorporating the enablers.

6.3.4. Validating suggestions for barrier B5- Team members unwilling to accept changes as old commitments need to be kept:

All the experts upheld suggestions *S7- Keep changes transparent, S4- Share positive insights from other projects, S5- Concentrate of advantages in application of enablers and S8- Ensure management support in adopting enablers,* for overcoming barrier B5. In the context of overcoming B5, two things were added. Firstly, concerning S5 and S7, the possible disadvantages that could occur and the negative changes and any uncertainties that can befall as a result of applying the enablers should also be kept transparent. An answer to how to cope with this kind of change should be kept ready while putting these suggestions to practice. Secondly, concerning S7 and S8, the management and project leaders must show willingness to change and make it visible. Also, the management and project leaders should provide the team members a strong reason to do so.

6.3.5. Validating suggestions for barrier B6- Unacceptable by few contractors:

The experts confirmed suggestions *S5- Concentrate on advantages in application of enablers and S10- Create alignment towards common goal*. As a complement to S10, additional suggestion added by experts was to actively involve the contractors in the process of implementing the enablers as it will result in creating alignment towards a common goal. For S5, in addition to advantages, the focus should be on why it should be acceptable by contractors. Another suggestion to overcome this barrier is to mention it as a criterion in the tender procedure, for example, stating that the contractors should work flexibly or in lines with implementing the flexibility enablers. This will enable contractors to cope with this criterion in a very early stage of the project.

6.3.6. Validating suggestions for barrier B7- Lack of trust from stakeholders:

Although suggestions *S10- Create alignment towards common goal, S11- Provide estimations from pilot testings, S12- Show strong commitment towards process of applying enablers,* can prove helpful in overcoming barrier B7, for enablers like late locking and continuous locking it is important to involve some stakeholders early in the process of implementing the enablers. According to experts, an attempt must be made for achieving collaborative planning with responsible stakeholders instead of keeping the decisions of late locking and continuous locking only within the project teams and steering groups, because it will keep the stakeholders involved and gain their trust to align the process. Additionally, it is important to explain the stakeholders and inform them about the possible advantages of using a new way of working.

6.3.7. Validating suggestions for barrier B8- Lack of people collaboration and active participation:

According to experts, the set of proposed suggestions, viz. *S9- Encourage management and teams to adopt the enablers and S10- Create alignment towards common goal*, to overcome the barrier B8 is valid only for enablers of iterative planning, iterative delivery and short feedback loops. It was suggested to conduct some integration sessions to meet, discuss and evaluate the application of flexibility enablers. For late locking and continuous locking, it is required to incorporate the mentioned suggestion on management level prior to incorporating it on project level.

6.3.8. Validating suggestions for barrier B9- Unwillingness to put more efforts:

In general, the experts found the suggestions *S9- Encourage management and teams to adopt these enablers, S10- Create alignment towards common goal, S12- Show strong commitment towards process of applying enablers and S2- Provide trainings and workshops*, suitable for overcoming barrier B9. According to experts, unwillingness is effect caused by lack of understanding and acknowledgment. Thus, this set of suggestions might overlap some of the previous suggestions (S1-S8). If previous suggestions have been utilized properly, then there are lower chances of occurrence of this barrier.

6.3.9. Validating suggestions for barrier B10- Notion that it can lead to additional delay and cost expense:

The stated suggestion *S11- Provide estimations from pilot testings* was considered suitable for barrier B10 by all experts. However, according to one of the experts, this barrier can be overlooked in the process as bringing a change to the way of working or in managerial processes might cost time and delay, which must not be considered negative. Another expert suggested to draw risk analysis for both scenarios- one using the flexibility enablers and another using the traditional (currently used) methods.

6.3.10. Validating suggestions for barrier B11- Notion that certain enablers cannot be applied to construction industry:

The experts confirmed suggestions *S11- Provide estimations from pilot testings and S9- Encourage management and teams to adopt these enablers*, to be applicable to resolve barrier B11. According to the experts the notion for the five flexibility enablers has been proven false for the design phase in the construction industry. However, there is still a need to ensure its possibility in the execution phase.

In conclusion, the proposed suggestions (S1-S12) will help in overcoming the identified barriers (B1-11) occurring in the process of implementation of five flexibility enablers as validated by the experts and therefore can be applied in practice. There was an overlap observed in certain sets of suggestions for some barriers, which according to experts, is necessary to tackle the mentioned barriers as well as additional barriers associated with it. Also, the additional suggestions obtained from the experts should be recognized.

6.4. Conclusion

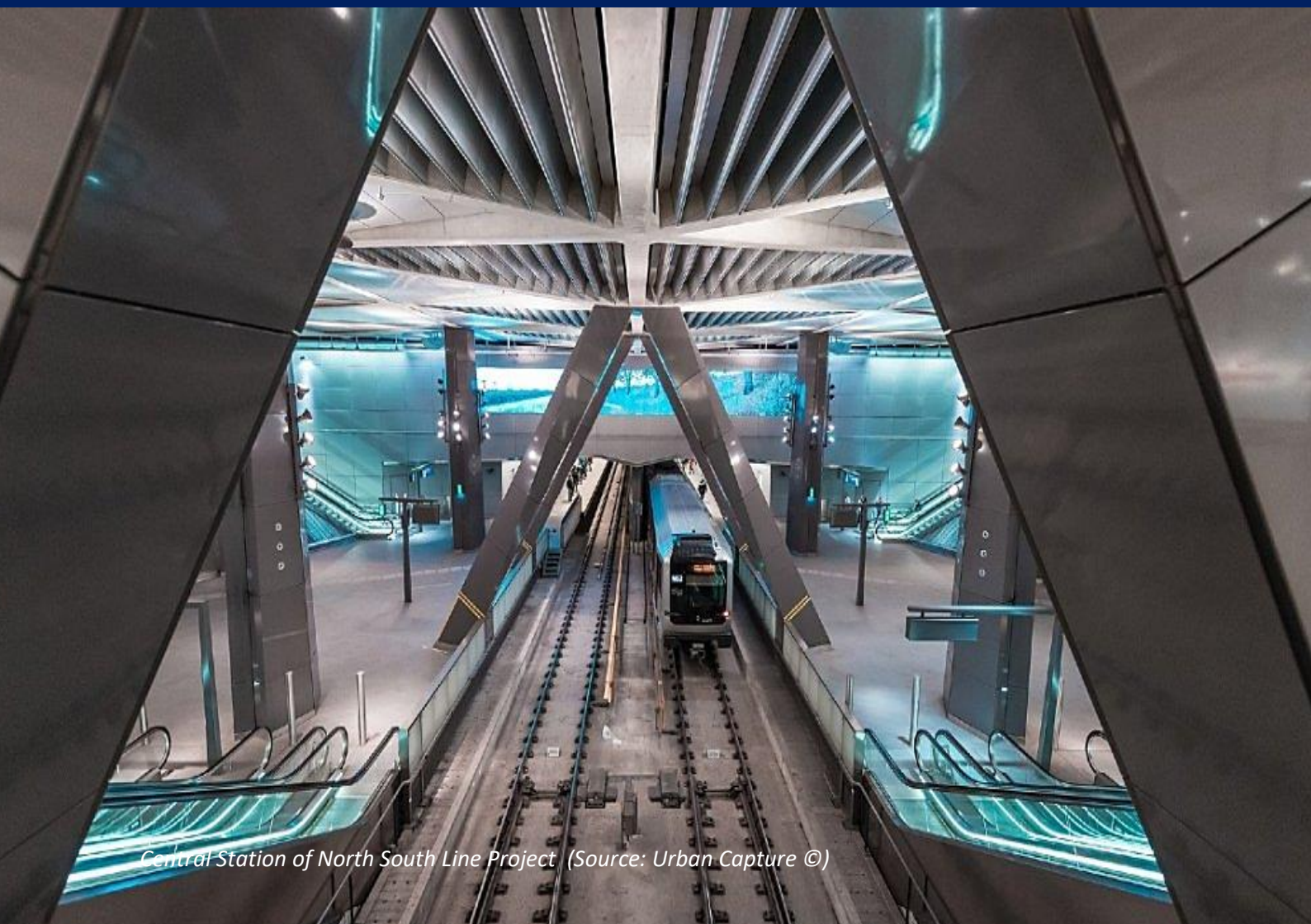
In this chapter, the proposed conceptual framework for overcoming the identified barriers in order to stimulate the incorporation of enablers was evaluated and validated by four experts by conducting expert interviews. The expert validation also evaluated and validated the proposed suggestions to overcome the barriers identified in incorporating the five flexibility enablers from case studies.

The chapter was initiated by explaining the expert validation set-up that stated how the expert validation was performed. Following this, the proposed (AIEI) framework was evaluated and validated by the experts. The experts evaluated the framework for its applicability and workability in the construction industry, especially the infrastructure and healthcare real estate sectors. Certain suggestions and improvisations mentioned by the experts were also discussed. These points can be applied to the framework based on the project requirements. The suggestion on providing the framework along with the table 5.1 was agreed upon in order to provide a concise information on which suggestion can be directly applied to which barrier. The suggestion on the possibility to keep layer 1 and layer 2 of the framework interchangeable was agreed upon and it is decided to incorporate it in the framework and can be used in practice. Other than this, no further changes were made to the proposed framework. Overall, the experts confirmed that the proposed framework is applicable for the construction industry and has required clarity in its implementation, which can not only help to overcome the barriers but also facilitate the incorporation of flexibility enablers.

Subsequently, the proposed suggestions from S1-S12 were validated one by one for each of the barriers B1-B11. Overall, all the proposed suggestions were confirmed by the experts and they agreed to its applicability. Some additional comments and suggestions mentioned by the experts were also discussed. The validation of proposed suggestions by the four experts provides an answer to sub-research question five of this research. In conclusion, both the proposed framework and the proposed suggestions for overcoming the identified barriers in incorporating the enablers were validated by the experts and can be applied both to the infrastructure sector as well as healthcare real estate sector.

7

Discussions, Conclusions & Recommendations



Central Station of North South Line Project (Source: Urban Capture ©)

Chapter 7: DISCUSSIONS, CONCLUSIONS & RECOMMENDATIONS

This chapter contains discussion based on the findings in this research, research limitations, conclusions and recommendations. It is constructed as follows. Section 7.1 discusses the research findings by reflecting upon the steps followed in the research in order to achieve the research objective. Section 7.2 discusses the limitations of this research that influence the research findings. Section 7.3 presents the conclusion by answering the main research question in section 7.3.1 and section 7.3.2 presents about the application of the validated framework in practice. Finally, in section 7.4 recommendations are provided separately for practice in section 7.4.1, followed by providing recommendations to project managers on implementation of framework in section 7.4.2 and for further research in section 7.4.3. In the end, the thesis closure is done by presenting a personal reflection for the readers.

7.1. Research Findings

Based on the discussion in chapter 1, the growing complexities and dynamism in today's project environment call for a flexible approach in project management as the traditional project management is not always fully able to cope with these complexities. Although the literature supports the need to shift from a traditional approach to a flexible approach, there is limited literature that suggests the methods and techniques that stimulate flexibility in project management. Flexibility being a broad concept, the research scope was narrowed down to focus on flexibility in planning and decision-making by conducting exploratory interviews. In consideration to this, the research objective was to stimulate the flexibility in project management in terms of planning and decision-making in the construction industry by first identifying if flexibility is currently implemented in practice and in what manner and further identifying the barriers that occur in its implementation and providing suggestions to overcome these barriers.

Hence, this research aims to provide an answer to the following main research question: "How can flexibility in project management in terms of planning and decision-making in the construction industry be stimulated?" The starting point of this research was the five flexibility enablers from the research of Jalali Sohi (2018), viz., iterative planning, iterative delivery, short feedback loops, late locking and continuous locking, the result of which states that these enablers incorporate flexibility in project management. These five enablers form the WHEN category of flexibility enablers, which corresponds to the planning (and scheduling) and decision-making processes.

To answer the main research question, firstly an extensive literature study was conducted, which formed the foundation of this research and provided with the theoretical background of the research. It briefly explained the development in project management and the need to shift to flexible project management, further explaining the concepts of flexibility in project management in different aspects. Based on this and the exploratory interviews, it was retrieved that flexibility in construction project management often refers to flexibility in process, which helped align the research direction. It presented the concept of flexibility in planning and decision-making processes and explained the five flexibility enablers- iterative planning, iterative delivery, short feedback loops, late locking and continuous locking, which formed the starting point of this research. This section explained how these

enablers have been used in practice in other industries and their implications in the construction industry. However, there was a lack of available literature that specified the methods or techniques to incorporate these enablers in the construction industry as these enablers are not well established in the construction industry compared to other industries, which is one of the major barriers in implementing these enablers. Lastly, a theoretical framework was established based on the identified barriers and difficulties that occur during incorporating the five flexibility enablers. The outcome of the literature study was used in the next phase of the research.

In the second phase of the research, a case study analysis was performed for four different projects, two each from the infrastructure sector and the healthcare real estate sector. The outcome of the case study analysis provided with the results on whether these enablers are identified by the practitioners and how these are currently implemented in practice. Although most of the practitioners adopted traditional project management practices, they felt an increasing need for implementing flexible practices to cope with the growing complexities in the project and project environment. For the practitioners in the infrastructure sector, it deemed necessary to be flexible in terms of planning and scheduling process. The main reason recognized for this is- infrastructure projects are longer in duration and are influenced by a lot of other external factors like parallel projects running alongside and involvement of a number of stakeholders, which requires constant adaptation in its plans and schedules, which sometimes also requires scope changes. On the other hand, for practitioners in the healthcare real estate sector, it deemed necessary to be flexible in terms of the decision-making process. The main reason recognized for this is- the decision to construct the hospital projects are taken earlier during which the information about the latest technology and medical equipment to be required and installed after the construction of hospitals is not available, which requires them to keep the decisions open in order to install and equip the hospital building with the latest technology. However, even after the felt need to be flexible in their practices, most of the practitioners lacked awareness about the methods or practices that would incorporate flexibility in terms of planning and decision-making in construction projects.

In the context of five flexibility enablers, one of the main findings of this research is that the practitioners in the construction industry were not very familiar with the terms used for enablers, especially the terms like iterative delivery and continuous locking. All four projects chosen for case studies adopted a traditional project management methodology. However, in order to cope with certain project circumstances, a few practices were found to be implicitly implemented in these projects that resemble the flexibility enablers. Practices like integral planning (case 2) and time chainage diagram (case 1) resembled the iterative planning enabler that allowed the project team to be flexible in making alterations to their plans and schedules and monitor those regularly. The practice of release management (case 2) resembled the iterative delivery enabler, which was used for the first time in an infrastructure project, which allowed to divide the project into smaller parts and test, validate and deliver each of these parts iteratively, thereby making continuous improvement. Applying iterative delivery resulted in the successful delivery of a complex project like case 2. The practice of conducting reflective meetings and daily meetings resembled the short feedback loops, which allowed to be flexible in implementing small changes and monitoring progress. The practice of late locking implemented in cases 3 and 4 also allowed to be flexible in the decision-making process, but the practitioners lacked tools or techniques to implement this enabler. Although a few flexible practices were recognized in the case studies, it was observed that not all project members were willing to adopt these enablers/practices as they were skeptical about applying these enablers as well as they resisted to change from their traditional way of working.

Even though certain practices implemented in case studies resembled the flexibility enablers, in the conducted literature study, it was not stated if iterative delivery (release management) can be used in the construction industry and how it can enable flexibility. Thus, implementing release management in case 2 acts as an exemplar for the successful implementation of iterative delivery in infrastructure projects, which can be used for similar projects. The insights from this project as well as its pilots can be provided for applying this process in other infrastructure projects. Similarly, the insights of applying time chainage diagram in case 1 and late locking for cases 3 and 4, should be provided for applying these methods in other construction projects. Moreover, the identified flexible practices must be made explicit in the construction industry, which was observed to be done only in case 2 for iterative delivery. The recommendation to do so is provided in the recommendations section 7.4.1. This will create awareness and inform the project teams about the existence of the flexibility enablers and some methods that can facilitate its incorporation in the construction industry.

Additionally, it was observed that literature has established the definitions of flexibility as well as the five enablers in the context of the software industry and manufacturing industry, but not in the context of the construction industry. Findings in this research on the incorporation of some enablers demonstrate the presence of certain flexibility enablers in construction projects. These results contribute to the existing literature available on flexibility in construction project management. Furthermore, the second phase of research also consisted of identifying the barriers that occur during the implementation of flexibility enablers in practice, most of which occurred as a result of lack of awareness and methods to incorporate these enablers.

Following this, a cross-case analysis was performed that provided the similarities and differences in the incorporation of flexibility enablers in two different construction sectors. Out of the five enablers, short feedback loop was incorporated in both the sectors, the practices/methods of which were similar to that mentioned in the literature. Thus, it is concluded that the project managers and consultants from AT Osborne are familiar with the enabler of short feedback loops in comparison to other enablers. The main conclusion obtained from the cross-case analysis was- the enablers iterative planning and iterative delivery (flexibility in planning) were recognized and incorporated in the infrastructure sector, while the enablers late locking and continuous locking (flexibility in decision-making) were recognized and incorporated in the healthcare real estate sector, which confirms the argument made above. Here, it is important that within the same company, the project managers from the infrastructure sector share their practices and techniques applied for flexibility enablers with the project managers from the healthcare real estate sector and vice versa, which was not observed and practiced in the company.

In addition to the above, through cross-case analysis a link was established between the theoretical framework for the identification of barriers and the barriers recognized in practice in all four cases. This resulted in identifying the most commonly occurring barriers in practice experienced by the project managers. Here it was observed that the occurrence of barriers was enabler specific and not industry-specific, because the barriers that occurred in the software industry (from theoretical framework) were observed to occur for same enabler also in the construction industry. Besides, in theory, more barriers for identification and incorporation of flexibility enablers were listed to occur due to organizational behavior and management processes, as can be seen in the theoretical framework. Contrastingly, in practice, more barriers occurred due to lack of awareness and lack of methodologies for flexibility enablers and due to resistance of project team members to change and accept new practices. It is a point of discussion as the reason for this can be- flexibility enablers are still not established in the construction industry. If the enablers were well established with respective methodologies in construction as compared to that in software and manufacturing industries, the

barriers in practice could have occurred as a result of organizational behavior and management processes that lie further ahead in the implementation process.

Furthermore, in order to stimulate the flexibility in project management using flexibility enablers, it is necessary to overcome the barriers that occur during implementing the flexibility enablers. The next phase of the research focused on developing a conceptual (AIEI) framework following a linear step by step approach of creating awareness, providing insights, encouraging teams and implement these enablers, and providing suggestions to overcome the most commonly occurring barriers, as identified from the cross-case analysis. The main aim of this conceptual framework is to make these enables explicit in the construction industry so that they can be put to practice by the practitioners. The last phase of the research focused on validating the proposed framework for its applicability, thereafter, validating the proposed suggestions for each barrier by conducting expert interviews. As the main idea behind stimulating flexibility by incorporating flexibility enablers was to identify and overcome the barriers that occur in its incorporation, hence adopting the proposed framework helps in achieving this goal and providing a solution to the main research question.

Concerning the formulated problem statement in chapter 1, it can be concluded that this research extends existing knowledge on the implementation of flexibility enablers in the construction industry, which by far have not been explicitly identified in practice. Moreover, this research aimed at providing suggestions and recommendations to overcome the barriers to facilitate the implementation of flexibility in the construction industry. This has been achieved by developing a conceptual framework that focuses on making the enablers explicit and attempting to overcome the barriers in its application. Correspondingly, it is important to note that there is research available for overcoming the barriers in implementing the flexibility enablers with a focus on IT and manufacturing industries. However, there was no research available for the same with a focus on the construction industry; as a result, this research has been able to add to the existing knowledge in this field, with a limitation of clients' perspective.

7.2. Limitations of research

This section will discuss the limitations of this research that should be considered in the interpretation of the research findings. These are discussed in the following three sections.

7.2.1. Limitations of literature review:

- The literature review on the methods to implement flexibility enablers specific to the construction industry is not explained due to the lack of available literature in this industry.
- The theoretical framework for the identification of barriers has been established based on twelve research papers in total and consists of five clusters of barriers due to the limited availability of literature. If more literature was available on this topic, then the list could have been more reliable and complete.

7.2.2. Limitations of research methodology and obtained data:

- The projects chosen for case study methodology were delivered during the same time span. But the (few) respondents chosen for interviews were not present during the entire project duration due to which their responses in the interviews are based on their limited experience in the project. This provides with limited data for specific project phases instead of the entire project.
- As the first point of contact for each case study was either the project director/project manager, they were requested to assist with possible team members to approach for interviews. As a result, the choice of interviewees could have a potential bias and influence the outcome of the research. However, in order to tackle this, three interviews were conducted per case study and efforts were made to obtain a holistic view for analysis and drawing conclusions.
- The research was limited project team and did not take into account the clients' perspective, which otherwise would have influenced the interview responses as well as results.

7.2.3. Limitations of generalization of results:

- The case studies as well as the interviews conducted were limited in number and domain. The outcomes of the research would have been possibly different if more case studies from different domains of the construction industry were explored, and more interviews were conducted. Similarly, the identification of methods used to incorporate the flexibility enablers as well as its barriers was limited to the chosen case studies. Hence, the obtained data and results would have been different for different cases.
- Even though the proposed framework is quite generic and can be applied step by step to facilitate the implementation of enablers and overcome the barriers in the construction industry, it based on the commonly identified barriers from the chosen case studies and the proposed suggestions to overcome those specific barriers.
- This research is conducted in one company and is influenced by the project management methodologies adopted by this company alone, which is more inclined towards traditional practices. Hence, if other companies might have already been using the enablers and have adopted a flexible way of working, then the proposed framework must be adjusted.
- Also, the validation of proposed suggestions and framework by conducting expert interviews was slightly influenced by project management methodologies adopted in this company as all the experts were chosen from AT Osborne. Thus, their views and opinions on the proposed suggestions and framework could have been slightly biased and focused, based on their experiences in projects undertaken by AT Osborne.

7.3. Conclusions

In this section, the main research question and corresponding sub-research questions are answered. To achieve the research objective, the following research question has been formulated:

How can flexibility in project management in terms of planning and decision-making (the WHEN category) in the construction industry be stimulated?

To answer this main research question, the following sub-research questions are formulated:

SQ1: What is flexibility in project management?

SQ2: What is flexibility in terms of planning & decision-making and what are its enablers?

SQ3: How are these enablers currently implemented in practice?

SQ4: What are the barriers to incorporate these enablers?

SQ5: How can these barriers be overcome?

In the following section, all the sub-research questions are answered in sequential order, followed by the answer to the main research question.

1. What *is flexibility in project management?*

The concept of flexibility in project management is often considered as a part of a fundamental dilemma in project management. In consideration with the projects in today's environment, on the one hand, the projects need to be stable and controlled. On the other hand, it needs to be flexible to adapt to the changing requirements, due to which there is an increase in research in the direction of flexible project management. Flexibility being a broad concept, different authors have summarized different definitions of flexibility as summarized in table 2.1 (Chapter 2), with a focus on various domains like organizational flexibility, process flexibility, product flexibility, operational flexibility, general management flexibility, flexibility in agile project management; all of which revolves around flexibility in project management as being '*a response to adapt the project according to the constantly changing environment*.' In this research, it was observed that flexibility in project management in terms of the construction industry is often referred to as flexibility in process. Flexibility in process is '*the ability of the project team to implement changes in the management processes to those parts that need to be changed while keeping the other parts stable, in order to deal with the unforeseen circumstances*' (Regev & Schmidt, 2006). The literature review conducted in the research has acknowledged different aspects of flexibility in project management that have given direction to this research and has attempted to define the aspects of flexibility that can be adapted to the context of the construction industry. As several definitions on flexibility in project management were obtained from the literature, and based on the starting point of the research, this research adopts the following definition:

"the ability of the project teams to deal with the project dynamics."

2. What is flexibility in terms of planning & decision-making and what are its enablers?

Flexibility in planning and decision-making is a subset of flexibility in process in the context of project management. Initially, flexibility in terms of planning and decision-making was considered as a negative connotation, but after the advent of agile project management, it gained a positive response. Flexibility in planning is "*the ability to align project plans and schedules and adapting it to meet the project priorities and project requirements to cope with the changes and uncertainty in project environment*" (Mahmoud-Jouini, Midler, & Garel, 2004; adopted in Drury-Grogan, 2014); which can be achieved by not rigidly prescribing to a definite step in a schedule when such a step depends on circumstances which would be understood only at a later time and not deciding upon an earlier stage that would unnecessarily limit the spectrum of future possibilities. In lines with this, flexibility in decision-making is "*the ability to make the irreversible decisions more reversible or postpone the irreversible decisions until the required information is available*" (Olsson, 2006). The exploratory interviews obtained the practitioners' perspectives on flexibility in terms of planning and decision-making which is-

"having an ability to define and change or alter when certain tasks should be realized and by having an ability to make changes to the initially fixed decisions."

Referring to the starting point of the research, flexibility in terms of planning (and scheduling) and decision-making aligns with the WHEN category of flexibility enablers. Literature has identified five enablers that help to incorporate flexibility in planning and decision-making, viz.,

iterative planning, iterative delivery, short feedback loops, late locking and continuous locking,

in which the first three correspond to flexibility in planning while the last two correspond to flexibility in the decision-making process. These five enablers were adopted from the research of Jalali Sohi (2018). An attempt was made to search for additional enablers that can be added to the WHEN category of enablers. However, 'contingency planning' was recognized as a flexibility enabler to extend this list but was not included in the research as it was categorized under the 'HOW' category of flexibility enablers in the research of Jalali Sohi (2018). Iterative planning, iterative delivery and short feedback loops gained recognition from the iteration model of the agile methodology applied mainly in the software industry that follows the steps of iteration planning, iteration execution, iteration review and iteration retrospective, making use of sprints and scrums for discussions and retrospections. Similarly, late locking and continuous locking gained its recognition in the manufacturing industry, where the stage-gate models were used for incorporating them. These five enablers are applied in this research in the context of the construction industry.

3. How are these enablers currently implemented in practice?

As mentioned previously, the literature identified the iteration model and stage gate reviews from the software and manufacturing industry respectively as the methods to incorporate the five flexibility enablers. However, there were no methods available in the literature that suggest the incorporation of enablers in the construction industry. Hence, using a case study methodology, it was acknowledged whether the practitioners recognized and incorporated these flexibility enablers and which practices incorporated by them resemble these five flexibility enablers.

It was observed that the practitioners from both infrastructure and healthcare real estate sectors failed to identify all of the five enablers. While a few practitioners explicitly used certain enablers in various project phases (planned flexibility), the application of certain enablers emerged out of the

need in the process (actual flexibility). The main point of conclusion was the enablers of iterative planning and iterative delivery were recognized and implemented majorly in the infrastructure projects. In contrast, the enablers of late locking and continuous locking were recognized and implemented majorly in the healthcare real estate projects. The vice versa was not the same. Only the enabler of short feedback loop was recognized and incorporated in both infrastructure and healthcare real estate sectors.

The ways in which the flexibility enablers are currently implemented in practice are mentioned separately for each enabler as follows:

a) *Iterative Planning:* This enabler was explicitly incorporated in the infrastructure sector and also to a certain extent in the healthcare real estate sector, where the iterations were made in the plans and schedules, usually on a quarterly basis. The iteration loops followed a similar process as discussed in the literature (section 2.4.1), following the steps of iteration planning, iteration execution, iteration review and iteration retrospective. This process was complemented using methods like time-chainage diagram and additional visualization tools to ensure timely iterations. Integral planning approach identified from one of the case studies was found to be similar to the iterative planning process. In case 3, iterative planning in the design phase was performed using a similar process, as discussed in section 2.4.1.
b) *Iterative Delivery:* This enabler was explicitly incorporated in the infrastructure sector, where it was incorporated using a technique called release management. It is a robust system integration process where each delivery is planned, executed, tested and validated, with each cycle being evaluated and adapted as a result of planning. In another case study, iterative delivery was incorporated using a similar approach as discussed in the literature (section 2.4.1), where it followed the steps of iteration execution, iteration review and retrospective during the testing and commissioning phase.
c) *Short Feedback Loops:* This was the most identified and incorporated enabler in both infrastructure and healthcare real estate domains which was implemented in the form of progress meetings, review meetings, reflective meetings, a few of which resembled the daily standups and scrum meetings. The daily standups and scrum meetings were conducted for a duration of 15-20 minutes, while each loop of progress meetings and reflective meetings was conducted weekly, bi-weekly and/or monthly in different cases for a duration of 30-60 minutes. This enabler was mostly incorporated in the execution phase for both infrastructure as well as healthcare real estate sector.
d) *Late Locking:* It is a common practice to incorporate this enabler in the healthcare real estate sector. Although literature identifies stage gate reviews as one of the tools to incorporate this enabler, no tools or techniques were identified in practice. Late locking was incorporated by mere consensus of steering groups and project management teams.
e) *Continuous Locking:* This enabler was the least recognized and incorporated of all the enablers by the practitioners. It observed to have an implicit usage in healthcare real estate projects, which was implemented to a certain extent by consensus of project teams for decisions based on ordering and installation of medical equipment. No tools or techniques were identified in practice to incorporate continuous locking.

4. What are the barriers to incorporate these enablers?

As the practitioners were unable to identify and explicitly incorporate all of the five enablers in practice, the barriers in the identification and incorporation of these enablers were identified. It was found from the literature that the main causes of barriers were due to lack of awareness and

methodologies to adopt these enablers, resistance to change (change in the way of working and changes due to applying the enablers), organizational behavior, management processes, and few other miscellaneous reasons. These main causes were classified into five clusters of barriers. An occurrence of 30 different barriers was identified for the five enablers from the literature, which were categorized into one of the five clusters, thereby establishing a theoretical framework for the identification of barriers, as mentioned in table 2.2. Thereafter, through case studies, six additional barriers that were found in practice were added to the theoretical framework. The barriers in identification and incorporation of flexibility enablers are presented in table 4.11, which answers this sub-research question.

Due to an extensive list of barriers, only the most commonly occurring barriers faced by the practitioners were used as input for the next phase of the research. Those were:

- *Lack of understanding of these enablers.*
- *Lack of guidance/methodologies from theory to implement these enablers.*
- *Skepticism towards a new way of working.*
- *Organizations resistant to adopt these enablers out of fear of consequences.*
- *Team members unwilling to accept changes as old commitments need to be kept.*
- *Unacceptable by a few contractors.*
- *Lack of trust from stakeholders.*
- *Lack of people collaboration and active participation.*
- *Unwillingness to put more efforts.*
- *Notion that it can lead to additional delay and cost expense.*
- *Notion that certain enablers cannot be applied to the construction industry.*

Table 4.12 presents which of the above listed barriers were identified to occur in the context of which five flexibility enablers.

5. How can these barriers be overcome?

Certain suggestions obtained from literature are proposed to overcome the identified barriers. Proposed suggestions were supplemented by the suggestions applied by the practitioners in the cases, few of which were comparable to the literature. Most of the proposed suggestions were applicable to overcome more than one barrier, as shown in table 5.1, and all these suggestions were validated by experts in the expert interviews for its applicability and verifiability to overcome the barriers in practice. For all considered barriers, general suggestions are drawn out on how to overcome the identified barriers, which are as follows:

- *Create awareness about the flexibility enablers.*
- *Provide training sessions and workshops on the application of these enablers.*
- *Provide training to management.*
- *Share positive insights from other projects on implementing the enablers.*
- *Concentrate on advantages in the application of enablers.*
- *Start with pilot testing using these enablers to gain acceptance.*
- *Keep changes transparent.*
- *Ensure management support in adopting the enablers.*
- *Encourage management and teams to adopt these enablers.*
- *Create alignment towards a common goal.*
- *Provide estimations from pilot testing.*
- *Show a strong commitment towards the process of applying the enablers.*

7.3.1. Answering the main research question:

How can flexibility in project management in terms of planning and decision-making (the WHEN category) in the construction industry be stimulated?

In the context of Business Process Improvement (BPI), in order to stimulate a process, it is necessary to define and understand the process, find the difficulties it faces, try to avoid/overcome/minimize its difficulties and then implement it again (Attong & Metz, 2013). This idiosyncrasy was applied in answering the main research question of this graduation research.

In this research, the concept of flexibility in project management was defined and explored, with a focus on flexibility in terms of planning and decision-making process. From the literature, five flexibility enablers were identified that facilitate the implementation of flexibility in planning and decision-making, viz., iterative planning, iterative delivery, short feedback loops, late locking and continuous locking. Thus, as a starting point for this research- it was considered that flexibility in terms of planning and decision-making in the construction industry could be stimulated by incorporating these five flexibility enablers.

Based on the findings from the case studies, it was observed that the traditional nature of the construction industry does not embrace the incorporation of all the five flexibility enablers. Moreover, these enablers are not well recognized in practice in the construction industry. Several barriers were identified from the literature as well as in practice that hampers the identification and incorporation of flexibility in terms of planning and decision-making by making use of these enablers. The suggestions proposed in this research help in overcoming these barriers, which were validated by the experts. Based on the literature review, findings of this research, proposed suggestions and expert validation, a conceptual framework is presented. The validated conceptual framework can be seen in figure 7.1 below, which is a linear model consisting of four steps.

As it was identified from case studies that the main reason for the occurrence of barriers itself was the lack of awareness and proper understanding of these enablers in the construction industry. Thus, in order to stimulate flexibility in planning and decision-making using the flexibility enablers, first and foremost, it is important to raise awareness and inform the project teams about these enablers. Doing so will help them identify these enablers as well as their practices that resemble these enablers. Provision of training and workshops both to the management and project team will provide with an understanding of these enablers, which can be further strengthened by providing examples and insights from other construction projects (and projects from other industries), which corresponds to the second step of the framework. Doing so will not only highlight the (new) flexible practices in construction, but it will also help to develop these practices further as well as additional methods and techniques to incorporate the flexibility enablers, the availability of which is limited both in literature and practice.

The proposed suggestions in this thesis strongly focus on making the five flexibility enablers explicit in the context of the construction industry as these enablers are still not recognized and accustomed to in this industry. Thus, it is important to encourage the management (step 3 of the framework) and project teams to incorporate these enablers in practice and bring a change from their traditional way of working towards a more flexible approach. Likewise, if management encourages teams to adopt these enablers, there will be no hesitation to apply them, and the teams will gain more confidence in using these enablers, thereby further stimulating the process. Following steps 1, 2 and 3 will not only help overcome the barriers but also facilitate its implementation, thereby leading to step 4- IMPLEMENT of the framework. Therefore, rather than developing newer methods of implementing

the flexibility enablers in order to stimulate flexibility in terms of planning and decision-making, in this research it has been done by attempting to overcome the barriers by proposing suggestions that would create an awareness in the construction sector, by providing insights from other projects for its application, further encouraging the management and the project teams to incorporate it and finally implementing it, thereby stimulating the flexibility process.

The linear conceptual framework in figure 7.1 illustrates the above discussion. In the expert interviews, this framework was discussed and validated by the experts, and suggested alterations were incorporated, viz. making layers 1 and 2 interchangeable while implementing the framework. Based on their feedback, it can be concluded that the proposed suggestions as well as the framework can stimulate flexibility in project management in terms of planning and decision-making.

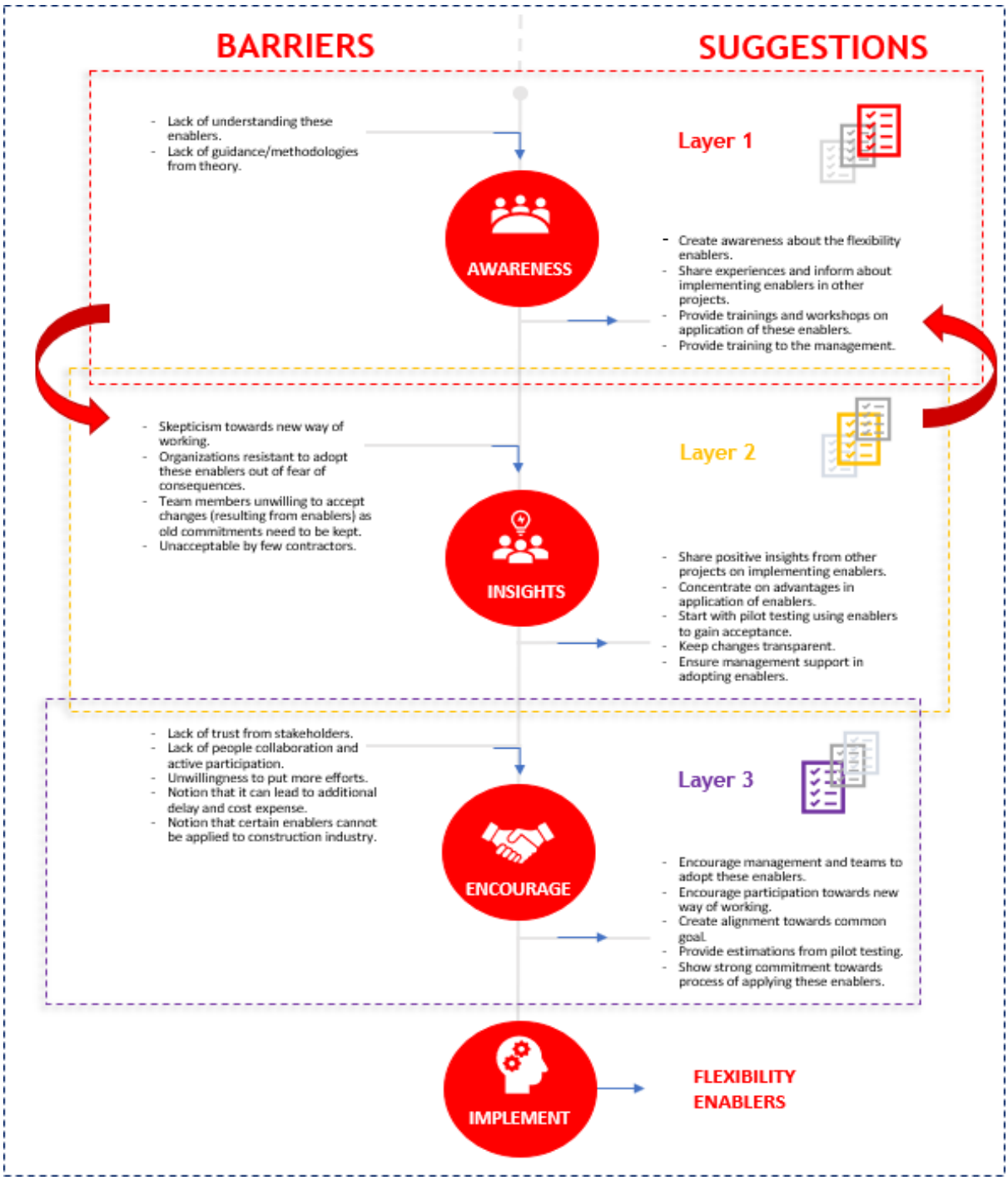


Figure 7.1: *Validated Framework (AIEI Framework)*

7.3.2. Applying the framework in practice

While certain construction projects are relatively straightforward and predictable, many others are highly complex and risky. With the growing complexities in many construction projects today, each project requires a different approach when it comes to how a project should be managed. From a traditional project management perspective, it is often observed that many project managers in the construction industry are strict disciplinarians when it comes to applying the traditional practices, which they attempt to force to fit to a particular project, regardless of its size and complexity because that is what they are most familiar with; thereby limiting the flexibility in the adopted project management methodology. With the increasing need of the project managers to incorporate flexible approaches in their projects in order to cope with the growing complexities, they need to expand their thinking to acknowledge and embrace themselves with different forms of flexible approaches, which lacks in the construction industry. Keeping this into consideration, the proposed framework in this research aims to aware and acknowledge the construction industry with the flexibility enablers and make them explicit, which would stimulate the implementation of flexibility enablers. Having developed the framework and validating it, this section presents how and when a project manager can introduce and apply the proposed AIEI framework in the arc of different phases of a traditional construction project.

As observed from the case studies, all the five enablers could be applied in the design and planning phase, execution phase, commissioning/monitoring and project closeout phase; the framework can thus be introduced and applied by the project manager in these phases, as depicted in the following figure:

Figure 7.2: *Application of Framework in various project phases (Own Illustration)*

After the initiation/conception phase, the feasibility of the project and its requirements would be identified. Once the project's objectives are fully defined, a project manager can first introduce the framework (to the clients/organization/management/project teams/stakeholders) in the kickoff meetings conducted for the planning and design phase, as in this phase, alternate ways to attain the project objectives can be taken into consideration. Hence, by applying this framework in the design and planning phase itself, its first step will create awareness about the flexibility enablers in the early project phases; further following its step 2 of providing insights from other projects, would help identify the project teams about how these enablers are implemented and would provide them with an understanding if it could be incorporated in their project. Also, until the detailed design phase, it can be clear to the practitioners which of these enablers can be put to practice in this phase as well as the successive phases. Further adopting step 3 would encourage the practitioners to use one or all five enablers based on the project requirement and the required need for flexibility (whether in planning or decision-making), thereby adopting step 4 of implementing the required enablers, which will help achieve flexibility in their practices.

With the introduction of the framework in early project phases and adopting a step by step approach, the practitioners will also understand the barriers that are faced in incorporating the enablers. On identifying which barriers belong to which of the three layers from the framework, a suitable suggestion from that layer can be applied to overcome that barrier, as shown in the framework and listed in table 5.1. Similar to introducing and applying the framework in the design and planning phase, the project manager can again introduce the framework by following its four steps in the execution as well as the commissioning and closeout phases, which will help to make these enablers explicit and implementing them in those phases, thereby achieving flexibility. The project manager must create a sense of urgency in applying a flexible approach and inform the project teams as well as the management about applying the flexible approaches, which are now required as the projects are becoming more complex. Depending on the project requirement and the need to achieve flexibility in planning and decision-making processes, the framework can be applied iteratively (as suggested in the expert interviews) in different project phases, as mentioned above and must be introduced to different project teams. Since flexibility has been achieved by implementing these enablers, as derived in the PhD research (starting point of research) and as seen from the case studies, it can be said that applying the framework and following its steps can stimulate the implementation of flexibility in project management in the construction industry.

7.4. Recommendations

This section consists of recommendations provided for the company as well as for further research, that are partly forthcoming out of the findings of research and the research limitations.

7.4.1. Recommendations for AT Osborne and for practice:

During this research it was observed that the company is not yet completely familiar with the flexibility enablers and flexible approaches of project management. In this section the recommendations for AT Osborne will be provided, which will help them acknowledge the flexibility enablers as well as their flexible practices and stimulate the implementation of flexibility in their applied project management methodologies. The recommendations are as follows:

- The project managers and consultants from AT Osborne do not follow a specific project management methodology for managing different projects, but apply the best practices obtained from various methodologies; it is recommended to establish an overview of the adopted practices from different projects. This will help in identifying the new practices if any, as well as distinguish between the traditional practices and flexible practices.
- It is recommended that the company should formally document the lessons learned from past projects and the best practices applied and share both.
- It is recommended that the management provides more sponsorships in organizing training that create awareness and a sense of urgency in implementing these flexibility enablers and its practices. These training can be either from the construction industry or other industries where the enablers have been implemented. This will inform the company about the existence of such enablers. For example, training for implementing agile Scrum practices, iterative planning practices in front end phase, trainings on conducting stage gate reviews for locking, which are also being provided by various organizations that promote such practices.
- It is recommended that the company recognizes its own adopted flexible practices and make them

explicit. This is because a few project managers in the company have been incorporating practices that resemble the flexibility enablers but are unable to recognize them as flexible practices. The steps in the proposed framework can serve this purpose.

- Following the previous recommendations, the company should organize knowledge sharing sessions where the project managers can share their experiences of implementing the flexibility enablers or similar practices and highlight the barriers they faced. It is necessary because it was observed that all project managers are not aware of flexible practices used by other project managers within the same company. Moreover, this recommendation can also help in getting suggestions and solutions from other project managers to tackle those barriers. Also, an inter-departmental and joint knowledge sharing sessions should be organized as it will promote the practices adopted in different areas of construction. For example, the project managers from the infrastructure sector should share their experiences and practices on iterative planning and iterative delivery to project managers from the healthcare sector. Likewise, healthcare sector project managers should share their experiences and practices on late locking and continuous locking with the infrastructure sector project managers.
- It is recommended that the project managers and consultants involved with the client companies should make the clients aware of the limitations associated with the traditional project management methodology and the need to adopt a more flexible approach in project management, further encouraging the clients to incorporate the flexibility enablers.
- As currently there is no established approach specific to construction projects that can implement flexibility, it is recommended to conduct pilot testing using these five flexibility enablers on smaller parts of the projects. The results obtained from the pilots should be discussed within the company, based on which these practices should be optimized.
- The project managers must explore how the identified barriers function in their projects based on which the adopted enablers and practices can be further developed and/or optimized to overcome these barriers.
- To further stimulate the flexible practices early in the project also by the contractors, it is recommended to mention the incorporation of the flexibility enablers as one of the criteria in the tender procedures.

7.4.2. Validated Framework for Stimulating the implementation of Flexibility Enablers (AIEI Framework)- Recommendations for project managers for implementing the framework:

This section includes suggestions made to the project managers and AT Osborne on the implementation of the conceptual framework in practice which has been validated by experts and alterations have been made to it accordingly. In the validated framework, steps 1 and 2 have been proposed to be interchangeable, and either of the two steps can be used as the first step depending upon the level of acknowledgment of flexibility enablers and the experienced barriers.

The main aim of the framework was confirmed by the experts. Moreover, the experts agreed that the project managers and consultants at AT Osborne, even though they incorporate certain flexible practices identical to the five enablers, they fail to recognize it and make it explicit. This can be accelerated using the proposed framework. As the implementation of the framework for the first time in the company will not be very handy and that it also needs recognition within the company, a few implementation steps are listed below. These suggestions were complemented with the responses obtained from the expert interview answers during validating the framework.

- Prior to starting with step 1 of the framework, it must gain recognition in the company by using some promotional strategy. For example, in AT Osborne this can be done using the weekly Newsflash that is circulated weekly to all the members within the companies.
- The step 1 'Awareness'- the proposed suggestions of which consists of providing training and workshop to overcome its corresponding barriers from layer 1, can be achieved by firstly introducing this framework along with table 5.1 in the consultation meetings (Marktgroep meetings in AT Osborne) for both Infrastructure and HVG. Here, the training can be provided either by the consultants of the company who are experienced with flexible approaches or by external consultations by the agile experts and stage-gate experts. Examples of such training include- Scaled Agile Framework for Enterprises SAFe (Leffingwell, 2011), 'Adaptive Planning-Release and Iteration Plan'- a section from PMI-ACP training, OTC Stage-Gate Model (OTC, 2019). This training can be included as a part of the Project Management module in AT Osborne academy, which can be accessible to all project managers and consultants.
- Implementation of step 2 which highlights providing insights to overcome the corresponding barriers in layer 2, can be achieved within the company by organizing joint knowledge sharing sessions where the project managers share their experiences on new flexible approach and techniques used by them in their projects (integral planning, release management and late locking- as obtained from case studies). It will provide with the methods of application as well as the benefits and challenges experienced by the project managers. The discussions and suggestions from this session can leverage developing upon these techniques for further application.
- The project managers can also conduct such sessions with the clients during the process of project brief as it will gain confidence and support from the clients and also help gain their permissions for conducting pilot testing, if not a direct application of enablers on the projects.
- It is observed that certain barriers occur due to friction from project teams as mentioned in layer 3, that leads to following step 3- 'Encourage' from the framework. Management must encourage the project teams to initiate the implementation of flexibility enablers. As suggested by one of the experts, certain gaming workshops can create a collaborative environment and encourage the teams to try using the enablers. This step can be implemented in the company by conducting gaming workshops like- action learning (for iterative planning, iterative delivery and short feedback loops) and consensual-decisioning (for late locking and continuous locking) (MTarnowski, 2015; Scheller, Radoslaw, 2018; vBonacci, 2015); which will lead to the successive step 4- 'Implement,' either using pilots or with (smaller parts of) projects.

In this way, the project managers and the company can begin with the implementation of this framework, which was agreed upon and verified by the experts. However, it is important to identify what type of barriers/difficulties have been faced in the company and the projects in order to adopt a suitable layer from the framework. Also, based on the level of identification of enablers and the occurrence of barriers, it should be decided whether to interchange layers 1 and 2 and start with step 1 or step 2.

7.4.3. Recommendations for further research:

Due to the exploratory nature of this research, it has left room for possibilities for further research. Altogether, this research contributed to the knowledge of flexibility in the context of the construction industry by identifying its enablers and the barriers in its implementation, thereby providing suggestions to overcome it. However, due to limited literature of flexibility in the context of

construction and limited availability of methods/techniques to implement it, the recommendations for further research have been laid. The recommendations for further research are as follows:

- In this research, the literature study was limited to investigating five flexibility enablers. In further research, it is recommended to investigate additional enablers that can facilitate flexibility in terms of planning and decision-making processes.
- The literature study on identification of barriers was limited to five clusters. Future research can explore how each of these barrier functions for each of the five enablers.
- This research was performed with limited cases from the infrastructure and healthcare real estate sector and conclusions were drawn based on limited results. It is recommended for future research to perform this research using additional cases and in other domains of construction like industrial buildings and offshore.
- The research proposed suggestions to eleven barriers from the theoretical framework, upon which the steps in the proposed framework are based. Although these suggestions are applicable to overcome other barriers, it is recommended to investigate the remaining barriers from the theoretical framework in-depth and propose suggestions to overcome those.
- The steps in the framework, as well as most of the proposed suggestions, are recognized to be consistent with the change management theory. Further research can investigate the influence that change management will have on incorporation of each of the five enablers.
- As this research did not acknowledge the clients' or contractors' perspectives on implementing flexibility enablers and flexibility in general and the difficulties that they would face, it would be interesting to perform the same research by acknowledging their views and opinions as eventually they are the ones who own and construct the project respectively.
- It is highly recommended for further research to investigate new practices, tools and techniques that facilitate and enhance the incorporation of flexibility enablers as well as additional enablers that would be applicable to the construction industry.
- Further research can investigate how the proposed framework can be tailored for its application in other projects and what adjustments need to be made for its application in projects from other domains of construction.
- As this research was conducted at only one company not completely familiar with all five enablers, it would be interesting to perform this research in other companies to investigate their level of identification and incorporation of flexibility enablers, thereby comparing the results. This will help identify whether it is a company-specific problem or a common problem faced in the construction industry.
- Lastly, further research can study the effects of the company's culture on flexibility and flexibility enablers.

7.5. Personal Reflection

"You can either fix the scope and be flexible in time OR you can fix the time and be flexible in scope."

The above was quoted by one of the interviewees from the case studies- Gerard Scheffrahn, which I remembered instantly while writing this reflection over the past six months spent on the research carried out for my graduation thesis. From the two stances quotes above, I chose the latter.

Even before starting with my thesis, I was determined to complete it within 6-7 months period and graduate by August 2020. I had planned the activities that need to be done to complete the thesis and allotted definite time to those activities with keeping buffers for some. Keeping this timeline in mind, the first step of the thesis began with conducting a literature review and exploratory interviews and writing a draft for the proposal. I wished to schedule the kickoff before the Christmas break as I had planned a trip to Italy, which would give me a kick start to begin with the actual research from the start of the year 2020. Unaware of the research scope proposed during the kickoff, it came to my surprise that it was too much to do for a master's thesis. Thankfully, the graduation committee provided me a good direction in the kickoff meeting to minimize the scope and conduct the main research.

January 2020 marked the beginning of my main research that began with the main literature study. Initially, this was quite interesting as the topic of flexibility in project management, although broad but is quite a new topic in the construction industry. I liked to read about the different aspects of flexibility and how I can use that literature for my research. However, after reading a lot about it, there came a time when I ran out of literature on flexibility in the context of construction industry especially when no new enablers and methods were, after which I decided to refer to literature from other industries. At this point, I started questioning myself whether my research was still going in a right direction and is this what I wanted to do. I constantly discussed this with my first supervisor and company supervisor who always motivated me to keep moving with the flow, which was appreciable. During this time, I learned that literature is plenty and to complete this research, it was extremely important to take decisions and make selection on what needs to be focused on. Meanwhile, within two months my first midterm was scheduled during which I was again asked to limit the scope of my research. It was this time that I realized in what way I should have approached this research since the beginning. However, it is never too late to mend, after this meeting I focused more to limit the research scope and complete it within my decided timeline.

So far so good! Everything was going as per the schedule until the outbreak of COVID, which definitely affected everyone's working habits and schedules. While the lockdown had just begun, it was that duration of research when I had to conduct case studies and interviews. This entire lockdown and work from home scenario, taught me to be flexible (just as my thesis suggests) with my work habits. Although it did not create strong impact on my working habits, but it definitely affected my schedule as most of the interviews got postponed by a week and all the interviews were conducted virtually for a fixed time duration. Although conducting online interviews saved the travel time, but failed to provide an experience of conducting interviews in person. I would have loved to travel to different locations and meet the interviewees in person which unfortunately didn't happen. Additional delay that occurred which surpassed my buffer time allotted for case study methodology was due to cancellation of one of my case studies. This was a difficult time as I had already conducted interviews, after which the case study got cancelled, due to which another project had to be found as a replacement to this. Keeping the project management theory in mind, this situation came to me as

uncertainty as I did not account this risk. This taught me to be critical about the risk assessments done for the project and expect the unexpected. My company supervisor helped tackle this issue quickly and we made selection of another case within a week and proceeded with that case.

Finally comes the analysis part, which was undoubtedly the most interesting and at the same time most challenging part of the entire research. It was difficult and stressful at certain times to draw out conclusions. My company supervisor always advised to talk to different project managers and get their insights and I think this advice helped in obtaining suggestions for the research. Taking his advice, I even got back to the interviewees in case of any doubts with their responses which gave a clear and better picture. But as the research is exploratory in nature, it gives lesser handles on where to go and focus on the results and structure it well, which the graduation committee insisted on this to be achieved. Eventually, following the flow and by being flexible in scope to achieve the research objective, it was possible to draw the results and come to a conclusion, and submit this report without any delays. Looking back I think I tried my best to progress throughout the graduation process not alone academically but also as a project manager to my own project, keeping aside the shortfalls and, within the desired time and flexibly adjusted limited scope.

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APPENDICES

Appendix A

A1: Interview Protocol for Exploratory Interviews (Prepared for generic overview)

This semi-structured exploratory interview is conducted in AT Osborne and the participants involved are the project managers and consultants of AT Osborne. The interviews were conducted before the thesis kick-off meeting and before making the selection of flexibility enablers. The aim of conducting this interview is as follows:

1. To identify the current practices and difficulty in current practice
2. To identify the status of flexibility in practice
3. To make selection of enablers from a list of 26 enablers provided in the research of Jalali Sohi (2018).

General Information:

Subject: Exploratory Interview

Interviewer: Madhura Surve

Interviewee: …….

Date: ……

Time: ……

Location: ……

Introduction:

- MSc Construction Management & Engineering student at TU Delft
- Graduation research
- Context and Objective of research

General Questions:

- Which department do you currently work in?
- What is your current role?
- What is your highest level of study and field of education?
- How many years of experience do you have?

Projects and Project Management Methodology:

- What kind of projects are you involved in and what kind of projects have you managed so far?

- Which project phases are you usually involved in?
- What type of project management practices are you involved in? (Waterfall, PRINCE2, Agile, etc.)?
- If answered waterfall or PRINCE2, what are the difficulties that you face in practice?
- What would you like to change from the adopted methodology?

Flexible project management:

- What according to you is flexibility in project management?
- Are you involved in any flexible project management practices? If yes, in what manner?
- In which project activity or aspect would you like to induce flexibility?
- What benefits did you have of using flexible techniques as compared to the traditional method?
- What are the cons for it?
- What factors hamper adopting to flexible project management in practice?
- Have you heard about agile project management? If yes, which techniques from agile have you applied in any projects so far?
- Follow up to previous question, if not applied agile so far but aware of it, which techniques would you like to apply to construction projects?
- Keeping contractual requirements aside, you as a project manager/consultant would opt for flexibility in project management techniques or stick to the traditional methods and why?

A2: List of Respondents for Exploratory Interviews

Sr. No.	Name	Organization
1	Erik Dijkman	AT Osborne
2	Pelle de Wit	AT Osborne
3	Bastiaan Sommeling	AT Osborne
4	Gerard Scheffrahn	AT Osborne
5	Matthijs Winkelaar	AT Osborne
6	Wouter van de Siepkamp	AT Osborne

Table A2: *List of respondents for exploratory interviews*

Appendix B

Stage-gate model:

In search for increasing the efficiency in the product development process in the manufacturing industry and to improve flexibility in the decisions made in the product development process, Dr. Robert Cooper developed a model that focused on innovation process in New Product Development (NPD), called as the stage-gate model (Mulder, 2018). A stage-gate model or process is a conceptual and operational model that applies a consistent planning and review techniques throughout the process from idea to discovery to launch and beyond, in order to increase the efficiency in product delivery. It is like a blueprint that is created to manage the development of process of a new product (Cooper, 2008). It is composed of two main components, the 'stages' and the 'gates', the functions of which is explained as follows:

- *Stages:* Stages consists of set of activities that are organized and executed by project team by gathering information and data followed by analyzing it and subsequently producing the results and deliverables.
- *Gates:* Every stage is followed by a gate which serves as a decision-making point, quality check point, go/kill check points and marker for action plan for subsequent phase. All the deliverables of the previous stage are examined and values according to the project requirement. Each gate thus provides one of the following decisions: (a) Go, (b) Kill, (c) Hold, (d) Recycle.

The typical stage-gate system for a five-stage, five-gate system is shown in the figure below:

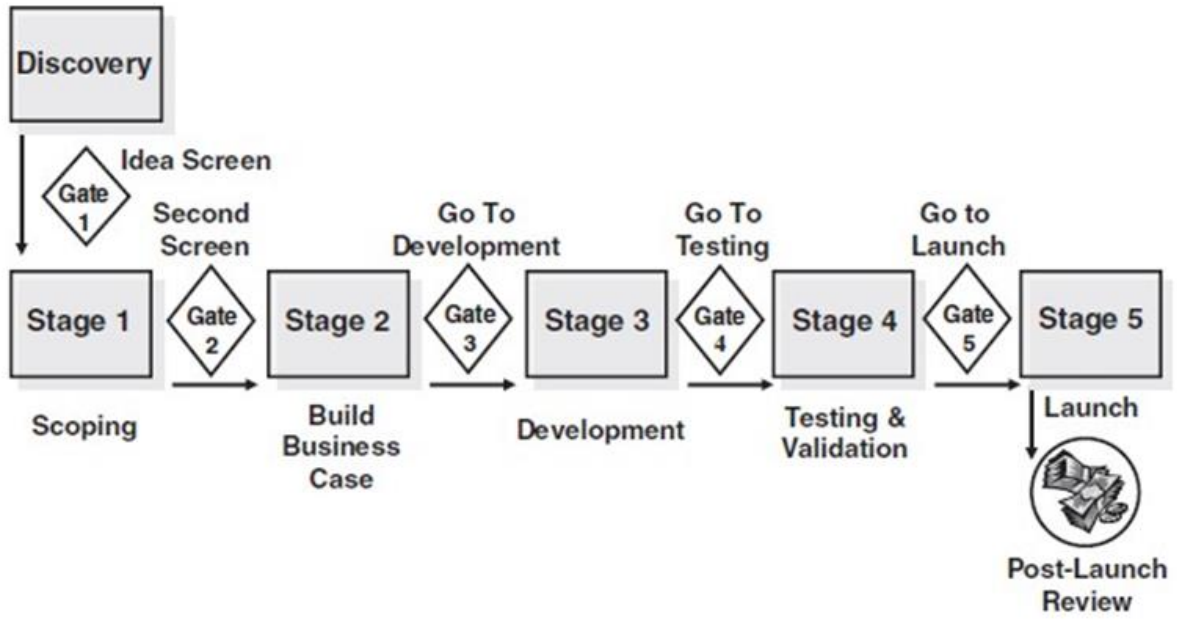

Figure B1: *An Overview of Typical Stage-Gate® System for New Product Developments, (Cooper R. G., 2017)*

The stage-gate model gives the flexibility to decide on the number of stages required for a particular project based on its size and complexity. Since major decisions are made at the gates, it can be used as a model to decide whether the decision should be locked in early or late in the process. Not all activities or decisions made can pass through all the gates. Those activities or decisions which have certain reservations can be hold back to first or second gate and can be reviewed later in development

process. This prevents rapid and early decision making and thus provides an opportunity to hold certain decisions for later stages, thereby enabling either continuous or late lock-in (Cooper D. R., 2008).

As the Cooper's stage-gate model largely influenced decision-making in production processes, efforts were made by group of researchers and companies during the Process Protocol (1995-2000) to develop a similar model for managing delivery of construction processes, named as the Generic Design and Construction Process Protocol (GDCPP) (Panas, Pantouvakis, & Edum-Fotwe, 2005). Moreover, it is not new for the construction industry to adapt practices from the manufacturing industry to accelerate the improvement in its project performance. The analogy of stage-gate model in construction lies in comparing its phases to stages, where the objective is to prepare the activities for the particular phase of a construction project for which the deliverables must be pre-determined, which on completion must be passed on to the gate for review and approval, followed by decision-making. If the outcomes pass successfully through the gate, it can be locked-in or partially locked- in, otherwise it could be kept on hold for locking at the later stages, as mentioned in (Eskerod & Ostergren, 2000).

Appendix C

C1: Case – Study Interview Protocol

Part 1: General Information

Introduction:

- Introduce myself
- Introduce thesis topic and context
- Mention objectives of the thesis and objectives of conducting interviews
- Mention that the information is confidential

Personal information of the interviewee:

- Name:
- Designation and Organization:
- Years of experience:
- Role in the project:

Personal information General Questions on flexibility in process:

1. What according to you is flexibility in process (with respect to the planning and decision-making process)?
2. How did you try to be flexible with respect to the planning and decision-making process for this project?
3. What were the reasons/objectives that made you deviate from the previous plans and decisions made?

Part 2: Main Questionnaire

Section 1: Questions on flexibility in process of planning and decision-making

4. In the survey you mentioned you recognized iterative planning and you did it (at 'X' intervals) for ('Y) phases? Can you explain how you did that?
5. What factors influenced making changes and/or iterations in planning process? How often were the changes/iterations made for this project?
6. What were the barriers/difficulties in making these changes and iterations to the plans (or in the identifying and implementing iterative planning)?
7. In the survey you mentioned you recognized iterative delivery and you did it (at 'X' intervals) for ('Y) phases? Can you explain how you did that?
8. What were the barriers/difficulties in identifying and/or implementing iterative delivery process?
9. In the survey you mentioned you recognized short feedback loops and you conducted it (at 'X' intervals) for ('Y) phases? Can you explain how you did that?
10. What were the barriers/difficulties in identifying and/or implementing the short feedback loops?
11. In the barriers that you faced for these three enablers, did you try to overcome these barriers and how?

Section 2: Questions on lock-in

12. How did you fix the decisions for this project and at what moments?
13. What type of decisions were kept for late lock-in? Can you come up with some examples?
14. Why did you decide to keep it for late lock-in?
15. What barriers/difficulties did you experience while keeping the decisions for continuous lock-in?
16. What type of decisions were locked continuously/iteratively? Can you come up with some examples?
17. Why did you decide for continuous lock-in?
18. What were the barriers/difficulties you experienced during continuous lock-in?
19. In the barriers that you faced for these two enablers, did you try to overcome these barriers and how?
20. How did keeping the decisions for later moments benefit you/this project?

Section 3: Questions on difficulties and consequences in implementation of enablers

(If answered didn't recognize barriers then following questions)

21. What were the difficulties you experienced when you tried to be flexible in terms of planning and decision-making process (OR project scheduling)? OR What were the reasons that you couldn't be flexible in terms of planning and decision-making process? *(Either of the two questions will be asked based on the previous answers)*
22. What are the consequences if we don't have flexibility in planning and decision-making (project scheduling)?
23. Why do you think these 5 enablers have not been used in construction projects?

Part 3: Closure

- Thank you for participating
- Agreement and anonymity
- Do you have any questions/comments?

ALTERNATIVE QUESTIONNAIRE:

These questions will be asked if the enablers have not been recognized or applied.

1. How did you do the project scheduling (OR planning and decision-making) in the project?
2. Do you think it was flexible?
3. To what extent was it flexible?
4. What tools/techniques did you use?
5. Why did you NOT use the mentioned enablers for project scheduling (OR planning and decision-making)?
6. In what way would you have used these enablers if you had applied it?

C2: Survey for Case – Study Interviews

Identification of flexibility enablers

Please read the write-up provided with this survey link and answer the survey questions.
*Required

1. Name *

2. Designation and Organization *

3. Years of experience *

4. Role in the project *

5. Given the definitions in the write-up, do you recognize any of the following enablers? *

Tick all that apply.

- [ ] Iterative Planning
- [ ] Iterative Delivery
- [ ] Short Feedback Loops
- [ ] Late Locking
- [ ] Continuous Locking

Iterative Planning	It is a process to adapt to the project as the project progresses by making changes to the plans and/or adjusting the schedule as and when needed in order to suit the project requirements.

6. Did you apply Iterative Planning? *

Mark only one oval.

- ◯ Yes
- ◯ No

7. If Yes, in which phase of the project and what was the duration of each iteration?

Tick all that apply.

	Weekly	Bi-Weekly	Monthly	Quaterly	Half yearly	Annually
Conception	☐	☐	☐	☐	☐	☐
Design and Planning	☐	☐	☐	☐	☐	☐
Execution	☐	☐	☐	☐	☐	☐
Project Closeout	☐	☐	☐	☐	☐	☐

8. Any tools or techniques used for iterative planning? Please specify.

9. Provides flexibility in project management?

Mark only one oval.

- ◯ Yes
- ◯ No

Iterative Delivery	It refers to dividing the work into smaller parts/subprojects and delivering the smaller parts/subprojects within a specified time. In the context of construction, it refers to delivering the changes made in project plans in the iterative planning process and reviewing it for continuous improvements.

10. Did you apply Iterative Delivery? *

Mark only one oval.

- ◯ Yes
- ◯ No

11. If Yes, in which phase of the project and what was the duration of each delivery?

Tick all that apply.

	Weekly	Bi-weekly	Monthly	Quaterly	Half yearly	Annually
Conception	☐	☐	☐	☐	☐	☐
Design and Planning	☐	☐	☐	☐	☐	☐
Execution	☐	☐	☐	☐	☐	☐
Project Closeout	☐	☐	☐	☐	☐	☐

12. Any tools or techniques used for iterative delivery? Please specify.

13. Provides flexibility in project management?

Mark only one oval.

- ◯ Yes
- ◯ No

Short Feedback Loops

It refers to conducting short term meetings and giving frequent feedback for the tasks that are going to be delivered in order to keep the team focused on the project goals and objectives.

14. Did you use Short Feedback Loops?

Mark only one oval.

- ◯ Yes
- ◯ No

15. If Yes, in which phase of the project and what was the duration between each feedback loop?

Tick all that apply.

	Daily	Weekly	Bi-weekly	Monthly
Conception	☐	☐	☐	☐
Design and Planning	☐	☐	☐	☐
Execution	☐	☐	☐	☐
Project Closeout	☐	☐	☐	☐

16. Any tools or techniques used for short feedback loops? Please specify.

17. Provides flexibility in project management?

Mark only one oval.

- ◯ Yes
- ◯ No

Late locking	It refers to keeping certain decisions open until the last possible moment or later moments (postponing the fixing of decisions) and not fixing those decisions upfront in the early phases.

18. Did you use Late Locking? *

Mark only one oval.

- ◯ Yes
- ◯ No

19. If Yes, in which phase of the project?

Tick all that apply.

- ☐ Conception
- ☐ Design and Planning
- ☐ Execution

20. Any tools or techniques used for late locking?

_____

21. Provides flexibility in project management?

Mark only one oval.

- ◯ Yes
- ◯ No

Continuous locking	It refers to keeping certain decisions open and fixing the decisions after reviewing it as the project progress (fixing the decisions continuously as and when required) and not fixing those decisions upfront in the early phases.

22. Did you use continuous locking? *

Mark only one oval.

- ◯ Yes
- ◯ No

23. If Yes, in which phase of the project?

Tick all that apply.

- ☐ Conception
- ☐ Design and Planning
- ☐ Execution

24. Any tools or techniques used for continuous locking?

_____

25. Provides flexibility in project management?

Mark only one oval.

- ◯ Yes
- ◯ No

Thank you for participating in the survey!

C3: List of Interviewees

Code	Name	Organization	Date
1.1	Martijn Donders	Mott MacDonald	April 1, 2020
1.2	Alexander Schutte	AT Osborne	April 1, 2020
1.3	Tom van der Kamp	Gemeente Utrecht (POUHL)	April 9, 2020
2.1	Pelle de Wit	AT Osborne	April 6, 2020
2.2	Gerard Scheffrahn	AT Osborne	April 10, 2020
2.3	Matthijs Wentink	AT Osborne	April 10, 2020
3.1	Erik Dijkman	AT Osborne	April 3, 2020
3.2	David Bikker	HollandPTC	April 8, 2020
3.3	Erik Schipper	J.P. van Eesteren	April 10, 2020
4.1	Folkert Jans	PTG Advies	April 16, 2020
4.2	Alexander Eppens	PM² Bouwadviseurs	April 21, 2020
4.3	Jaap Vriesema	Adviesbureau J. Vriesema	April 27, 2020

Table C3: *List of respondents for case study interviews*

Appendix D

Case Study Analyses

This section presents analysis for identified barriers in implementation of flexibility enablers. The barriers presented in chapter 4 for each case have been identified and obtained from the interview responses. Here, for every case the interview responses for the question- "*What barriers/difficulties you faced for implementing the (X) flexibility enabler?"* is presented in a tabular format. These responses provide evidence for the barriers mentioned by the interviewees in the interviews for each enabler. These responses have been compared with the theoretical framework, the results of which have been provided in tables 4.3, 4.5, 4.7 and 4.9, for cases 1, 2, 3 and 4 respectively. It is important to note that the repeated responses by the interviewees about the same enablers have not been considered. Following this section, the observations were made for the suggestive measures undertaken by the practitioners (if any) to overcome the mentioned barriers.

D1: Analysis Case I- Uithoflijn Project

This sub-section presents the interview responses for the barriers mentioned by the practitioners in implementing the flexibility enablers for case 1, the results of which are provided in table 4.3. Further, it presents the suggestions mentioned and used by practitioners to overcome some of these barriers.

Enablers	Responses for identified barriers	Link to theory
Iterative Planning	"Our contracts did not allow to change repeatedly. We had a few fixed price contracts did not allow for any planning iterations." "Due to contractual requirements the management does not support such processes to be used."	Contractual requirements do not allow for changes; Lack of management support.
	"Changes made in plan even for quarterly iterations and updates were questioned by the politicians."	Political vulnerability.
	"Decision-makers did not agree on this process and the changes that come along with it. Everybody wanted to achieve the set start date of project for July 2019 which cannot be achieved if milestones keep changing or iterations are made to schedule…..This leads to lot of discussions and prevents using this enabler."	Team members unwilling to accept changes as old commitments need to be kept.
	"Internally we wanted to change milestones for the plan we made for internal purpose but there was difficulty to get people onboard while making changes."	Lack of people collaboration and active participation.
	"Also, the asset managers who had to maintain the line were quite skeptical of the process and planning. They said it couldn't be done and we don't have all documents needed and all these procedures will take more time than planned and require extra cost."	Skepticism towards new way of working; Implementation of iterations can be difficult; (Not in literature) Unable to estimate time and budget.
	"Contractors do not accept such processes as they think it takes more time to realize the project."	Notion that it leads to additional delay and cost (Not in literature).
Iterative Delivery	"People didn't understand this process well." "It was difficult to understand and we didn't have any method to use this enabler. So we used it to our own understanding for testing the signaling system. Some members resisted this method as they were unclear of what needs to be done"	Lack of guidance from theory to implement enablers; Lack of understanding this enabler.
	"In the process we used it for it seemed like rework for many people. Continuous validation to be done for fixing the systems often lead to teams not taking the work seriously." "This process was definitely time-consuming and without any conformity for results…Although we managed to successfully install the system but still entire organization was unsure if the applied testing and validation	Over scoping and rework; Unwillingness to put more efforts; Organizations resistant to adopt these enablers out of fear of consequences.

	process will give good results or have heavy consequences. Probabilistic analysis provided with certain estimates.	
	"The contractor had issues with iterative delivery, as the contractor had some issues with their planning. They were not able to adapt to the divisions of planning. They needed to give their buffers and it delayed the process and added to expense. They didn't accept this way of working and were against using such processes in construction projects"	Unacceptable by contractors; Implementations of iterations in plan can be difficult; Unable to estimate time and budget; Skepticism towards new way of working.
	"It was difficult for us to decide between different deliveries. The testing over a longer period of time brought new issues to light which made it difficult to prioritize the activities."	Difficulty to decide and prioritize between different deliveries.
Short Feedback Loops	"No barrier as such were faced for it but it was observed that the daily standups were annoying for some people and eventually lacked participation from some members." "People did not show active participation and are mostly responsible on one other to attend those meetings and undertake the actions discussed in these meetings."	Lack of people collaboration and active participation; Over-scoping and rework.
Late Locking	"Didn't understand the meaning of late locking and how it can be done." "Other than postponing the commencement date, don't know if it was used as I cannot understand the meaning of this enabler and I cannot recognize an example where it was specifically used."	Lack of methodologies from theory to implement enablers; Lack of understanding enabler.
	"Unacceptable by stakeholders and other projects parties as there were other projects running simultaneously with this project…Owners need explanations as to why decisions were kept for late locking. It is better to stick to previously made decisions to satisfy the owner requirements and later change decisions when necessary than using some enabler to do it. In general, it is better to have all decisions made in advance and not use such enablers in big infrastructure projects. Moreover, the owners do not want to face additional consequences out of use of a new enabler." "Stakeholders don't have trust in project teams if timely decisions are not made and this enabler postpones decisions that can lead to miscommunication and uncertainty."	Lack of management support; Lack of trust from stakeholders; Notion that certain enablers cannot be applied to construction industry (Not in literature); Organizations resistant to adopt this enabler out of fear of consequences.
	"Owners expect to know everything in advance to get their support. It becomes difficult to keep important things open and not convey to owners."	Management of expectations is difficult.
	"If late locking is used, it can cause to create alterations in plans and schedule again due to late locking of certain decisions, which can become tedious to use and can disrupt the progress and cause delay to not just this but other parallel projects."	Over scoping and rework; Notion that it can lead to additional delay and cost expense (Not in literature).
Continuous Locking	"Difficult to use such enabler for infrastructure projects as so many stakeholders are involved who need reasons for everything. Without making decisions and providing reasons for every decision made the stakeholder don't trust the project teams." "In the project management team not everybody has same opinion and acceptance of continuously fixing some decisions. The managers didn't want any continuous locking and wanted all activities to be executed as planned to avoid reword and changes in scope." "Stage gate facilitates this process but not many in the project team know about stage gate and how it can be used and so it was not used in this project to avoid additional confusions."	Lack of guidance to implement it; Lack of understanding the enabler; Lack of trust from stakeholders; Organizations resistant to adopt the enabler out of fear of consequences; Notion that certain enablers cannot be applied to construction.

Table D1: *Case Analysis- Uithoflijn Project*

The extracted information from the interviews resulted in providing some suggestions mentioned by practitioners to avoid some of the above identified barriers. These were very limited as practitioners did not incorporate all enablers explicitly.

D1.1: Here, it was the decision of project manager and project planner to adopt such a process for conducting successful testing of tram lines. It was observed that the organization at first did not

approve of implementing process like iterative delivery for the testing and validation of coaches and signaling systems. Even the contractors had issues in the beginning with using iterative delivery enabler in the process. In order to tackle to gain acceptance by organizations to use this process, the project planner organized a joint session with all team leaders and dependent stakeholders of POUHL organization and explained them the process of iterative delivery by giving examples of his previous projects where he had used the same in another project (not disclosed). He provided step-by-step procedure of how it was adopted in his past project and how it can be beneficial to this project. The presentation given by the project planner was confirmed in the document review. According to him the project teams need to know how a process like iterative delivery can be put to practice and be beneficial to their project to align the members with this way of working and gain their confidence in it. Nonetheless, he provided the estimations of his previous projects as well as the results of pilot testing which served as an example for applying this enabler in the Uithoflijn project. Estimations gained trust from stakeholders and the project teams and cleared their misconceptions of adopting this process. He further stated that conducting this joint session first for team members and then contractors was time-consuming but proved to be beneficial to avoid some of the barriers as stated above. He suggested the same to be applied to other projects to gain acceptance by team and encourage them to use this method as it had positive results.

Thus, based on this it can be said that the suggestion S4- 'Share positive insights from other projects' was used to overcome barriers B3-'Skepticism towards new way of working' and B4-'Organizations resistant to adopt the enablers;' and S11-'Provide estimations from pilot testing' was used to overcome barriers B7-'Lack of trust from stakeholders', B10-'Notion that it can lead to additional delay and cost expense' and B11-'Notion that certain enablers cannot be applied to construction industry.'

D1.2: Similar to the above mentioned, the practice of iterative planning lacked encouragement and participation from team members. Time chainage diagram was used to complement this process. As this process was used for the internal plan only, the project director was directly responsible for it. He stated- "*Any iterations made in planning were quite stable by using time-chainage diagram. The time chainage diagram is very helpful for understanding where the major works are taking place. For projects like this- it's a linear project which is 9km in length - you won't be constructing in one place at whole time. So, its beneficial to have a time chainage diagram. That is why I encouraged everyone to use this it for making any iterations in plan. You can say it was similar to a strong decision made by the project director himself to use this tool. Everyone agreed to it and we started using collaborative tools like BIM to continue using this approach. But this was only for internal use and internal plan. The stakeholders and politicians were not aware of this approach."*

Thus, based on the above statement it can be said that the suggestion S9-'Encourage management and teams to adopt these enablers' can be used to overcome barriers B8-'Lack of people collaboration and active participation' and B9-'Unwillingness to put more efforts'.

D2: Analysis Case II- North South Line Project

This sub-section presents the interview responses for the barriers mentioned by the practitioners in implementing the flexibility enablers for case 2, the results of which are provided in table 4.5. Further, it presents the suggestions mentioned and used by practitioners to overcome some of these barriers.

Enablers	Responses for identified barriers	Link to theory
Iterative Planning	"It was not easy to adapt integral planning as it was used first time in such a project. Hence, initially team members faced difficulty in adjusting the milestones due to commitment to old milestones….There was difficulty in implementing integral planning as most team members were not habitual to use it." "Due to newness of this approach there was an underestimation of time that will be required to complete every iteration."	Team members unwilling to accept changes as old commitments need to be kept; Implementations of iterations in plan can be difficult; Planning fallacy and optimism bias.
	"Since certain fixed milestones required well controlled iterations. It led to interfaces problem and coordination problems between sub-contractors." "The project team constantly had to monitor what the effects of iteration would be on final milestones. This was additional work to be done with one or two team members doing it."	Poor interfaces between design and construction and improper coordination; Over scoping and rework;
	"Traditional contractors opposed iterations in plan. Also, the three months baseline seemed smaller for iteration duration leading to poor interfaces."	Unacceptable by contractors; Poor interfaces between design and construction and improper coordination
	"Organizations and steering group initially didn't allow for integral planning as it can lead to cost expense and delays….Also, they are answerable to politicians and can lead to certain political implications."	Notion that it leads to additional delay and cost (Not in literature). Political vulnerability.
Iterative Delivery	"Initially there was a hesitation is implementing release management model due to no available full proof methods as well as less acknowledgement by team members." "Release management when used at the start had no trainings by the management and hence it was not acceptable by team members. Firstly the entire organization had to be convinced for this way of adaptive thinking as there was a traditional approach followed by everyone in the team and also the organization."	Lack of guidance from theory to implement enablers; Lack of understanding this enabler; Insufficient training and coaching; Skepticism towards new of working.
	"Fixed starting date did not allow more scope changes and trying another way of working. It was very difficult in the beginning to adopt release management. It faced opposition from both internal and external groups as they had no idea of what will happen if it does not work fine." "Oppositions from all sides at the beginning did not facilitate smooth application….During this phase a lot of political implications had to be faced due to several parallel deliveries at various areas."	Over scoping and rework; Skepticism towards new way of working; Team members unwilling to accept changes as old commitments need to be kept; Organizations resistant to adopt these enablers out of fear of consequences; Political vulnerability.
	"There was no trust between the parties, between project team and contractors and also stakeholders did not trust the project team to successfully apply this new technique. Although stakeholders accepted it later, convincing them was very difficult. Same was with contractors for whom this method was not preferred way of working as it is not suitable for such projects"	Unacceptable by contractors; Lack of trust from stakeholders; Unacceptable by contractors; Notion that certain enablers cannot be applied to construction industry.
	"While implementing this technique more efforts were needed to manage parallel works. Which troubled the team members and they did not want to spend time on these activities anymore." "There were around 15-20 interfaces and every interface were challenging. As this method was new there were certain interfaces problems that caused delays and a little more cost for delivering certain parts, especially in station area as we couldn't estimate this delay."	Difficulty to decide and prioritize between different deliveries; Planning fallacy and optimism bias; Over-scoping and rework; Unwillingness to put more efforts; Poor interfaces between design and construction and improper coordination.

Short Feedback Loops	"Reflective meetings were efficient but as project was large, it were very exhaustive….Monitoring issues from previous feedback loops had bit of troubles due to size of project which sometimes lost interest in teams to attend these meetings and extend additional efforts." "Some project managers had hesitation to discuss their issues and at times did not attend the meetings." "Sometimes not every issue could be discussed which had to discussed later in next feedback loop which was considered as rework."	Lack of people collaboration and active participation; Unwillingness to put more efforts; Over-scoping and rework.
Late Locking	"It was difficult to recognize this enabler and more difficult to apply it as the scope was fixed and also the milestones were fixed in time. We had a roadmap laid out already and other than the commencement date no other decisions were postponed. Had this been done there would be political problems as many politicians were involved in the project."	Lack of methodologies from theory to implement enablers; Lack of understanding enabler; Political vulnerability.
	"In this project giving reason as lack of information was certainly unacceptable as it can lead to loss of trust and confidence from several stakeholders. Moreover, the four main contractors did not and would not have accepted if decisions were kept open or postponed."	Lack of trust from stakeholders; Unacceptable by contractors;
	"Not sure if it is good to keep decisions open and it can lose quality of decisions as well. No training was available like that given for release management to use such an enabler."	Insufficient training and coaching.
Continuous Locking	The respondents mentioned almost similar barriers as experienced in late locking. They were unable to identify this enabler and had no knowledge of incorporating it. According to them, such enablers cannot be used in the infrastructure and won't be acceptable by contractors as well as a few stakeholders.	Lack of guidance to implement it; Lack of understanding the enabler; Unacceptable by contractors; Notion that certain enablers cannot be applied to construction.

Table D2: *Case Analysis- North South Line Project*

The extracted information from the interviews resulted in providing some suggestions mentioned by practitioners to avoid some of the above identified barriers. These were very limited as practitioners did not incorporate all enablers explicitly. Most of the suggestions mentioned were limited to the practice of release management (iterative delivery).

D2.1: The concept of release management was applied for the first time in a metro project. There were no available methods or guidelines available to be used when it was decided to use release management in the execution and project close out phase. It was used for testing of metro line signals and systems for all stations. In project like NSL with so many parties involved, it was difficult to test something that was always changing. So in 2015, the integration testing of tracks was started, the systems were first tested individually by the builders and then the suppliers. All of it was done using release management where the project was divided into different released. The releases were done stepwise with testing and release of each component separately. The technology used for this project was one of the latest technologies which required a different type of management. This different type of management was the V2V system as they call it which consists of 3 major components, one of which was release management.

Being a new method of management, it lacked understanding. Project teams were unaware of this process and there were no prescribed methods to use it. There was opposition by most of the members in using a new process and team members were not ready to accept any change as the project had already incurred high cost and significant delay. As it was finalized to use this process, it was important to inform entire team and train them. To avoid any difficulties in implementing this process, training were provided to entire team in small batches. The responsibility to provide training lied with the project director and the commissioning manager. They organized trainings were

delivered by agile experts which also consisted of certain workshops. The team was explained about all the required steps to perform release management. These training provided with examples of using the enablers in construction as well as software industries. It also provided with comparisons and expected errors that can occur in its implementation. The team members were also informed about the expected changes that can occur in their process and how they can deal with it. It provided with successful insights from projects where release management was applied and how it can guarantee success in NSL project. Additionally, as software systems were applicable in context of this project due to the latest technology used, training on agile component like iterative planning and scrum were also provided once in two months in batches for different team members. A record of such trainings have also been provided in the evaluation reports.

The project director and commissioning manager both suggested to provide proper trainings before application of any of the five enablers as leads to awareness and also encouraged the project team thereby reducing any resistance to incorporate it. Thus, based on this discussion, suggestion S2-'Provide training sessions and workshops on application of enablers' was used to overcome barriers B1-'Lack of understanding of flexibility enablers' and B2-'Lack of guidance from theory to implement the enablers.'; and S4-'Share positive insights from other projects' was used to overcome barriers B3-'Skepticism towards new way of working', B4-'Organizations resistant to adopt this enabler' and B5-'Team members unwilling to accept changes as old commitments need to be kept.'

D2.2: Additional to the provided training, prior to using a new technique for entire project it was decided by the project director and steering board members to conduct pilot testing for intermediate releases. Two stations of intermediate releases were selected for conducting pilot test as these two releases were fixed in scope and there were no more changes expected or required to be done at these two stations. Contractors were involved in conducting pilots. The main reason for conducting pilots was to get contractors in confidence for implementing release management which proved to be beneficial. This increased collaboration and contractors' expertise was also used in this process. Thus, based on this discussion, suggestion S6-'Start with pilot testing using enablers to gain acceptance' was used to overcome barrier B6-'Unacceptable by few contractors.'

D3: Analysis Case III- Holland PTC Project

This sub-section presents the interview responses for the barriers mentioned by the practitioners in implementing the flexibility enablers for case 3, the results of which are provided in table 4.7. Further, it presents the suggestions mentioned and used by practitioners to overcome some of these barriers.

Enablers	Responses for identified barriers	Link to theory
Iterative Planning	"It became difficult to identify where this process was leading to and if the iterations in design phase were conducted at right time because there was no method that team could stick to and refer the guidelines. This process seemed like guesswork and it seemed it required more time than usual and further increase cost. All team members were dependent on project manager for every iteration and every change in plan." "Due to no available method, team members will face difficulty in implementing the enabler and organize timely iterations and monitor progress."	Lack of guidance from theory to implement enablers; Notion that it can lead to additional delay and cost expense; No initiation from project members to adapt this enabler; Dependency on project managers to assign tasks; Implementation of iterations difficult for employees.
	"This process was unacceptable by some people who didn't provide with good information that was required to conduct this process smoothly." "Process was not acceptable by clients as well as contractors and there are often communication issues, and also can cost more time and money. People in the team were not sure if such a process works well even in design phase. In execution, it happened for all sub-team managers as they also were unsure if such an enabler can work."	Unacceptable by few contractors; Notion that it can lead to additional cost and delay; Skepticism towards new way of working.
	"Mostly teams want to maintain critical path planning, so members stick to original plans and don't change plans more. Also, in iterative planning process, the iterations revolved around critical planning in order to not make more changes and put less efforts." "Deviations from end results are unacceptable in every phase of project. As no consequences are known and estimations are not available, people oppose to use this way of working."	Team members unwilling to accept changes as old commitments need to be kept; Unwillingness to put more efforts; Tendency of team members to stick to initial plans and decisions; Organizations resistant to adopt these enablers out of fear of consequences.
Iterative Delivery	"Assumptions made during iterative delivery process in installation of medical equipment can be false assumptions to shorten the process. It is because there is no guideline mentioned in PRINCE2 to use such process. The project here was managed using PRINCE2 and we had to follow it throughout the project….Using such an approach was doubtful for applying in hospital projects…Since it was decided to use PRINCE2 management did not want to use any other approaches." "It is difficult to use this enabler in hospital buildings. There are strict regulations of buildings to be followed for getting desired permits. It can be used in software but here people don't understand it and there are no methods that we are aware of or PRINCE2 provide." "Need more information and guidelines to use this method without which how can we use this directly to project. It is risky. It can cost heavy expense and time too."	Lack of guidance from theory to implement enablers; Lack of understanding this enabler; Lack of management support. Skepticism towards new way of working; Notion that certain enablers cannot be applied to construction industry; Notion that it can lead to additional delay and cost expense.
	(For ordering and installations of equipment) "Iterative delivery led to repetitive efforts to make calculations for equipment to see how much cooling and power/power units they require. Some team leaders refused to do it and provided estimations based on previous experiences. Even after this the estimates were not proper and due to repetitions; it was difficult to confirm one estimate and answer the clients and contractors."	Over scoping and rework; Unwillingness to put more efforts; Organizations resistant to adopt these enablers out of fear of consequences; Unwillingness to put more efforts; Unable to estimate time and budget.
	"Suppliers did not provide enough information or didn't provide with specifications of equipment again and again. We hired structural and mechanical advisors who could provide with proper estimations but even	Unacceptable by contractors; Implementations of iterations in plan can be difficult;

	they made guesswork certain times and detailed calculations were slightly incorrect to make decisions. Clients opposed using the repetitive process of calculation which did not provide with full proof estimates. Using incorrect data will create additional problems which had to borne by them."	Unable to estimate time and budget; Skepticism towards new way of working; Organizations resistant to adopt this enabler out of fear of consequences
	"Project manager initiated with effective process to be used and took initiation of such process, of course following PRINCE2 methodology but as far as other team members were concerned, nobody willingly took responsibility of adopting to different process, be it this enabler or feedback loops."	Difficulty to decide and prioritize between different deliveries; No initiation from project members to adapt flexibility enablers.
Short Feedback Loops	"PRINCE2 methodology was used and it was idea of project manager to implement short feedback loops, but it was difficult to get people on board for these meetings. The communication was not effective, and it lacked interest." "There was no right way to escalate the issues to higher authority and proper information was provided by the team members."	Lack of people collaboration and active participation; No initiation from project teams to adapt flexibility enablers.
Late Locking	"It was in favor of clients as they wanted to initiate late locking but contractors urged for more information in the beginning itself. It was a traditional contract and all the contractors and stakeholders expected all decisions to be provided in the beginning…The dependent stakeholders started losing confidence in the project management team as they considered it inefficient to keep decisions open…Due to this postponing decisions or late locking as you call it, there were arguments between few stakeholders and project teams. Stakeholders should have been informed about this earlier." "If contractors were informed about open decision, they considered that the clients are facing some difficulty as a result it can harm contractors' planning and scheduling. They always wanted every information in the beginning to not take responsibility on their shoulders and so did not agree to late locking."	Lack of trust from stakeholders; Unacceptable by contractors; Fear of conflicts between project teams and stakeholders.
	"For certain decisions it is wise to use late locking, but it doesn't mean that we keep every decision for late locking as it reduced trust between parties which later in process prevented to keep other important decisions open." "Late locking prevents making proper decisions on finance and budgeting and it often happen that people don't use it wisely…More efforts are needed to monitor the risk as decisions are open and there was always one person taking care of this factor. So sometimes even team members are skeptical to use it."	Lack of trust from stakeholders; Unable to estimate time and budget; Requirement of constant risk monitoring (Not in literature); Skepticism towards new way of working.
Continuous Locking	"Understood and applied late locking but did not understand the process of continuous locking….Did not find any differentiation between late locking and continuous locking."	Lack of understanding the enabler;
	"Continuous locking is intensive, requires constant monitoring and also right risk assessments. You can lose time and grip on planning which can lead to difficulties. The stakeholders will not allow it. There will be delay in obtaining permit. You don't have correct estimations at the end of process."	Requirement of constant risk monitoring; Unable to estimate time and budget; Notion that it can lead to delay and cost expense. Lack of trust from stakeholders.

Table D3: *Case Analysis- HollandPTC Project*

The extracted information from the interviews resulted in providing one suggestion mentioned by practitioners to avoid some of the above identified barriers. It was very limited as practitioners did not incorporate all enablers explicitly.

D3.1: Although late locking is commonly used enabler in hospital building projects especially for decisions based on order, installation and testing of heavy medical equipment, it needs support from the clients. The project manager in the interviews mentioned that the application of late locking was not solely his decision but came from the management. It was consensually decided between the steering group and project manager to adopt late locking for decisions based on heavy medical equipment. There was no tool or technique that supported implementing late locking but since it had came from the management and had support from the management, it was easier to implement it and was not opposed by other team members or stakeholders if it will work in this case. Hence, as a suggestion the project manager stated- "*Gain management support first to ease the incorporation process. This way the team members accept it and don't question on keeping decisions open or even postponing it. It will only provide flexibility for team members in decision-making and provide with enough time to make rightful decisions after gathering more information."*

Thus, based on above discussion, the suggestion S8-'Ensure management support in adopting enablers' was used to overcome barrier B3-'Skepticism towards new way of working.'

D4: Analysis Case IV- Imaging Center Project

This sub-section presents the interview responses for the barriers mentioned by the practitioners in implementing the flexibility enablers for case 4, the results of which are provided in table 4.9. No suggestions were identified to be implemented in practice to overcome the experienced barriers.

Enablers	Responses for identified barriers	Link to theory
Iterative Planning	"Due to traditional contracts it is difficult to start using some new method and keep changing plans and schedules. Also, not everybody knows about such a process which makes it difficult to apply. Other than a few members I believe there were not many people who acknowledged this enabler as we worked with a traditional team and traditional practices." "Don't know how iterations can be done in execution. Never read or heard about any technique to do it in building projects.	Lack of guidance from theory to implement enablers; Lack of understanding this enabler; Lack of qualified members.
	"It is suitable in design phase but not later and this process is very difficult to adapt to... Due to traditional setting, making changes to plan was not acceptable both by contractor and project management teams. They wanted to use original plans and follow the plans as decided during project brief. Nobody had a mindset to accept changes even for good cause. According to them it increases complexity. More changes bring more cost." "Contractors claimed more cost for frequent changes to plans because of which clients did not want to apply any iterations again and again."	Tendency of team members to stick to initial plans and decisions; Team members unwilling to accept changes as old commitments need to be kept; Organizations resistant to adopt this enabler out of fear of consequences.
	"The traditional setting put constraints on project leader to change the plan and he had his own doubts to make changes to plan and proceed with such a process which he is not sure if will be used properly. He did not want any extra work or resources to be applied for applying some new enablers." "Iterative planning is not adaptable and can lead to unnecessary schedule delay and cost overruns."	Unwillingness to put more efforts; Organizations resistant to adopt these enablers out of fear of consequences; Skepticism towards new way of working; Notion that it can lead to additional delay and cost expense.
Iterative Delivery	This enabler had similar type of responses for occurred barriers as compared to iterative planning. "Don't know this enabler and didn't understand what it can mean for construction. No training available for using this process then how can the team members be qualified to use it. So it is better to keep away unnecessary process from construction sector." "Such processes are unsuitable for construction projects and there are not practices to refer to or tool to monitor it for construction…The project members were very traditional following traditional practices who refused any additional changes and different processes. They wanted simplicity in managing project throughout all phases. They didn't want to do additional work for something they considered wont work for this project. Nobody wants to face consequences of what such a process will bring with it."	Lack of guidance from theory to implement enablers; Lack of understanding this enabler; Insufficient training and coaching; Lack of qualified members; Skepticism towards new way of working; Notion that certain enablers cannot be applied to construction industry; Organizations resistant to adopt this enabler out of fear of consequences; Unwillingness to put more efforts.
	"Using such process can delay the process of acquiring the necessary permits and extend its corresponding procedures which can ultimately increase project cost."	Notion that it can lead to additional delay and cost expense.
	"All members as well as contractors had defined set of activities, defined schedules and resources allotted for each activity. They followed it thoroughly and faced no difficult as such so why would they use a process of which they are unaware of and can bring in some change to their commitments and hamper their way of working."	Team members unwilling to accept changes as old commitments need to be kept.

Short Feedback Loops	"No difficulty observed as such but people did not know how to use Scrum properly or even how the regular feedback meetings could be used beneficially."	Lack of people collaboration and active participation; No initiation from project teams to adapt flexibility enablers.
	"Conducting feedback loops involving all major actors seemed a tedious job so we didn't conduct any such meetings." "Even the regular meetings that were supposed to be conducted as decided during the project start were not conducted at regular and specific intervals which had lesser involvement of many members and no active participation." "Frequent feedback loops were not considered helpful as the process becomes slower. Not all team leaders took initiative to conduct these meetings. Team leaders depended on project manager to conduct meetings as and when required. It was also not feasible for management to conduct frequent meetings if issues were not very important and urgent."	Lack of people collaboration and active participation; No initiation from project teams to adapt flexibility enabler; Dependency on project managers to assign tasks; Lack of management support.
Late Locking	"Late locking was used purely based on experience of project managers and team leaders. Organization hesitated to use as there was no method used for late locking and was done only by consensus. It was difficult to understand its consequences and whether or not this process will be suitable. It was a risky business and not much support was offered by stakeholders. Stakeholders did not have confidence on project manager when this enabler was proposed to be used even for less important decisions."	Lack of guidance from theory to implement enablers; Lack of trust from stakeholders; Lack of qualified members;
	"It can cost more money to keep open decisions also for certain medical equipment and its installations. It is difficult to estimate the money required to close the decisions at later project phases. If estimates are not timely provided the contractors cannot begin with certain building works. The contractors don't want to accept any risks and are never in favor of late locking."	Notion that it can lead to delay and cost expense; Unable to estimate time and budget; Unacceptable by contractors.
Continuous Locking	This enabler had similar type of responses for occurred barriers as compared to iterative planning. At first none of the interviewees were able to recognize this enabler, the reason being they never heard about it and mainly as they couldn't distinguish between late locking and continuous locking as stated in their responses. "How is this different than late locking?....Cannot make distinction between this and late locking. Not aware of technique or methods that have explained this enabler."	Lack of guidance from theory to this implement enablers

***Table D4**: Case Analysis- Imaging Center Project*

Appendix E

E1: Expert Interview Protocol

Prior to conducting the expert interviews, a presentation was given to the company in the presentation series called 'Afstudeerpitches' organized by company on May 29th, 2020. This presentation was attended by all experts as well as other project managers and consultants from AT Osborne. As all the experts were consulted prior to the delivering this presentation, all the four experts had joined the presentation. In this presentation, the research was explained. The research context, research objectives, methodology and case study results were presented. The expert interviews were conducted in the following two weeks. As the research was already presented to the chosen experts, only an overview was provided during the expert interviews to save time. In the interviews, the proposed suggestions and proposed conceptual framework was validated by the experts. Each interview lasted for a duration of 80-90 minutes.

The protocol followed for expert interview session is as follows:

1. Introduction and Overview of research and case study results. *(Duration: ≈ 10 minutes)*
2. Validation of proposed suggestions: Presenting and explaining table 5.1 from thesis. One by one discussion of all 11 barriers with its proposed suggestions. *(Duration: ≈ 40 minutes)*
3. Validation of proposed conceptual framework: Presenting and explaining the framework (Figure 5.2). Discussion based on following five questions. *(Duration: ≈ 40 minutes)*
   (a) Do you think the proposed model is valid and applicable from both infrastructure and healthcare real estate projects?
   (b) Which steps/suggestions are not clear from the framework?
   (c) What should be changed or restructured from the proposed framework to make it more applicable?
   (d) Do you think the current working culture of AT Osborne is suitable for implementing this framework?
   (e) The suggestions provided in the framework are not new or unknown, then why don't the practitioners use them?

E2: Expert Interview Participants

Sr. No.	Name	Organization	Date
1	Frits Verhees	AT Osborne	June 5, 2020
2	Bastiaan Sommeling	AT Osborne	June 8, 2020
3	Geertje van Engen	AT Osborne	June 8, 2020
4	Sandra Brouwer	AT Osborne	June 10, 2020

Table E2: List of Expert interview participants

Appendix F

Release Management (Iterative Delivery)- North South Line Project (Case 2):

The figure below shows the schematic presentation of V2V model adopted in the commissioning process of NSL project. The release management approach was a part of this model. The commissioning process started in 2015 with an aim to implement and deliver the scope of various parts on the project as assigned to various contract teams and contractors. The main method used to control the commissioning process was release management.

Release management stems from taskforce planning. Adopting this process, entire NSL project was divided into smaller parts called releases. It consisted of stepwise reduction of remaining scope of the project. Every release was considered as a part of a big system and was planned, scheduled and managed for its delivery through the stages of constructing, testing, deploying and validating the release. Here, the project was considered as a product-based paradigm and several releases were delivered simultaneously. Each of the releases were tested for its technical requirements prior to its delivery, thereby adopting the concept of iterative delivery. As the releases were delivered simultaneously, it led to quickly identify possible defects of a particular release or in the integration of two releases and fix it prior to the final delivery. It increased the collaboration as the joint release teams consisted of project team members as well as members from contractors and users. This facilitated in continuous improvement in the delivered metro line thereby not facing heavy interface or technical issues. This process of continuous delivery led to practicing and learning during the commissioning process and guaranteed flexibility in process by keeping the flexibility in scope but not in time. It also gave flexibility to make early adjustment, both by the builders, owners and suppliers. In this way, due to its flexible approaches to test and validate the metro systems, formed the backbone for the entire Commissioning process, thereby leading to its successful implementation.

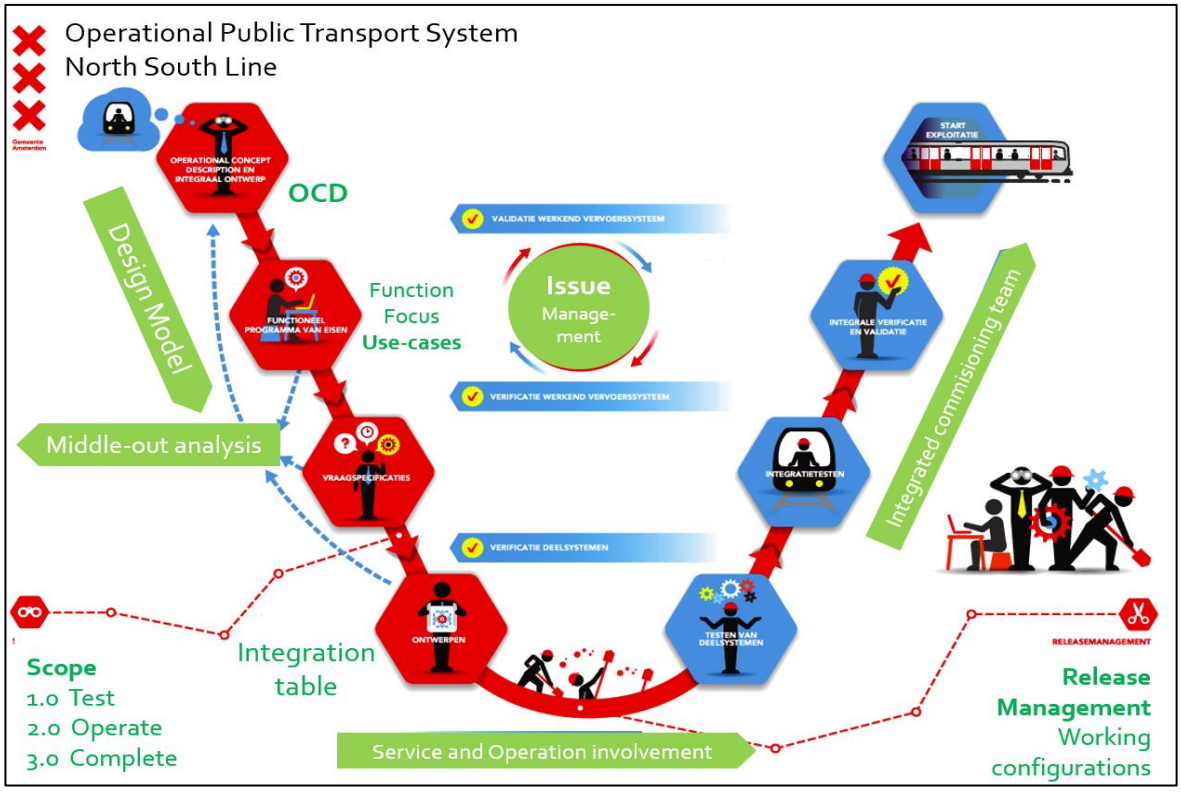

Figure F1: *Release Management (AT Osborne repository- NSL Commissioning process, 2015)*

Appendix G

Time Chainage Diagram - Uithoflijn Project (Case 1):

Time Chainage Diagram, also known as time location or diagonal line diagram, is a fully-featured planning application used for managing linear type construction projects that include highways, railways, metro lines, bridges, tunnels, transmission lines and pipelines. It uses the critical path method to provide time-based information similar to traditional Gantt charts, but additionally, it improves the visualization of construction project schedules by providing extra dimensions like the distance and production rate of associated activity. For projects of a linear/repetitive nature like the tramlines, railways and tunnels, the time chainage diagram provides a clearer, more easily understood picture of the plan than a bar chart because it has a more graphical structure. The two-dimensional format (time and distance) allows progress rates to be shown, which can be compared with different tasks or between planned and actual. Moreover, even complex projects can be displayed on a single chart and still provide a clear picture of what is going on. It can be created by importing data from Primavera P6 or MS Project, which is most often used by the project planners.

Looking at the benefits of the Time Chainage Diagram and the flexibility it provides in organizing the plans and schedules, it was used as a complementary tool alongside the Iterative planning enabler in the Uithoflijn Project (Case 1) for its internal plans. Time Chainage Diagram provided a user interface that was simple and quick to navigate around while making iterations and adjustments in plans. It was possible to use separate tables for planned (original plan), adjusted (iterated plan), and actual progress to allow maximum flexibility in data input. It also provided with project analysis and graphical reports, which made it easier to convey to the project teams about the iterations made in the plan using the same interface, thereby leading to ease in communicating the updated changes made to the plans and schedules.

Time Chainage Diagram has been often used in infrastructure projects. Looking at the efficiency and flexibility it offered in complementary to the iterative planning approach, it can be used in buildings projects as well, which will aid in smooth monitoring and handling of changes made in the plans and schedule using the iterative planning.