Managing the Influence of Stakeholders on the Scope of Major Construction Projects to Prevent Scope Creep in the BIM Era

by

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Declaration

This work has not been submitted in substance for any other degree or award at this or any other university or place of learning, nor is being submitted concurrently in candidature for any degree or other award. This thesis is being submitted in partial fulfilment of the requirements for the degree of PhD. I hereby declare that the work presented in this thesis is my own work and other sources are acknowledged by explicit references.

Mohsen Jamshidi
April 2023

For my parents and sister, who offered unconditional love and support and have always been there for me.

Preface

I would like to express my sincere gratitude to my supervisors Dr. Sohrab Donyavi, Dr. Julius Akotia, and also to my previous supervisors Dr. Sean Dodd, Dr. Phebe Mann, Prof. Allen Brimicombe, Dr. Paolo Falcarin, Dr. Bilyaminu Auwal Romo and Dr. Rawad Hammad for providing their invaluable guidance, comments and suggestions throughout the course of the project.

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Nomenclature

A number of key terms are used throughout this document and are defined here:

- Stakeholders: The people, groups, or organisations that have a vested interest in the project and could impact or be impacted by the project output.
- Stakeholders Influence Strategies: The stakeholders "means" through which they achieve their goals and objectives.
- Scope: In the project context, the term "scope" can refer to:
  - Product scope. The features and functions that characterise a product, service, or result.
  - Project scope. The work performed to deliver a product, service, or result with the specified features and functions. The term "project scope" is sometimes viewed as including product scope.
- Scope Creep: The uncontrolled expansion of project or product scope without adjustments to time, cost, or resources and without addressing its negative effects on project or stakeholders' agreement.
- Building Information Modelling (BIM): A methodology for managing the production, distribution and quality of construction information, including that generated by CAD systems, using a disciplined process for collaboration and a specified naming policy.

Abstract

The present PhD thesis is centred on investigating the challenge of scope creep within construction projects, denoting the phenomenon of an uncontrolled enlargement of project scope without essential adaptations. Stakeholders are identified as a major source of uncertainty and requests for changes in scope, which can result in risky events. Therefore, an overarching framework is needed to effectively resolve the problem of scope creep caused by stakeholder influence. The adoption of Building Information Modelling (BIM) is suggested as an effective methodology for the streamlined management of information in construction projects, thus enabling project managers to develop an appropriate solution for the identified problem. To develop this framework, a meta-analysis approach and case study strategy is employed to analyse and synthesise secondary data collected from the PMBOK GUIDE'S (PMI, 2017) project management processes, BIM-related standards, and six case study projects. The objective is to identify essential processes and activities, their sequence and interdependencies, problematic issues, and best practices.

The outcome of the research is the creation of a Process Framework designed to address the problem of scope creep triggered by stakeholder influence. The elements and concepts of this framework are verified by undertaking semi-structured interviews with five practitioners from the construction and infrastructure industry. The Process Framework functions as a unifying mechanism that combines project management and BIM processes, thereby ensuring coordination and integration towards the overarching objective of managing stakeholder influence on project scope and mitigating scope creep.

Additionally, this research contributes to the understanding of the relationship between BIM documents and project management processes. The study explores how BIM fits within project management processes and identifies the benefits of BIM for the resolution of issues in construction projects, including end product visualization, clash detection, and efficient information sharing. This study provides an extensive and meticulous analysis of scope creep within construction projects and presents a pragmatic framework for dealing with this issue.

Chapter 1 Introduction

1.1 Background to the Study

Construction projects are a fundamental and significant component for the economic development of any nation, as they satisfy the essential requirements of the country by providing residential, social infrastructure, and transportation (Badewi, 2016). Also, the achievement of project success and efficiency is determined by the timely delivery of projects with the intended benefits and adherence to the allocated budget (Badewi, 2016). Gharaibeh et al., (2020) acknowledged the construction sector as a dynamic industry that experiences constant unpredictabilities in its finances, procedures, and technological advancements. Besides, the involvement of various factors like project complexity, uncertainties in budgets, processes, and technology, and the augmented involvement of stakeholders make it difficult to manage construction projects, resulting in time and cost overruns (Gharaibeh et al., 2020; Ajmal et al., 2022).

According to the Project Management Body of Knowledge (PMI, 2017), a project refers to a temporary collaborative effort aimed at delivering a distinctive product, service, or outcome. In contrast, Kerzner (2017) characterises a project as a set of tasks and activities that have a specific goal, centred on producing business value, and must be completed within certain parameters. He explains the project has distinct start and end dates, as well as funding limits, and requires the use of human and nonhuman resources, such as money, personnel, and equipment. It is multifunctional, cutting across different functional lines (Kerzner, 2017). According to Yu and Shen (2015), a project is a process of change that involves a pre-project phase for thorough planning and a post-project phase to ensure successful integration into the core business.

Increasingly, projects across various industries are recognised as complex, high-stakes, and time-sensitive undertakings that are subject to uncertainty (Ajmal et al., 2020). Project management now encompasses more than just the proficient and capable management of individual projects; it involves a comprehensive range of systems, procedures, frameworks, and competencies that allow an organisation to embark on the appropriate projects (Drouin and Besner, 2012).

As megaprojects become increasingly complex in terms of project scope and environment, the traditional iron triangle of project management (time, cost, and quality) is no longer sufficient to explain project performance (Hu et al., 2015). This necessitates a broader view of project performance beyond the iron triangle, as megaprojects are more complex than traditional construction projects (Xue et al., 2018).

Previous research suggests that in addition to the traditional view of project management, which focuses on time, cost, and quality, megaproject performance can be further evaluated from two additional perspectives (Xue et al., 2018). One perspective involves the impact of organisational performance and interactions on the megaproject process, as seen from a micro level (Hu et al., 2015). The other perspective focuses on the effect of megaprojects on the local society, leading to a need to assess societal performance as a critical factor in determining the success of megaprojects, as seen from a macro level (Hu et al., 2015).

According to Xue et al. (2018), there are 10 aspects used to evaluate megaproject performance, ranging from the inter-organizational level to the project and societal level, such as coordination, communication, collaboration, cost, schedule, safety, quality, environmental protection, labour protection, and project transparency. Discussing the influence of formal and informal relationships on projects, Xue et al. (2018) exemplify trust as a critical informal tie among stakeholders to improve megaproject performance, while contracts are seen as essential formal links for stakeholder collaborations to deliver megaprojects. However, there has not been enough comprehensive analysis of the ways in which formal and informal interactions affect the execution of megaprojects (Xue et al., 2018).

There is no doubt that any unplanned deviation or uncertainty in the scope of the project will affect the other two pillars of time and cost in projects (Agyekum-Mensah and Knight, 2017). The majority of researchers have studied various elements of scope management, either explicitly or implicitly, under different terminologies such as quality management (Arditi and Gunaydin, 1997; Delgado-Hernandez et al., 2007; Rumane, 2017; Yu et al., 2019), client requirements management (T.W. et al., 2010; Hwang, Zhao and Goh, 2014; Kamara, 2017), or even value management (Finch et al., 2005; Kelly et al., 2014). But there are very few studies that approach this context under "Scope Management" terminology and from a comprehensive perspective. Since projects do not exist in a vacuum, one of the major issues in the management of projects is scope creep, which can result in delays, cost overruns, and even the termination of projects (Ajmal et al., 2020). Considering the issue persists in all projects worldwide, it is crucial that the causes of project scope creep be investigated to improve project management methods (Ajmal et al., 2020). Stakeholders are identified in the literature as one of the main sources of uncertainty and requests for scope change in projects (Ward and Chapman, 2003; Crawford, Pollack, and England, 2006; Nahod, 2012; Asadi et al., 2021). Accordingly, they may use different strategies to influence the project and focal firm to approach their objectives (Lin *et al.*, 2019). Therefore, stakeholders can cause uncertainty in projects, particularly in the scope of projects, which may lead to risky events such as delays and cost overruns (Fageha and Aibinu, 2013; Xue et al., 2020). Hence, communication and engagement of stakeholders play an important role in managing the influence of stakeholders on different aspects of a project, such as the project scope. Accordingly, Ajmal et al. (2020) state that it is recommended that project managers conduct a thorough evaluation of stakeholders' viewpoints concerning the factors impeding the successful definition of project scope. This approach can facilitate a balancing of the various stakeholders' expectations and enable the attainment of maximal benefits while minimising costs. It is essential that project management take into account the social connections with project stakeholders when formulating the project scope (Ajmal et al., 2020).

On the other hand, the occurrence of new technologies and methodologies creates new challenges and opportunities in the management of construction projects (Tomek and Matějka, 2014). Building Information Modelling (BIM) is one of these phenomena, designed for efficient management of construction projects' information and which opened many doors towards new ways of working (Brito and Ferreira, 2015). Hence, there is a need to approach BIM from a project management perspective as well to obtain a deeper understanding of how BIM fits within the project management sphere and evaluate its benefits for the resolution of different issues such as scope creep and stakeholder influence in construction projects. Using project management terminology, BIM can be studied as an information management system that should be embedded within the communication management process of project management.

1.2 Problem Statement

Despite its crucial role in the success of projects, scope management has received less attention from researchers compared to the other areas of project management. In addition, there is a lack of a comprehensive and integrated approach for managing the uncertain issue of scope creep caused by the influence of stakeholders in projects to resolve this issue. In regards to BIM, the majority of the previous research focused on its technological aspects, whereas it is more about people and processes.

According to Moustafaev (2014), it appears that project scope management is one of the project management disciplines that gets the least amount of attention. In addition, Moustafaev (2014) argues in his book that unfortunately, there is a great deal of variance in the nomenclature and structure of the scope components across industries and sometimes even between books.

Olsson (2015) emphasises the significance of managing costs in railway infrastructure projects and the need to control possible reductions. The paper aims to investigate the implementation of potential scope reductions in finished railway projects, including the factors affecting their implementation, such as budget contingencies and experienced cost overruns. Moreover, the study examines the attributes of implemented scope reductions while considering that the use of reduction lists has been controversial. Olsson (2015) claims that one disadvantage of these lists is that they must be decided at an early stage, which can affect the quality and usability of the infrastructure. Additionally, the reduction lists represent a small portion of the overall budget and are therefore not an effective tool for achieving cost control. Although reduction lists may not completely eliminate overruns, they can still be useful in decreasing them (Olsson, 2015).

According to Agyekum-Mensah and Knight (2017), the major causes of delays in construction projects are poor commercial decisions and health and safety issues. They argue that practitioners also suggest that underestimating project complexity can cause delays. However, there is limited discussion in the construction management literature regarding the causes of delays related to unclear project objectives and scope creep. Despite the granting of an extension of time, scope creep continues to be a problem, and delays beyond the original completion date are still classified as such (Agyekum-Mensah and Knight, 2017).

Ajmal et al. (2020) state that although several studies have explored factors contributing to project success, there has been little research on the interrelationships of these factors or on in-depth investigations of failed projects to identify reasons for failure (Alami, 2016; Sanchez and Terlizzi, 2017). As a result, megaproject performance has not improved, with cost, time, and benefit targets often not being met (Flyvbjerg, 2014). According to Ajmal et al. (2020), it is necessary to conduct further research to identify the causes of project failure and, specifically, poor project scope. Additionally, exploring the interrelationships among these factors is crucial for better project management (Ajmal et al., 2020).

In a report, it was discovered that 31% of the projects were deemed complete failures and only a mere 16.2% of projects fulfilled the requirements (Alami, 2016; Ajmal et al., 2020). Nonetheless, there is a scarcity of research that has thoroughly analysed failed projects to identify the exact causes of failure (Alami, 2016; Ajmal et al., 2020). The main reason for this knowledge gap is the difficulty in obtaining access to failed projects, and the majority of research on this topic is based on successful projects (Sanchez et al., 2017; Ajmal et al., 2020).

Ajmal et al. (2020) suggest that software development projects can become costly and even fail due to a lack of stakeholder engagement, which can result in an unclear project scope and longer time required to understand project objectives (Kloppenborg, Manolis and Tesch, 2009; Project Management Institute, 2013). According to Ajmal et al. (2020), to achieve project success, it is important to balance the needs of stakeholders during project execution, given that stakeholders may have varying views of what constitutes a successful project (Ajmal et al., 2020).

Considering the problem persists in all projects worldwide, it is crucial that the causes of project scope creep be investigated to improve project management methods (Ajmal et al., 2020).

Additionally, Ajmal et al. (2020) state that the literature fails to discuss the connections between the many causes of scope creep (Sanchez et al., 2017). Moreover, few studies have looked at failed projects to determine what went wrong (Alami, 2016; Ajmal et al., 2020).

Based on Ajmal et al.'s (2020) findings, project managers may better meet the needs of all parties involved by maximising benefits while minimising costs if they conduct a thorough investigation of stakeholder viewpoints on the variables that impede an effective project scope. In order to successfully design the project scope, project management must take into account the social interactions among project stakeholders (Ajmal et al., 2020).

In another study, Ajmal et al. (2022) argue that further research is needed to highlight the causes of projects exceeding their schedule and budget and to decrease the number of project failures. They claim this is because the literature does not adequately define project scope creep and its causes in the context of the UAE.

A number of gaps can be identified in the literature and research related to stakeholder influence on construction projects. Firstly, although some leading construction companies are adopting the idea of social responsibility (SR), it has not been analysed systematically and remains reactive and isolated in terms of examining stakeholder interactions (Loosemore and Lim, 2017; Lin et al., 2019). Secondly, studies investigating stakeholder influence in construction projects are scarce and typically concentrate on the impact of individual public stakeholders, such as policymakers, NGOs, and mass media, with limited exploration of complex stakeholder interactions (Apostol and Näsi, 2014; Lin et al., 2019). Thirdly, the approach that stakeholders adopt in order to exercise their power in achieving desired goals, as well as how different influence strategies impact project implementation, are both uncertain (Derakhshan, Turner and Mancini, 2019). Finally, stakeholders' aggressive influences endanger project implementation by causing extensive delays and cost overruns, necessitating project managers to be able to better anticipate such behaviour to proactively address and reduce potential conflicts (Boutilier and Zdziarski, 2017; Lin et al., 2019). Additionally, Lin et al. (2019) argue that while stakeholder influences can be influenced by various social, political, and cultural factors, there may still be commonalities that can be useful for project management across different regions. Thus, they suggest further comprehensive studies are necessary to compare the effectiveness of different stakeholder influence strategies in diverse social, economic, and political contexts.

When it comes to the ever-changing interests of stakeholders, ElWakeel and Andersen (2020) point out a gap in the literature on stakeholder management. Whereas several citations show that the stakeholder environment of projects may be extremely dynamic, not much empirical data or study has been published on this subject.

Yu et al. (2019) claim that most studies related to Offsite Construction Projects (OCPs) defect management have focused on defect detection and analysis (Wang *et al.*, 2016), but very few have investigated OCP quality defects from a stakeholder perspective. As a result, Yu et al. (2019) state there are no effective methods for practitioners to evaluate stakeholder impacts on OCP quality defects. According to Yu et al. (2019), traditional stakeholder evaluation methods like the interest/power matrix (Olander and Landin, 2005) and the stakeholder index (Olander, 2007) cannot be used to investigate dependencies among different stakeholders regarding quality performance, as they may overestimate or underestimate actual impacts. For example, the impact of a designer on defect occurrence will be mis-estimated if evaluated without considering the dependency between design and PC production.

Irfan et al. (2019) point out the negative impact of stakeholder conflicts on project completion and stakeholder relationships. They state that the consequences of such conflicts include cost and time overruns, loss of productivity and profit, and damage to business relationships. The literature emphasises the importance of avoiding stakeholder conflicts, as they may compromise the time, cost, quality, and scope of projects during the design and implementation phases (Olander and Landin, 2005). However, the literature on conflict emergence in the construction industry is limited, and its linkage with construction project constraints is insufficient (Irfan et al., 2019). Therefore, more research is needed to explore these issues and identify effective strategies for managing stakeholder conflicts in projects.

Irfan et al. (2019) highlighted the significance of stakeholder conflicts in project constraints and suggested that effective communication is crucial for managing conflicts in the construction industry. However, the existing literature has not adequately explored the factors that lead to stakeholder conflicts and their impact on project constraints, nor has it delved into the potential use of technology to improve communication (Irfan et al., 2019). Therefore, further research is necessary to address these knowledge gaps. While Irfan et al.'s (2019) study focused on developing countries, future investigations should also explore this topic in developed countries. Additionally, their study was limited to only a few factors that trigger stakeholder conflicts, and it is suggested that future research should include other factors as well.

Molwus et al. (2017) argue that the construction industry has struggled to achieve project success despite efforts to improve it. They claim that stakeholder management, originally a business management concept, has become increasingly relevant in construction management, but it requires principles tailored to the unique nature of construction projects and processes. According to Molwus et al. (2017), Yang et al. (2009), and Yang and Shen (2014), a framework for successful stakeholder management in construction projects has been developed that identifies critical success factors (CSFs) for stakeholder management. However, the framework does not measure interrelationships among the constructs, which is necessary to inform a logical stakeholder management process (Molwus et al., 2017). Additionally, some CSFs, such as appropriate procurement routes and flexible project organisation, were not included (Yang et al., 2009; Yang, 2014).

Beringer et al. (2013) suggest that effective stakeholder management is critical for the success of projects, as both research and practice have demonstrated. It is essential for project managers to possess the ability to comprehend the often obscured power and influence of different stakeholders (Bourne and Walker, 2005; Aragonés-Beltrán et al., 2017). According to Aragonés-Beltrán et al. (2017), one of the significant queries in this area is "how stakeholders can influence project management." However, Aaltonen and Kujala (2010) argue that this query has not been adequately addressed in the literature. Answering this question is not a straightforward task because there are various viewpoints to define the concept of "influencing project management," and stakeholders can employ different strategies to influence the project (Aaltonen et al., 2008; Aragonés-Beltrán et al., 2017).

Yang et al. (2015) point out that while previous research has made significant contributions to stakeholder management in ordinary construction projects (Ward and Chapman, 2008; Jepsen and Eskerod, 2009; Yang et al., 2010, 2011b), there is a lack of focus on managing stakeholders in mega construction projects. According to Yang et al. (2015), this gap in the literature has resulted in industry demands for more studies in this area, particularly in conducting systematic reviews of stakeholder management in mega construction projects. Mega construction projects are more complex and involve more stakeholders, creating greater uncertainty and risk (Yang et al., 2015). As a result, more research is needed to address issues such as stakeholder identification, prioritization, and engagement in the context of mega-construction projects. The authors suggest further investigation into how stakeholder interests and influences, stakeholder management processes, stakeholder analysis methods, and stakeholder engagement strategies can be improved specifically in mega construction projects (Yang et al., 2015).

Lucas et al. (2009) claim that inadequacies exist in prior BIM tools that fail to provide full support for a project's lifecycle processes. These tools only enable referencing a model and associated information, but they do not facilitate easy manipulation of the data or decision-making to support project processes. Lucas et al. (2009) state that to be deemed a true BIM, a model should not just allow for referencing, but also integrate processes that enable data manipulation. The full potential of BIM can only be realised when the requirements of lifecycle processes are met, and non-modelled digital information is structured and included in the model (Lucas et al., 2009).

Succar (2009) suggests that many sources argue that BIM can bring about significant changes in the construction industry, including reducing fragmentation, increasing efficiency and effectiveness, and lowering costs associated with interoperability. According to Succar (2009), these claims are derived from various fields, including organisational studies, information systems, and regulations. However, the lack of a research framework to organise domain knowledge highlights the need for systematic investigation of the

BIM domain. Additionally, practitioners and educators may benefit from a systematically defined BIM framework (Succar, 2009). Succar (2009) claims that a framework is required to position BIM as an integration of process and product modelling, instead of merely a collection of disparate processes and technologies. Additionally, a framework is needed to bridge the gap between the industrial and academic understandings of BIM by providing a research and delivery structure that can accommodate their distinct but complementary needs (Succar, 2009).

Merschbrock and Munkvold (2012) conducted a literature study on Building Information Modelling (BIM) in construction in order to find areas where Information Systems (IS) research might contribute to this domain. In addition, Merschbrock and Munkvold (2012) identified certain areas in Information Systems (IS) research that require further exploration, including the use of BIM for inter-organizational collaboration, the relationship between BIM's functional affordances and human agency, the impact of organisational culture on BIM practices, the determination of the business value of BIM, and the potential of BIM to transform industry practices. Merschbrock and Munkvold (2012) noted that there is an existing knowledge base in Information Systems (IS) research that can be utilised to examine these issues. Merschbrock and Munkvold (2012) state that researchers in the field of building information modelling need to adopt a more holistic viewpoint that combines "functional affordance" and "human agency" in order to explain how effectively BIM achieves the aims of its end users. According to Merschbrock and Munkvold (2012), in the context of construction projects, Building Information Models (BIM) provide a platform for collaborative discussions among the parties involved in the project. However, despite the crucial role of BIM in facilitating such discussions, the existing literature on BIM inadequately explores the connection between technical and social aspects (Merschbrock and Munkvold, 2012). Therefore, they assert that there is a need to enhance BIM research in this area. In addition, Merschbrock and Munkvold (2012) argue that the relationship between BIM and organisational culture is not adequately studied in current BIM deployment literature, even though the practises and identities of each organisation are mutually influenced when using shared information technology. Conflicts resulting from differences in organisational cultures between actors, such as architects and contractors, may hinder effective communication in construction projects. Previous research on information technology and organisational culture could inform efforts to strengthen BIM research in this area. Merschbrock and Munkvold (2012) discovered a lack of literature discussing the potential for BIM to be used as a strategic asset to transform organizations. They noted that the current focus on optimising existing processes rather than redesigning them highlights an untapped potential similar to that identified in earlier reengineering literature. Thus, their review supports the argument that the transformative potential of BIM to revolutionise and alter the way in which AEC organisations operate has yet to be fully comprehended (Merschbrock and Munkvold, 2012). Finally, Merschbrock and Munkvold

(2012) discovered just a few papers that attempted to evaluate the business value of BIM. In these articles, the unit of analysis was confined to examining first-order impacts, such as BIM's impact on scheduling or cost estimation precision (Merschbrock and Munkvold, 2012).

Arayici et al. (2012) conducted a study to demonstrate how a firm's deployment of building information modelling (BIM) might alleviate management and communication concerns on a remote building project. They propose Building Information Modelling (BIM) as a solution to the interdisciplinary inefficiencies in construction projects. Arayici et al. (2012) claim that despite the numerous potential benefits of BIM adoption, it presents interesting challenges regarding how BIM integrates the business processes of individual practices.

Won et al. (2013) conducted a study to determine the CSFs for four queries that were raised often by businesses during the initial phase of BIM implementation. Won et al. (2013) argue that despite the increased adoption of BIM over the last decade, its full potential has not been realised due to technical and organisational obstacles. The determinants of successful BIM adoption are multifaceted and include factors such as people's attitudes, corporate culture, industry-wide legal precedents, communication density, and organisational barriers. While the literature has highlighted many barriers and success factors, these studies have limitations in providing a comprehensive list of solutions or determining the criticality of issues (Won et al., 2013).

With the use of a product, organisation, and process (POP) data definition framework, Chen and Luo (2014) investigated and explained the benefits of 4D BIM for a quality application based on building codes. Chen and Luo (2014) argue that while BIM is thought to improve design quality by avoiding conflicts and decreasing rework, little study has been conducted on the use of BIM throughout a project for construction quality control and effective information usage. Chen and Luo (2014) found that the research community is in agreement that building information modelling (BIM) may be useful to enhance project quality and that more projects will likely utilise BIM in the future to communicate with the construction trades. In spite of this, they claim BIM's potential to improve quality has not been well mapped out (Chen and Luo, 2014). Additionally, Chen and Luo (2014) state that previous research has aimed to enhance information sharing and connect fragmented data. Nevertheless, these studies did not effectively leverage the digital information contained in design documents to transmit quality-related data to the construction stage, and they inadequately accounted for the interconnectedness of the three primary elements in quality management: process, organization, and product (Chen and Luo, 2014).

In another study, Xu et al. (2014) found that there is also a lack of life-cycle information and experience accumulation since current construction information systems are phase-specific. To rephrase, they believe data collected during the design phase cannot be used during construction, and data collected during construction and design cannot be used during operation. Ultimately, Xu et al. (2014) claim that many academics have explored the use of BIM in information management, but they have not fully considered the potential of BIM in life-cycle management, which needs additional consideration. Another issue mentioned by Xu et al. (2014) is that although BIM is useful at every stage of a building project, the BIM model is not transferred from one party to another; rather, each party creates its own BIM.

Talebi (2014) found significant evidence regarding the existing comprehension and view of the advantages and difficulties associated with BIM throughout the project life cycle. He claims that the results reveal a lack of comprehensive knowledge required to establish a precise framework and measure the benefits attained by BIM implementation. Furthermore, it was observed that a substantial amount of previous research has emphasised technical obstructions while disregarding the hindrances related to people, management, and costs (Talebi, 2014). Talebi (2014) points to the absence of a unified framework in the industry to support the adoption and assessment of BIM. He claims that, despite some identified benefits, limited measurable criteria and sparse framework approaches have increased uncertainty. According to Talebi (2014), this has left owners unsure of whether to embrace BIM solely based on its theoretical benefits. Consequently, there is a demand for consistent and flexible guidelines applicable to all industry sectors and organisations of varying sizes. These guidelines should be capable of quantifying benefits and considering both financial and managerial implications (Talebi, 2014).

Singh et al. (2021) conducted research to determine the most effective methods, enabling factors, and advantages of stakeholder management within BIM-implemented projects. They claim that although there has been significant research on the technical aspects of Building Information Modelling (BIM), there is a dearth of research on non-technical aspects, particularly the management of stakeholders and associated challenges in BIM-implemented projects. The benefits of stakeholder management in the construction industry have not been extensively studied, highlighting the necessity for research on management techniques and the advantages of managing stakeholders in the context of BIM implementation (Singh et al., 2021).

Zhang et al. (2022) argue that BIM is recognised as having a positive impact on cost, time, communication, coordination, and quality, but its impact on project performance is not straightforward and requires close integration with project management processes (Tang, Chong and Zhang, 2019). According to Zhang et al. (2022), effective stakeholder management is essential for improving project performance, but several factors, including the lack of support from owners and managers, the lack of BIM knowledge among practitioners, and difficulties in stakeholder coordination, can hinder BIM-enabled project performance (Yang and Chou, 2019; Tang et al., 2021). In this regard, Zhang et al. (2022) state that to understand the mechanism of stakeholder management's impact on project performance, a clear comprehension of the critical success factors (CSFs) for stakeholder management in BIM-enabled projects and their relationship with project performance is required. Therefore, an in-depth analysis is needed to determine the path of the relationship between BIM and project performance from the perspective of stakeholder management.

Mani et al. (2022) to identify the dimensions of stakeholder management that are affected by BIM-induced changes and assess their importance in both the public and private sectors. They argue that there are gaps in research related to stakeholder management and the adoption of Building Information Modelling (BIM) in construction projects. These include a need for more research on the human side of BIM adoption and its impact on stakeholder management strategies, as well as a lack of understanding of the nature of BIM-induced changes in stakeholder management and stakeholders' ability to adapt to change (Merschbrock et al., 2018; Lindblad, 2019; Hassan and Jaaron, 2021). Additionally, there is a lack of research exploring the relationship between BIM and stakeholder management in both the public and private sectors (Lindblad and Guerrero, 2020).

1.3 Research Scope

The domain of this study is situated within the construction and infrastructure industries of the United Kingdom, particularly the major construction and infrastructure projects that confronted challenges in dealing with stakeholder and scope management issues, leading to scope creep during their implementation. According to the Chartered Institute of Building (CIOB) Planning Protocol 2021 (CIOB PP21), which is a technical information sheet released by the CIOB in February 2021, a major project is defined as a project where the estimated cost of the construction works is at least £10 million pounds sterling (Bahl et al., 2021). Although the significance of construction extends beyond its economic influence, it makes a considerable contribution to the UK economy. The construction sector, as defined, represents approximately 6% of the UK's economic production (Green, 2020). Nonetheless, the narrow definition employed for the industry disregards the roles of architects, engineers, and quantity surveyors, along with manufacturers and other firms involved in the industry, such as builders' merchants and plant hire companies. A more comprehensive interpretation of the industry, encompassing these roles, indicates that the industry is nearly twice as large as the recorded amount (Green, 2020). However, the incidence of construction project difficulties, such as inadequate risk mitigation, is concerning (Sherwood, 1999; Miller, 2020). According to nPlan, a consultancy that employs machine learning to enhance outcomes in construction project delivery and risk management, over 90% of construction projects encounter a delay exceeding 10% of the intended schedule based on its database of over 250,000 projects (Miller, 2020). This is frequently caused by the accumulation of a significant number of minor project tasks that are each affected by an issue resulting in a brief delay (Miller, 2020).

This thesis aims to investigate the impact of stakeholder influence on scope creep in construction projects in the United Kingdom. The research will use case studies from major construction projects in the UK to identify the causes and effects of scope creep and stakeholder influence, as well as to explore potential strategies for mitigating these issues. The research will also examine the technological advancements such as Building Information Modelling (BIM) on managing scope creep and stakeholder influence in projects. Plus, the study will focus on both internal and external stakeholders, including clients, contractors, consultants, suppliers, regulatory bodies, public and local communities. The thesis will use qualitative research methods such as interviews and document analysis to gather data.

The findings of this research will provide valuable insights into the challenges faced by the UK construction industry in managing scope creep and stakeholder influence, and will offer recommendations for enhancing project outcomes. The study will also contribute to the existing literature on project management, stakeholder theory, and construction industry practices.

1.4Research Questions

1. What are the main causes of scope creep in major construction projects and what are the best solutions for its management in order to prevent its negative impact on project success?

2. What is the role of stakeholder influence in the occurrence and management of scope creep in construction projects?

3. How effective is BIM in managing the scope of construction projects and preventing scope creep caused by stakeholder influence?

1.5 Aim

The overall aim of this research is to develop a new Process Framework to manage the influence of stakeholders on the scope of construction projects and prevent scope creep by using Building Information Modelling (BIM) processes and guidelines.

1.6 Objectives

For this purpose, four main project management processes of stakeholder management, scope management, communication management and risk/uncertainty management have been chosen from PMBOK GUIDE (PMI, 2017) as the main themes of this research. Also, three approaches/standards of Building Information Modelling, Collaborative Working and Integrated Project Delivery (IPD) are taken into account, due to their crucial roles in achieving current research's goals, as the preliminary themes. The Collaborative Working Approach and Integrated Project Delivery (IPD) approach constitute the basics of BIM which help to boost BIM application's efficiency and in mutual interaction, BIM can improve the effectiveness of these two in projects as well.

The research has the following objectives:

- To identify the main causes of scope creep in construction projects and the available solutions for its management.
- To identify the role of various stakeholder groups in the occurrence and management of scope creep in construction projects.
- To investigate how BIM impacts the management of stakeholders in construction projects.
- To evaluate the effectiveness of BIM in managing the scope of construction projects and preventing scope creep caused by stakeholder influence, and to identify the factors that contribute to its success or failure.
- To develop a process framework for effectively managing the influence of stakeholders on the scope of construction projects and preventing scope creep through the application of BIM.

1.7Research Approach

A comprehensive literature review is performed to study previous works and identify the most reliable methods, processes and approaches developed by other authors for managing stakeholders' influence and impacts, uncertainty, communication, scope management and building information modelling, together with the synthesis of their findings to be used within the framework stages. Meta-Synthesis (analysis) design is employed to collect and analyse secondary data. Meta-Synthesis is defined as bringing together and breaking down of findings, examining them, discovering the essential features, and, in some way, combining phenomena into a transformed whole (Schreiber et al., 1997). The goal of Meta-synthesis is to produce a new and integrative interpretation of findings that is more substantive than those resulting from individual investigations. This methodology allows for the clarification of concepts and patterns, and results in refinement of existing states of knowledge and emergent operational models and theories (Sherwood, 1999).

Both secondary and primary data collection and analysis techniques are used in this research. The secondary data collection and analysis is constituted of three parts. First, the stakeholder management, scope management, communication management and risk management processes presented in the PMBOKE GUIDE (PMI, 2017) are analysed by creating flow charts and tracking the inputs and outputs of each process. The main objective of doing this was to understand how stakeholder and scope management processes together with communication and risk management processes are interlinked. Particularly, to capture how the stakeholder management process influence the scope management process and vice versa to identify the critical connecting points and therefore mitigate the negative impacts and maximise the positive ones. In second part of secondary data collection and analysis, the BIM standard and associated concepts such as collaborative working and integrated project delivery are studied by analysing their steps, inputs, outputs, and essential documents. Then, the documents produced during BIM implementation and other required information are studied by linking them to the aforementioned project management processes to realise how BIM can help managing the scope of projects and stakeholder influence and at the same time, how the project management processes can enrich and support the BIM implementation process.

The third part of secondary data collection and analysis is dedicated to investigation and analysis of findings from 6 case study projects in construction and infrastructure industry published by National Audit Office (NAO), House of Commons and Learning Legacy website. The case study strategy is chosen for data collection and analysis in this research. Saunders et al. (2019) state that a case study explores a research topic or phenomenon in its context or within a number of real-life contexts. Also, the case study is helpful to gain a rich understanding of the context of research and processes being enacted. The case study has the ability to generate answers for 'why', 'what' and 'how' questions and is most often used in exploratory and explanatory research. A mix of data collection and analysis methods (qualitative and quantitative) can be used in case study research design (Yin, 2009). The main objective of using case study approach was to explore and explain the issues and difficulties that occurred during the implementation of construction projects (case study secondary data) in accordance with the topic of this research regarding the influence of stakeholders on managing the scope of projects and role of Building Information Modelling (BIM) in the resolution of these issues. The main aim of this phase is to consider and address these identified issues within a new Process Framework to create a comprehensive and effective approach towards the phenomenon being studied in this research. Also, an example of a successful construction project London 2012 Olympic Program will be studied to strengthen the primarily developed Process Framework to benefit from lessons learned and recorded experience.

Based on the steps above, the primary version of a process framework is developed for efficient management of project scope and stakeholder influence with the help of BIM. In the next phase, semi-structured and in-depth interviews with participants from industry is conducted to validate and verify the developed Process Framework in this research. Then, the final version of the developed process framework was developed based on the findings from this stage.

1.8 Significance of the research

The significance of this research lies in the development of a practical framework that integrates project management processes and Building Information Modelling (BIM) standards, processes, and guidelines to manage stakeholder influence on the scope of major construction projects and prevent scope creep. This framework will help project managers comprehend the impacts and benefits of BIM for resolving project issues and challenges and understand the interactions between this methodology and project management processes.

Additionally, this research contributes to the construction and project management fields by raising awareness of the importance of stakeholder influence and managing uncertain events like scope creep to avoid significant project failures such as delays, cost overruns, or termination. The study also provides consensus and integration among project management processes, such as scope, stakeholder, communication, and risk management, and identifies their relationships and interactions through analysis of their sub-processes, inputs, and outputs.

Furthermore, this research connects BIM aspects and processes to project management processes and knowledge areas, providing project managers with a clear understanding of how BIM fits within project management processes during the project lifecycle. The study explores the interactions and linkages between different BIM dimensions (3D, 4D, and 5D) and various outputs of project management processes, as well as the interaction and relationship between BIM processes and documents with project management processes. It also highlights the importance of considering BIM impacts from a wider perspective rather than a sole technological aspect, providing project managers with a more comprehensive vision of BIM in project management. In continue, each of these preliminary and main themes will be reviewed, the research methodology process will be explained and finally, the developed Process Framework will be presented.

This report is organised as follows:

Chapter 1 introduced this research and the main aims behind it

Chapter 2 reviews the project management literature in accordance with the topic of this research

Chapter 3 discusses Building Information Modelling (BIM) and its impacts on various aspects of project management

Chapter 4 describes the design of the research methodology

Chapter 5 describes the implementation of secondary data collection and analysis of case study projects

Chapter 6 describes the development of 'The Primary Process Framework'

Chapter 7 includes the analysis of primary data

Chapter 8 constitutes reviewing and discussion of findings from primary data collection and analysis, development of 'The Final Process Framework'

Chapter 9 conclusion, summary of findings, limitations, contribution to knowledge and recommendations

Chapter 10 references

Chapter 2 Literature Review

2.1 Introduction

This chapter serves as the literature review section of the project and discusses the works of previous scholars in the areas of stakeholder, scope, communication, and risk management. The investigation aims to identify knowledge gaps and to achieve several purposes. Firstly, it defines foundational concepts to emphasise the importance of scope in project management (section 2.1). Secondly, it discusses the literature on scope management and investigates the definitions and causes of scope creep in projects (section 2.2). The chapter then defines key terms of stakeholder theory and provides a summary of stakeholder management methodologies, identifying gaps in previous works and challenges in stakeholder management. It also identifies stakeholder influence strategies and their determinants, as well as the response strategies for firms and the determinants of these response strategies from the perspectives of uncertainty and risk management. The discussion regarding stakeholder communication management leads to the territory of BIM. Finally, the last section summarises the chapter.

2.2Foundational Concepts

Before diving into the theoretical concepts of this research, it is essential to describe the foundational elements of project management to obtain a thorough understanding of this discipline. In this regard, PMI (2017a) defines a project as "a temporary endeavour undertaken to create a unique product, service, or result." Also, Kerzner (2017) defines a project as an organised way to execute business change. Yu and Shen (2015) define a project as a change-oriented event that includes a pre-project stage and a post-project stage for guaranteeing effective planning and confirming successful integration into the core business, respectively. In addition, a project is defined in PRINCE2 as “a temporary organisation that is created to deliver one or more business products according to an agreed business case” (Axelos, 2017). In another definition, Cleland (2007) states that a project is pulling organisational resources together to create something that did not exist before and will provide a performance capability in the design and implementation of organisational strategies. From the aforementioned definitions, one can conclude that creating a temporary organisation with a definitive start and end to make unique deliverables for obtaining organisational objectives through driving change are the mutual elements of these project definitions.

In this regard, various scholars, standards, and organisations provide different definitions of project management. PMI (2017) defines project management as “the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements." Another definition of project management is provided by PRINCE2 (Axelos, 2017) as “the planning, delegating, monitoring, and control of all features of the project, and the inspiration of those involved, to achieve the project objectives within the expected performance targets for cost, time, scope, quality, risk, and benefits." Also, the CIOB (2014) defines project management as “the overall planning, coordinating, and controlling of a project from inception to completion for the purpose of meeting a client’s requirements to produce a functionally viable and sustainable project that is completed on time, safely, within budget, and to the required quality standards."

There are several sets of criteria and factors identified and proposed by different scholars as contributors to the project's success. One of the traditional sets of factors is the "Iron Triangle" or "Triple Constraints," which measures the project against time, cost, and scope. Kerzner (2017) refers to "Triple Constraints" as primary constraints that are used to measure project success and include time, cost, and performance; performance can be scope, technology, or quality, as shown in Figure 1.

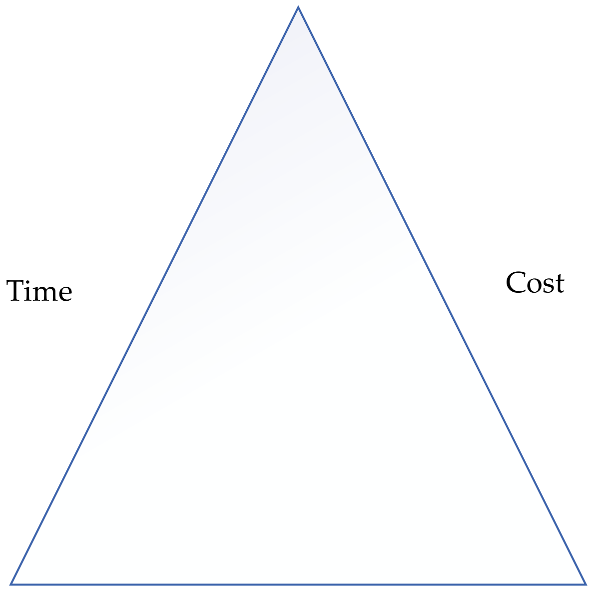

Figure 1 The triple constraints of project success (Kerzner, 2017, p.6).

There has been an ongoing debate about the effectiveness of these constraints for measuring project success and different scholars have created different lists of metrics, factors and constraints for this purpose. In this regard, Kerzner (2017) divided these constraints into primary and secondary, arguing that there can be multiple constraints rather than only three. He recommends using competing constraints terminology and states that sometimes secondary constraints may cause deviation from triple constraints. These secondary constraints include risks, reputation, and customer relations and the deviations or changes in constraints can result in trade-offs between primary and secondary constraints (Kerzner, 2017). Accordingly, PMI (2017) mentions time, cost, scope, and quality as traditional metrics for measuring project success, and points out the recent determination of achieving project objectives as an additional metric identified by other scholars. Plus, other types of measures and criteria are proposed for evaluating projects including meeting financial and non-financial objectives, fulfilling contract terms & conditions, achieving stakeholder satisfaction, quality of delivery, etc. (PMI, 2017). Also, Cleland (2007) states that there are four considerations involved in a project including time, cost, and technical performance objectives and adds the project's strategic fit and operational fit as the further elements which should be evaluated in every project. Besides, it is argued in the CIOB (2014) handbook of construction management that a wide variety of specialist services and skills are needed to balance the project constraints of time, cost, and quality/performance which contribute to the project's function, sustainability and safety. It is mentioned in PRINCE2 (Axelos, 2017) that there are six variables involved in any project which need to be managed such as costs, timescales, quality, scope, benefits, and risk. Hence, while it is admitted that the traditional approach to measuring time, cost and scope may still be valid, but it is recommended to use Key Performance Indicators (KPIs) to summarize the project status at a point in time (Axelos, 2017).

In conclusion, the construction projects are highly complicated enterprises, comprised of inherent features characterised by a high level of uncertainty, complexity, and uniqueness. Besides, the obvious ultimate purpose of every project is to satisfy the needs and expectations of project stakeholders. Regardless of what terminology, method, or approach one will choose to measure the success of a project, the project scope is considered in previous studies as one of the fundamental pillars of the Iron Triangle which can influence the other two pillars of time and cost. Therefore, the scope management concept will be discussed in the next section to obtain a deeper understanding of this constraint and investigate the features, risks and available methods and techniques for effective management of scope in projects.

2.3 Scope Management

Scope management has priority over budget and deadline limitations, as these two pillars and the third pillar of quality are dependent on the scope, and the failure to control and manage this aspect is one of the main reasons for project failure (Alp and Stack, 2012). Although it is an important and vital aspect of project success, unfortunately, scope management is neglected in literature and practice. Scope management is recognised as a crucial factor for project success in construction projects, and it involves managing changes required during project execution to achieve efficient and effective control over construction projects (Moustafaev, 2014; Tsiga et al., 2017). Project scope and changes made during execution are critical factors affecting a project's cost, schedule, and quality, and poor scope management can negatively impact a project's outcome (Ajmal et al., 2020). According to PMI (2017), "project scope management comprises the processes required to make sure that the project includes all the work required and only the work required to complete the project successfully." The primary step for this purpose is defining and controlling what is included and what is excluded from the project. The scope of a project can be segmented into two types: product scope and project scope. The project scope encompasses the necessary work to create the project deliverables, and it is specific to the work required to achieve the project objectives (Mirza et al., 2013; Xue et al., 2018). In contrast, the product scope pertains to the attributes and characteristics of the deliverables created by the project and is measured against the requirements (Mirza et al., 2013; Xue et al., 2020). The completion of these two is measured respectively against project management product requirements and project management plan (PMI, 2017).

Managing project scope should start early in the pre-project planning process to identify and analyse project risks and execute the project in a way that avoids key changes that can negatively affect project performance (Xue et al., 2020; Ajmal et al., 2022).

It has been mentioned by several scholars like Mitchell, Mitchell et al.(1997a) and Ward and Chapman (2008a) that stakeholders are one of the main sources of requests for changes in requirements or final product and consequently uncertainty in projects.

The causes of changes in the scope of construction projects have been identified through research in the area of scope change management by (Nahod, 2012) which is presented in Table 1. By considering these causes, it can be comprehended that stakeholders possess an important role in changing the scope of projects.

Table 1 Causes of change in construction projects (Nahod, 2012).

Cause of Change	% of Change	Source of Change
Stakeholders' change requests caused by additional recognized needs for a project	25	Project Stakeholders
Partially incomplete project documentation	21	Project stakeholders
Change of technology caused by the lack of availability of designed technology in the market	18	Project conditions
Lack of concrete construction material in the region caused by high or low current demand	12	Project conditions
Lack of financing for the timely completion of a project	10.5	Project constraints
Contractor's change requests for easier operations, higher income, within the allowable limits for the project	8	Project stakeholders
Project documentation alignment with new regulations adopted in the period between project design and realization	4	Project Conditions
Other	1.5	

According to the PMBOK GUIDE (PMI, 2017), the scope management processes include Plan Scope Management, Collect Requirements, Define Scope, Create WBS, Validate Scope, and Control Scope. Plan Scope Management includes documenting how the project and product scope will be developed, verified, and managed in a plan for scope management. "Collecting Requirements" is the process of identifying, documenting, and managing the needs and requirements of project stakeholders to achieve project goals (PMI, 2017). "Define Scope" involves developing a comprehensive description of the project and its output. "Create WBS" includes subdividing project deliverables and project activity into smaller, more manageable chunks. "Validate Scope" is the process of formally accepting the finished deliverables of a project (PMI, 2017). And finally, "Control Scope" is comprised of monitoring the progress of the project and product scope and managing any modifications to the scope baseline. Project life cycles can span a continuum from predictive methodologies on one end to adaptive or agile techniques on the other (PMI, 2017). It is explained that predictive life cycles involve defining project deliverables at the outset and managing any changes to the scope progressively. Conversely, adaptive or agile life cycles entail developing deliverables across several iterations, with a detailed scope established and endorsed for each iteration when it commences (PMI, 2017). According to PMI (2017), projects with adaptive life cycles aim to respond to significant change and necessitate ongoing engagement with stakeholders. The comprehensive scope of an adaptive project is broken down into a set of requirements and work, sometimes known as a "product backlog." The PMBOK® Guide outlines the Project Scope Management processes as individual processes with clear boundaries, but in reality, they often overlap and interact in ways that are not fully explained in the guide (PMI, 2017). Therefore, this process and its interactions with other project management processes like stakeholder management will be analysed in the next chapters. The overall process of scope management is captured and illustrated, according to PMI (2017), in Figure 2.

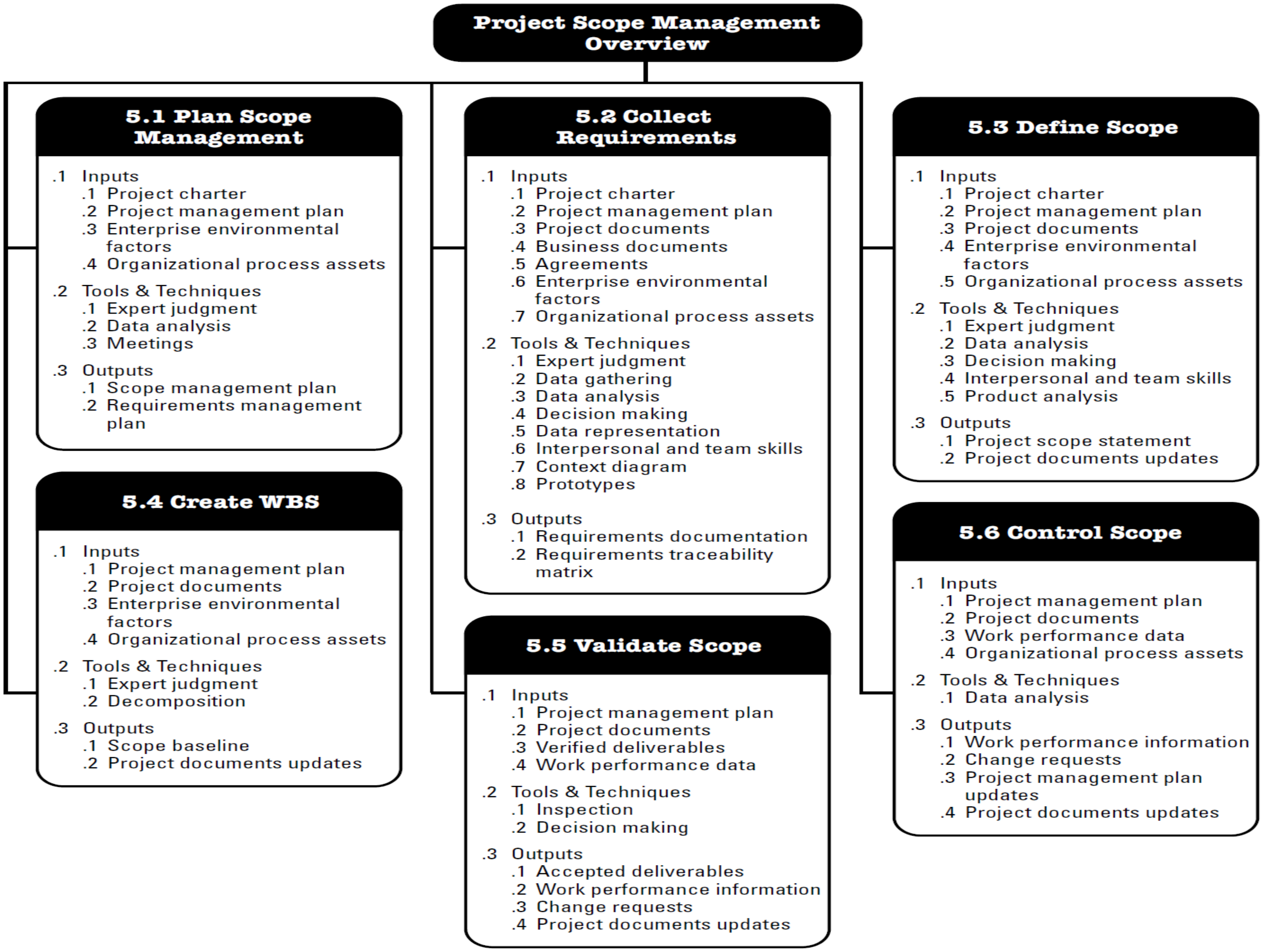

Figure 2 Overall process of scope management according to PMI(2017, p.130).

2.3.1 Definition of Scope Creep

Kuprenas and Nasr (2003) claim that the successful delivery of a project is contingent upon the critical task of designing projects to the approved schedule and budget. Hence, they define scope creep as a procedure where extra work is added to the project after establishing the scope, which can occur in different ways, like a fundamental change in approach to the design or as numerous small changes in the projects. Consequently, it has a detrimental impact on the schedule and budget, and due to the additional design work, it can result in extra charges for the design phase (Kuprenas and Nasr, 2003).

Yu et al. (2010) claim that some of the issues in the procedures for gathering requirements include slow response and improper timing. In this regard, they use requirements management terminology, which can be interpreted as a definition of scope creep in projects. Using Robertson and Robertson (2004) definition, they define requirement creep as entering additional requirements into the project after completion of the requirement management process or developing requirements beyond the project goals (Robertson and Robertson, 2004).

In addition, Hussain (2012) points out the difference between scope change and scope creep, stating that witnessing major scope changes is not unusual for practitioners in construction projects, but that scope creep and scope change are different phenomena. Accordingly, he argues that the client and project manager make the official decision about changing feature X to reduce or expand its functionality, and this scope change includes making adjustments to the schedule, costs, or other features (Hussain, 2012). Hence, the author defines scope creep as the tendency to extend a project beyond its initial boundaries (Hussain, 2012). Surprisingly, he claims that some of the project managers in Qatar's governmental construction projects accept scope creep as an inevitable fact and try to live with it by reducing its negative effects, while the others struggle to fight it (Hussain, 2012). Hussain (2012) elaborates on the definition of "scope creep" as a phenomenon where a project with X, Y, and Z features slowly grows beyond the scope originally defined in the statement of work, which happens unofficially without adjustments to time and costs.

Also, Yap et al. (2017) discuss that despite its widespread acceptance in the construction industry, design change has an undesirable effect on project performance, and any uncontrolled changes made without due consideration of their impacts on budget and schedule will result in scope creep (Project Management Institute, 2013, 2017). Additionally, Yap et al. (2017) point out that other scholars (Knight and Robinson Fayek, 2002; Shane et al., 2009) deem scope creep a risk event resulting in design cost overruns. They claim that the crucial task is identifying the causes of scope change through risk identification in a risk management process (Chapman, 2001).

Also, Shirazi et al. (2017) present a simple definition of scope creep as uncontrolled changes in a project that may lead to project failure. Furthermore, Shirazi et al. (2017) approach the concept of "scope creep" from the point of view of changes in projects as well. They claim that changes with positive or negative impacts can occur in projects due to their progressively elaborate nature in defining the detail information of the project during various steps. Hence, they state that changes in projects should be controlled as they cannot be completely prevented. Accordingly, they argue that scope control should include monitoring the status of the product and project scope to detect any scope changes and manage changes influencing other areas of the project such as cost, schedule, risk, quality, etc., ensuring agreement on changes and controlling factors which may cause a scope change.

Furthermore, Lehtonen and Martinsuo (2009) define scope creep as the process of adding functionality and features to the scope of a project without considering its impacts on the project management plan, project baseline, or customer agreement (Shirazi et al., 2017). Additionally, Shirazi et al. (2017) claim that scope creep will not happen during the first stages of the project and mostly happen during the next stages when more information on the project, problems, and solutions are available to the project team.

Amoatey and Anson (2017) point out the confusion around the terms "scope change" and "scope creep" and clarify that changes to the scope are not necessarily "scope creep." They explained that a "scope change" is any change known and accepted by the owner and contractor to be made to the current project scope, including compensable or non-compensable changes. The main point of this argument is that both the owner and contractor know about such changes and their impacts in terms of project time, cost, and quality and agree to implement them. On the other hand, Amoatey and Anson (2017) state that scope creep is making changes to the project where one party is not aware of it, there is no agreement on these changes by the involved parties, or the potential impacts are not reviewed or accepted. After reviewing the previous works of scholars, Amoatey and Anson (2017) conclude that scope creep is the extension of initial project boundaries caused by unexpected and uncontrolled changes in project requirements without taking into consideration the schedule and budget of the project.

Thakore (2010) claims that there are two categories of scope creep: business and technical. In this regard, the author elaborates that business scope creep is caused by external forces outside of the project manager’s control, like changes in market trends that make predefined requirements outdated. On the other hand, Thakore (2010) argues that technical scope creep is the result of the project team accepting the client’s requests for changes in the requirements to keep the client happy. Similarly, "gold plating" is another characteristic of technical scope creep where project teams add extra features beyond original requirements to please the client (Thakore, 2010). Also, Agyekum-Mensah and Knight (2017) claim that the theme of "scope creep" as the reason behind project delays is discussed sparsely in the project management literature.

Finally, one of the most comprehensive definitions of scope creep is provided by PMI (2017) as "the uncontrolled expansion of project or product scope without adjustments to time, cost, or resources and without addressing its negative effects on project or stakeholder agreement."

In conclusion, "Scope Creep" can be defined as the uncontrolled expansion of a project's scope beyond its initial boundaries, often occurring through numerous small or fundamental changes added after establishing the project scope (Kuprenas & Nasr, 2003). These changes can be either business-related, driven by external market forces (Thakore, 2010), or technical, stemming from the project team's attempts to please the client (Hussain, 2012; Thakore, 2010). Scope creep happens unofficially, without adjustments to time, cost, or resources, and without proper consideration of its impacts on the project management plan, project baseline, or stakeholder agreement (Lehtonen & Martinsuo, 2009; PMI, 2017). This phenomenon can lead to detrimental effects on project schedule and budget (Kuprenas & Nasr, 2003), as well as the potential for project failure (Shirazi et al., 2017).

2.3.2 Causes of Scope Creep

In order to provide proper remedies to the dilemma of project scope creep, it is necessary to raise awareness of its causes. Knowledge of these causes will facilitate improving organisational performance, which will enhance competitive advantage (Martens et al., 2018; Ajmal et al., 2022). Several scholars have emphasised the importance of defining the scope in the early stages of the project and stated that poor scope definition is a common source of difficulty (Cho and Gibson, 2001; Gibson and Gebken, 2003; Sharma and Lutchman, 2006). Accordingly, it has been mentioned that proper planning with a clear scope definition can prevent and reduce cost overruns, while failure to do so can result in expensive changes, cost and schedule overruns, delays, rework, and consequently project failure. Assaf and Al-Hejji (2006) state that the changes are due to uncertainties that happen in the early stages of the project. In addition, Fageha and Aibinu (2013) argue that change requests are the result of differentiation in stakeholders' perspectives, so adequate project and particularly scope definition is essential for dealing with this issue and project success. The role of project definition is more important in the public sector than the private one because the project will be of service to communities first, while in the latter the main concern is benefiting the owners and investors. Therefore, their needs and requirements should be reflected by involving the stakeholders from the early stages in order to prevent inadequate project definition (Sharma and Lutchman, 2006).

According to Moustafaev (2014), during the project implementation stage, it is possible and frequently happens that scope elements and features that were overlooked at the beginning of the scope definition process can cause unpleasant surprises. Plus, he adds that without a clear grasp of the project's scope, scheduling and budgeting are pointless endeavours. Hence, a project manager must always take into account how different scope components are interdependent on one another (Moustafaev, 2014). Moustafaev (2014) states that one of the most harmful and hardest-to-detect issues in the documentation of specifications is ambiguity in the requirements, in addition to the completeness of the requirements. Complete requirements imply that all conceivable substitutes and exceptions have been appropriately anticipated and resolved (Moustafaev, 2014). Also, misinterpretation of requirements and their measurement is another factor that can lead to rework and cost overruns during the project lifecycle (Moustafaev, 2014).

In terms of scope problems, Moustafaev (2014) identified several categories, including scope elicitation issues, lack of skills, project management issues, documentation issues, and scope management issues. In this regard, scope elicitation issues include the lack of communication between clients and the project team, the lack of access to the higher authority, the inability to see the entire project, and the lack of requirement prioritisation. Also, lack of skills are poorly trained requirements professionals, technical and requirements experts, and the lack of stakeholder education. Accordingly, the project management issues category consists of teams under pressure, the excess of scope, and quick de-scoping at the end of the project. Plus, the documentation issues group contains undocumented requirements, a vague scope, and the lack of measurability, while the scope management issues include customers having direct access to the technical people and frequent scope creep (Moustafaev, 2014).

Scope Elicitation Issues

Communication:

Communication problems are complex and can be caused by a variety of factors. Lack of communication can sometimes be attributed to stakeholders initiating the project who are too busy to spend time discussing the scope with requirements analysts (Moustafaev, 2014). Also, the stakeholders are often not prepared to evaluate the sheer complexity of the projects they are launching, as Moustafaev (2014) points out.

Access to Higher Authority:

As Moustafaev (2014) explains, when a member of the executive team initiates a project, there is nothing inherently wrong with it because top management has at least the initial, high-level requirements in mind. However, as the author states, the issue in this situation during the initiation or planning stages is that if the manager of the project manager cannot clearly answer the project manager's questions, the CEO would be the next person who could provide the answers. Therefore, the accessibility of the project manager to the CEO of the company would be crucial (Moustafaev, 2014).

Inability To See the Entire Project:

On the other hand, the project team and its stakeholders commonly miss the fact that the project's scope is larger than they first think it is because they have a limited understanding of it. This is particularly true for big firms carrying out large internal initiatives like regulatory, rebranding, technological projects, etc. (Moustafaev, 2014).

Lack of skills issues

Poorly Trained Requirements Professionals:

According to Moustafaev (2014), requirements professionals who are poorly trained often find their job frustrating because the process of requirements gathering, analysis, and documentation is not well organised or standardized. Executives at companies where this problem exists tend to assume that all project features are obvious and self-evident, without properly training their requirements professionals (Moustafaev, 2014). Another widespread misconception is that anyone with adequate technical knowledge, be they a mechanical engineer, architect, software developer, or accountant, can instantly and without additional training become a successful requirements analyst (Moustafaev, 2014). Moustafaev (2014) argues that unfortunately this is not true, as technical experts are specifically trained to receive a comprehensive set of clear, measurable, and unambiguous requirements and translate them into specific designs. Hence, the problem occurs when these technical experts are provided with ambiguous and incomplete features, which undermine their ability to convert them into an acceptable format (Moustafaev, 2014).

Lack of Stakeholder Education:

In some cases, project stakeholders do not appreciate the full complexity of the requirement elicitation process, which is one of the major issues faced by project teams (Moustafaev, 2014).

Project Management Issues

As mentioned before, Moustafaev (2014) explains that "the project management issues" category includes teams under pressure, an excess of scope, and quick de-scoping at the end of the project.

Teams Under Pressure:

Unfortunately, it frequently occurs for very large and complicated projects to be imposed with insufficient funding, manpower, and schedules. According to Moustafaev (2014), overestimating the abilities of the project team or underestimating the scale of the project can result in two possible consequences: either the delivered product has serious quality issues or is not delivered at all.

Excess of Scope:

In terms of the excess of scope, Moustafaev (2014) argues that the issue of "external pressure" is related to the issue of "too much scope." For whatever reason, it may have been presumed that the project scope is simple and small, and later the stakeholders may have realised that it is much larger and more complex than was initially thought. Alternatively, the size and complexity of the project scope may have been known to stakeholders from the very beginning of the project (Moustafaev, 2014).

Quick De-Scoping at the End of the Project:

Moustafaev (2014) discusses When a project is getting close to completion, senior stakeholders, such as customers or executives, may opt to reduce its scope because they know that it cannot be completed with all of the present requirements. However, it is extremely possible that this decision will have a detrimental effect on the project's timeline and budget, as well as create new technical hazards that seriously risk affecting the final product's overall quality (Moustafaev, 2014).

Documentation Issues

Undocumented Requirements:

Moustafaev (2014) explains that the requirements might be recorded by the project manager in different formats, like notebooks, emails, etc. But as the requirements process draws to a close, the project's stakeholders learn that many of the features stated by the clients did not make it to the final documentation or are lost.

Vague Scope and Lack of Measurability:

In this regard, Moustafaev (2014) exemplifies a situation where the stakeholders on the customer’s side use their own specific terms in communicating with the project management team, which might be difficult for them to understand and raise several questions directed at the customer.

Scope Management Issues

Direct access of customers to the technical people:

According to Moustafaev (2014), in this scenario, the communication channels were cut off with the project manager, who is meant to have access to all pertinent project information. Due to this, the project manager and the rest of the team were unable to evaluate the suggested change, take into account all of its possible effects, and weigh the risks involved, which resulted in significant issues closer to the project's closeout.

Frequent Scope Creep:

Another scope elicitation problem mentioned by Moustafaev (2014) is frequent scope creep. In this regard, Moustafaev (2014) claims that scope changes in projects are problematic even if the project manager knows about them. Additionally, he argues that scope creep depends on a number of factors. Hence, project scope changes can have a significant impact on the project depending on the frequency, size, and complexity of the changes and whether they occur in the early stages of the project or later.

According to Moustafaev (2014), it is always possible that a certain requirement was missed, misinterpreted, or incorrectly documented, no matter how many times the team and customer inspected the documentation. Additionally, the perceived constraints within or outside the project may have been misconstrued or changed during the life cycle of the project. For instance, the team may find out throughout the renovation project that the kitchen flooring needs to be reinforced in order to accommodate the new, heavy ceramic tiles. A third problem is that stakeholders are often unaware of the complexity of a project or the complexity of the technology involved (Moustafaev, 2014).

In another study, Ye et al. (2014) investigated the causes of rework in China's construction projects through a literature review, 13 semi-structured interviews, and a questionnaire survey. Love et al. (2004) provided a definition of rework as the repetitive process of carrying out an activity or process that was not correctly implemented at the first instance. Hwang et al. (2009) state that terms such as quality failures, non-conformances, defects, and quality deviations have been used interchangeably with rework in previous literature (Barber et al., 2000; Hegazy et al., 2011; Josephson et al. , 2002). In this regard, they primarily identified 39 factors contributing to rework in projects through a literature review, among which lack of a clear project process management system, poor quality construction technology, and the use of poor construction materials rank the highest. According to Ye et al. (2014), having a tight timetable and irrational decisions made by the clients sourcing from their unrealistic perceptions or vanity leads to the commencement of a project without adequate project management preparation. This results in a lot of unwanted reworks, which could be prevented by using more sensible project management procedures (Ye et al., 2014). Ye et al. (2014) discuss the fact that the quality of construction work can be severely impacted by the quality of construction technology. Accordingly, they claim that construction work in China is difficult to control for quality reasons, which frequently necessitates significant rework. This is due to the construction industry's continued conventional labour-intensive character in China and its limited use of modern technology. Hence, this amount of rework can be reduced by improving construction technology (Ye et al., 2014).

Additionally, Ye et al. (2014) identified 11 fundamental categories of these reasons, including project scope management, communication management, design management, field management, active rework, project process management, subcontractor management, owner capability, project plan changes, the external environment, and contract management. Although the paper provides a comprehensive list of factors contributing to rework in projects and recommends a brief list of solutions for each factor group, it does not specifically investigate the role of stakeholders' influence or the available strategies for responding to that. Also, despite the authors' emphasis on the importance of communications, they do not consider BIM impacts or benefits to resolve the identified issues. Plus, further study is needed to test the findings in other countries, like the United Kingdom.

11 underlying dimensions of rework

Contractor Field Management:

Several scholars have identified poor site management as one of the major causes of construction rework (Love et al., 2004, 2010; Palaneeswaran et al., 2008; Ye et al., 2014).

External Environment:

Additionally, Ye et al. (2014) claim that natural conditions, such as extreme weather, and end-user requirements, as well as social, cultural, legal, and market conditions make up the external environment. Despite the difficulty of controlling the external environment, suitable measures can still be taken to reduce its adverse effects on construction rework (Ye et al., 2014).

Contract Management:

This is claimed by Ye et al. (2014) that in addition to payment problems during contract execution, poor contract management can also result in rework due to ambiguous contract documentation. Thus, the terms and conditions of contracts should be carefully negotiated with contractors, and their performance should be monitored in line with the contract's terms and specifications. To avoid misunderstandings later on in the project execution process, it is vital to agree on and record any changes to the contract during the project implementation process (Ye et al., 2014).

Subcontractor management:

Ye et al. (2014) claim that due to the involvement of different expertise and knowledge requirements, it is difficult to conduct effective communication between various subcontractors. To reduce rework, it would be advantageous to hold regular coordination meetings, establish a subcontractor integrity system, and ensure the integrity of subcontractors on site (Ye et al., 2014).

Design management:

One important factor affecting rework in different countries, is design management (Hwang et al., 2009; Ye et al., 2014). Moreover, Ye et al. (2014) found that it is common practice for Chinese construction owners to require design firms to submit design drawings as early as possible in order to ensure that products are delivered as quickly as possible. Thus, many design companies sacrifice quality in order to meet the deadline for the submission. Furthermore, because design duties are carried out by diverse groups of design specialists, a lack of proper team communication leads to design omissions or errors as well as inadequate integration of design solutions. Ye et al. (2014) argue that in China, the dominant delivery approach is Design-Bid-Build which severely limits communications between design and construction participants, making design solutions less constructible. These problems lead to low design quality and extra rework during the execution phase.

Project Communication Management:

Also, Ye et al. (2014) found that most Chinese construction companies have a straight-line or functional organisational structure that is ineffective for communicating internally and externally. Thus, they recommend that it would be more appropriate to have a matrix organisational structure. Moreover, Ye et al. (2014) argue that Chinese contractors rarely utilise information and communication technology (ICT) in managing their projects, despite the fact that major international contractors use ICT extensively to improve their project communication management capabilities. Consequently, ICT can improve the efficiency of project communication and reduce the amount of rework associated with communication errors.

Project Plan Changes:

According to Ye et al. (2014), poor owner process management often results in schedule adjustments and investment changes in construction projects. Establishing a whole-process consultation system to integrate organisational and economic measures can decrease unwanted changes, increase the effectiveness of process management, and aid in successful change management, although it is hard to totally eliminate plan changes (Ye et al., 2014).

Active rework for quality improvement:

As opposed to previous studies, the findings of Ye et al.'s (2014) study indicate that rework does not always result in negative outcomes. They explain that during the design and construction process, designers and contractors may actively rework in order to reduce costs and time, improve quality, and meet the requirements of the project owners. Additionally, Ye et al.'s (2014) claim that reworks done early minimise the project's loss, so an early decision to rework is advisable.

Owner Capability:

It is stated by Ye et al. (2014), that several factors contribute to project success, such as the effectiveness of the owner in defining and formulating the project, owner construction experience, financial status, management competency, characteristics, and owner capability (Xia and Chan, 2010; Ye et al., 2014). Hence, they found that the management capabilities of Chinese project owners range widely depending on the type of project and organisational structures. For instance, the management capabilities of project owners in government-initiated projects are poor, owner duties are carried out by a temporary organisation established by the government. Hence, Ye et al. (2014) state that in order to prevent mistakes from being made again and again, which results in rework, it is necessary to transmit owner expertise and knowledge effectively from one project to another.

Project Scope Management:

According to Ye et al. (2014), the scope of the project is one of the most important factors in ensuring its success. While the Chinese construction industry has experienced quick development over the past 30 years, its maturity has not been fully realized, with many project owners focusing too much on the construction stages and early completion of the project, and not adequately recognising the importance of scope and strategic management in the early stages. Hence, Ye et al. (2014) claim that changes in project functions and frequent revisions during the design and construction phases can be caused by a lack of clear project scope during the early stages of the project.

Project Process Management:

Another issue with the Chinese construction industry is the shortage of project managers due to its rapid growth in recent years (Ye et al., 2014). As a consequence, some of the project managers in the Chinese construction industry are unwilling to follow or are unfamiliar with good project management practices. Accordingly, Ye et al. (2014) argue this can result in the construction period being improperly shortened, three-way projects being made (simultaneous surveying, designing, and constructing), and the basic programme of engineering construction being violated. There is a high likelihood of continuous changes in the construction phase of these three-way projects, resulting in additional rework. Also, Ye et al. (2014) state that three-way projects can be caused by violating regulations from owners, lack of supervision, and a lack of proper three-way measures such as a contractor process management mechanism, a reporting system, government notice, and a mechanism for shutting down three-way projects.

In conclusion, Ye et al. (2014) ranked the 39 identified causes of rework by conducting a questionnaire survey, among which the top 10 causes are shown in Table 2.

Table 2 Ranking of Causes of Rework (Ye et al., 2014)

Overall ranking	Causes
1	Unclear and ambiguous project process management
2	Poor quality of construction technologies used
3	Use of poor construction materials
4	Active rework made by the contractors to improve quality
5	Design error/omission because of too many design tasks and time boxing
6	Poor coordination of design team members
7	Project scope change after work had been undertaken/completed

8	Lack of constructability of design solutions
9	Poor communication path of project instructions
10	Lack of supervision of admission materials/equipment

Also, Table 3 shows the details of categories of factors contributing to rework in construction projects.

Table 3 Details of the factors and causes of reworks (Ye et al., 2014)

Rank	Factor	Components
1	Contractor Field Management	• Usage of subpar construction technology. • Failure to utilize advanced mechanical equipment. • Implementation of substandard construction procedures. • Ineffective utilization of construction management standards. • Construction errors resulting from a deficient understanding of design intent. • Usage of substandard construction materials. • Inadequate supervision of material and equipment admission.
2	External Environment	• Poor site conditions • Complex construction methods leading to changes • New requests from end-users for improved construction standards during the process • New requests from end-users during the final inspection and certification stage • Adverse natural conditions • Changes in government policies, laws, and regulations • Shortage of construction equipment and materials

		• Influence of social and cultural factors.
3	Contract Management	• Payment of low contract fees or delayed payment of contract fees • Ambiguity in the items listed in the contract documentation • Lack of a clear definition of contract documentation for working content • Poor execution of the contract.
4	Subcontractor Management	• Inadequate communication among construction managers • Ineffective coordination of subcontractors between upstream and downstream • Lack of communication among members of the construction team • Insufficient protection for completed works
5	Design Management	• Lack of constructability due to a disconnect between design and construction conditions • Poor coordination among design team members • Design errors or omissions due to time constraints and an excessive workload.
6	Project Communication Management	• Issuance of inappropriate or conflicting project instructions by managers • Inadequate communication path for project instructions
7	Project Plan Changes	• Changes in budget, either reduction or increase • Changes in schedule, either acceleration or shortening • Substitution of materials/equipment during construction.
8	Changes For Quality Improvement	• Changes made by the designers to improve quality • Changes made by the contractors to improve quality
9	Client Management	• Lack of communication and coordination between owners and end-users • Delays in providing necessary site conditions, including water and electricity, to the contractor.
10	Project Scope Management	• Project scope was changed after work had been undertaken/completed • Revisions and modifications of the project function initiated by the owner/end-user

11	Project Process Management	• Unclear and ambiguous project process management • Lack of strict adherence to project process management

Fageha and Aibinu (2016) conducted another study in Saudi Arabia to develop a model and procedure for measuring project scope definition completeness based on the interests and importance of stakeholders on the project. They collected data by conducting semi-structured interviews with 46 respondents and using the Analytical Hierarchy Process (AHP) to identify and prioritise the levels of various stakeholders' input into scope elements. Based on the inputs of stakeholders according to their importance weights, an evaluation framework has been developed by Fageha and Aibinu (2016) for evaluating the completion of project scope definitions for public building projects in Saudi Arabia. Fageha and Aibinu (2016) argue that changes during the execution stage can be caused by different stakeholders ,as internal influencers, that are the results of variations in their perspectives. These change orders are usually the result of an incomplete project scope definition or a poor understanding of how the work should be implemented. External influences, such as price fluctuations, unpredictable economic cycles, corruption, and high levels of competition, may also cause these changes (Fageha and Aibinu, 2016).

Moreover, the major reasons for the problem of abandoned public building projects in Saudi Arabia have been identified as inadequate pre-project planning, a poor definition of project components, and insufficient involvement of stakeholders (Al-Humaidan, 2011; Fageha and Aibinu, 2016). Additionally, changes in the scope of the project, unsuitable stakeholder involvement, and rework are mentioned as some of the main factors contributing to project delays in Saudi Arabia (Assaf and Al-Hejji, 2006; Fageha and Aibinu, 2016).

Yap et al. (2017) investigated the role of managing design changes in dealing with cost overruns and delays in construction projects, to identify the reasons behind design changes and the impacts on Malaysian construction projects, the impacts of rework on project performance, and explore the ways in which this problem can be addressed through effective communication and project learning. For doing this, they identified 39 factors contributing to design changes through a comprehensive literature review and categorised them into consultant, client, site, external-related, and contractor groups, followed by semi-structured interviews with 12 experienced practitioners. As a result of their findings, they developed a collaborative model for managing design changes through utilising an effective project-learning communication approach. Scholars discuss that design changes can affect the performance of projects and increase the likelihood of cost overruns and schedule delays, which can result in unnecessary claims and disputes (Yehiel, 2014; Abdul-Rahman et al., 2016; Yap et al., 2017).

Yap et al. (2017) define construction change as processes, methods, or work states that deviate from the original project specification or plan and arise from variations in scope changes, uncertainties, or work quality and conditions. They argue that uncontrolled changes can cause scope creep, leading to negative impacts on project performance, particularly on cost and time overruns. According to Olawale and Sun (2010), design changes are the primary cause of cost and time overruns in UK construction projects. Yap et al. (2017) found that design changes are the most critical factor contributing to cost and time overruns and can cause significant rework, degrading project progress and causing disruptions. Client-related factors such as willingness to use new materials or technology, additional requirements, and market demand also contribute to design changes, which are mostly initiated by clients. Additionally, poor communication between team members is identified as a significant factor contributing to rework, disputes, and project overruns. Also, Yap et al., (2017) mention that coordination between project team members can be negatively impacted by a lack of effective and timely communication.

Through conducting a comprehensive literature review and semi-structured interviews with practitioners, Yap et al., (2017) identified 39 contributing factors to design changes, as shown in Table 4. By doing this, they identified one additional factor called "driven by market demand or sales," which includes changes in plans by the client due to changes in economic conditions for marketing reasons or to meet customer demands. Accordingly, they categorised the identified factors into five groups of causes related to the client, consultant, contractor, site, and external factors. Yap et al., (2017) found that clients and consultants are the main sources of design changes. Plus, Yang and Wei (2010) found that design changes are mostly initiated by the client, while Muhwezi et al. (2014) argue that consultants and clients have the highest impacts on the project outcomes (Yap, Abdul-Rahman and Chen, 2017).

Table 4 Causes of design change from past literature (Yap et al., 2017)

Category	Causing factors of design changes
Client-related	1. Alteration of requirements or specifications 2. Application of value engineering (cost-saving methods, alternative materials)

	3. Unclear instructions from the client 4. Addition or omission of scopes 5. Introduction of additional requirements or features 6. Desire to use new technology or materials 7. Change in financial status, such as funding of the project 8. Slow decision-making 9. Change in the intended use of the building 10. Market-driven changes (based on sales).
Consultant-related	11. Inadequate coordination among different professional disciplines/consultants 12. Inadequate understanding of client's requirements 13. Insufficient soil investigation conducted before design 14. Errors/discrepancies in design documents 15. Omissions/incomplete drawings in design 16. Obsolete design (new technology/construction method) 17. Modification to design for improvement 18. Current design deemed too costly 19. Neglect of constructability during the design process (difficult to construct) 20. Adherence to quality requirements such as CONQUAS 21, QCLASSIC 21. Failure to comply with regulatory requirements
Contractor-related	22. Request to utilize existing materials 23. Alternative construction approaches to expedite schedule (such as using metal formwork, IBS) 24. To accommodate subcontractor design/requirements 25. Enhancing constructability (ease of construction) 26. Shortage of materials (resource availability issues)

	27. Rectifying construction errors 28. Enhancing the quality of works (fixing defects) 29. Improving safety and health aspects (temporary structures, work sequence) 30. Coordination of shop drawings due to inconsistencies 31. Scarcity of skilled labour in certain trades
Site-related	32. Unanticipated ground conditions (related to geotechnical factors) 33. Safety concerns on site (including soil erosion, access to the site, and scaffolding) 34. Interference with neighbouring structures 35. Undiscovered subsurface utility lines
External-related	36. Alterations in government regulations, laws, and policies 37. Issues related to neighbouring properties 38. Economic fluctuations (i.e., shifts in taxation, interest rates, exchange rates) 39. Criteria for planning permission set by local authorities

Yap et al., (2017) report that among the top causes of client-related changes, are extra requirements with added features, the desire to use new materials or technology, and factors derived from market demand or sales. For instance, they found that in one case, the client requested adding ultramodern gadgets to increase the value of the building. Moreover, they claim that modern building designs are influenced by customer preferences and the competition's product offerings. Other reported common factors in this category include changes in requirements or specifications and reducing cost through value engineering (Ye et al., 2014; Yap et al., 2017). Plus, design changes can occur as a consequence of clients' slow decision-making generated by their indecisiveness (Kikwasi, 2012; Yap et al., 2017). Additionally, major rework can be caused by the client's request for change, after the inspection and installation of materials (Hwang et al., 2014; Yap et al., 2017). For consultant-related causes, Yap et al., (2017) found that "poor understanding of the client's requirements" and "design improvements through modifications" are the major contributing factors to a design change in this category. In some cases, this can be attributed to an unclear design brief due to a lack of clear client expectations. It is also common for consultants to make changes in order to meet client demands for current designs or come up with a more viable alternative. Additionally, the consultants' lack of consistency and inefficiency in design may result in erroneous design documents, incomplete drawings, or design omissions (Chang et al., 2011; Chong and Mohamad Zin, 2012; Yap et al., 2017). Yap et al. (2017) found that the most common causes relating to the contractor, site, and external factors include improving buildability, unforeseen ground conditions, and changes in government regulations, laws, and policies. Thus, it is advised to involve contractors in buildability considerations before commencing the construction and to undertake proper and comprehensive site investigations (Tummala and Schoenherr, 2011; Mpofu et al., 2017; Yap et al., 2017). Moreover, Yap et al. (2017) argue that impeded building approval, delayed development schedule, and jeopardised profitability of the proposed development can be attributed to the unpredicted requirements. This necessitates regular communication and a good working relationship with the approving authority.

Shirazi et al. (2017) investigated the common change management and scope management approaches by conducting a questionnaire survey of 25 participants from 5 projects and utilising a fuzzy analytical hierarchy to select the most effective strategy for managing scope changes. Shirazi et al. (2017) identified nine major causes of scope creep in power plant projects, such as poor change control, poor documentation, poor information transformation, external changes, internal changes, unmanaged expectations, a lack of using Work Breakdown Structure (WBS), and a lack of a scope management plan. Accordingly, they identified the top four factors responsible for 70% of scope creep in projects through using Pareto rule, practitioners' opinions, past project documents, and scientific articles as shown in Table 5.

Table 5 Main causes of scope creep (Shirazi et al., 2017)

Categories	Description	Scope creep cause
Poor documentation	Poor scope definition and the improper construction of the project's scope and contract.	• Inexperienced experts involved in defining the scope. • Misinterpretation of the business needs. • Inadequate understanding of the client's requirements in defining the scope. • Unrealistic project objectives. • Variations in the size and level of detail in the scope

		statement without third-party validation. • • Unclear definition of system boundaries.
Poor change control	The responsibility of the project team based on the assumptions.	• Inadequate expertise in defining project procedures. • Exclusion of the project team in the procedure definition. • Lack of third-party verification for procedures.
Poor information transformation	Lack of comprehension of the project's objectives, scope baseline, and current status.	• Lack of configuration management plan. • Lack of communication.
External changes	Change of law, technology, weather and economical situation.	• Lack of risk management process

In their research, Amoatey and Anson (2017) studied the causes of scope creep in the real estate development industry in Ghana. They employed quantitative methods and used a survey approach to collect data, which included dispensing 100 questionnaires among personnel from the real estate development industry in Ghana. Accordingly, they identified the major contributing factors to scope creep in projects as client changes, unanticipated risks, and unclear scope, and proposed appropriate measures for managing these issues. However, the findings from this research may not be generalised, as it was conducted in the real estate development industry in Ghana, and the reasons for scope creep can be unique to individual country contexts. According to Amoatey and Anson (2017), there are a number of reasons why scope creep may occur, including the lack of a clear definition of the scope, employee attempts to improve a product, the unwillingness to reject clients, and the absence of formal reviews and approvals.

Hence, Amoatey and Anson (2017) presented a list of contributing factors to the occurrence of scope creep in projects through undertaking interviews and a comprehensive literature review. This list includes factors such as unforeseen risk, new laws, client change, new insight, new technologies, unclear scope, and a new economic situation. Project scope creep or project failure can result from unforeseen risks creeping up on an organisation without being anticipated (Amoatey and Anson, 2017). The new law factor encompasses unavoidable external demands that are beyond the control of the company. Also, Amoatey and Anson (2017) state that scope creep can be caused by changes initiated by the client or new insights sourced from new information or ideas that were not available at the outset. They add that new technologies that become available on the market and can be applied to the project are another source of uncertainty in the project's scope. Moreover, ambiguity in the scope of a project and the status of a country's inflation, financial position, and price fluctuations can influence the occurrence of scope creep in projects (Amoatey and Anson, 2017). Also, Amoatey and Anson (2017) ranked the identified causes of scope creep in the Ghanaian real estate industry, and the top three factors include: 1. client-initiated change. 2. an unforeseen risk; and 3. an unclear scope. In this regard, it is claimed by Amoatey et al. (2015) that client change orders are one of the top five causes of delay in construction projects. Plus, Amoatey and Anson (2017) reported that client change is ranked as the major cause of scope creep in construction projects by clients, consultants, and contractors involved in this study. According to Amoatey and Anson (2017), the unforeseen risk, as the second-highest ranked factor, describes a situation where risks are not anticipated and, if they occur, can result in changes to the project scope. Accordingly, Tummala and Schoenherr (2011) stated that firms must identify potential risks as well as their probability, impacts, and severity. During the risk identification process, all of the project events and items should be investigated by the project team to identify different categories of risk, particularly the risks with the potential to negatively impact the project (Amoatey and Anson, 2017). In this case, the problems which may influence the scope of the project during its lifecycle. Accordingly, Kerzner (2013) claims that one of the major reasons behind the occurrence of scope creep is the lack of formal risk analysis and planning processes in projects. Also, lack of clarity regarding the scope of a project was rated as the third most significant contributing factor to scope creep in Ghanaian construction projects (Amoatey and Anson, 2017). According to Kerzner (2013), features may be added without any coordinated approach if there is no documented, approved, and enforced process supported by all project parties. As a result, scope creep will occur due to difficulty in controlling the project scope.

Yu et al. (2019) investigated the impacts of different stakeholders on the occurrence of quality defects to enhance quality defect management in off-site construction projects. Thus, they developed an evaluation model based on a Bayesian Network approach for measuring the influence of stakeholders on the occurrence of defects in off-site construction projects. Also, they tested the developed model within a project in China. Accordingly, Yu et al. (2019) identified the major contributing factors to quality defects in off-site construction projects as faulty precast components, mistakes by workers, and ineffective quality inspection and testing during assembly and construction. Plus, they claim that based on their findings from the case study, contractors are the most influential stakeholder affecting the occurrence of quality defects.

According to Yu et al. (2019), it is necessary for multiple stakeholders, including the developer, designer, precast component manufacturer, precast component transportation company, and contractor, to work together to deliver an offsite construction project successfully because different project activities are interdependent ((Li *et al.*, 2016); Xue et al., 2018; London and Pablo, 2017; Jiang et al., 2016; Teng et al., 2017). Yu et al. (2019) argue that because stakeholder activities are interdependent, quality defects created by one stakeholder can have a considerable impact on the quality performance of other stakeholders. Dimensional discrepancies in precast components, for example, produced by the manufacturer, might have a negative impact on the building contractor's quality performance. As a result, the identification of key stakeholders must be done in a defect management plan, and their interdependencies with respect to quality performance must be examined (Yu et al., 2019).

In their study, Ajmal et al. (2020) investigated the causes of scope creep in projects from the main stakeholders' point of view. To approach this, they used a commonality analysis of stakeholders' opinions and an interview research method for collecting data from several projects in the UAE. In this study, the authors focused on the causes of scope creep in projects from the stakeholders' point of view to develop a framework for managing project scope creep. Accordingly, they considered four stakeholder groups: the project management office, the project team, consultants, and clients/customers, to investigate the dynamics among them and their roles in project management. To do this, the authors collected data from public and private large-scale projects in the United Arab Emirates. From their literature review, they identified several causes of scope creep, such as project complexity, tasks, specifications, risk, communication, customer/end-users, technicality, and environment. Through conducting semi-structured interviews with practitioners in the UAE's construction industry, the authors identified 38 major causes of scope creep in projects and categorised them into nine groups or common themes, as shown in Table 6.

Table 6 Stakeholders' views of causes of project scope creep (Ajmal et al., 2020)

Main factor	Sub-factors
Tasks	• Tasks overlapping • Hierarchical structure • Lack of organisation for task execution • Task requirements variety

Specifications	• Lack of comprehensive specifications • Unclear customer needs • Imprecise language to describe specifications
Technicality	• Technical complexity • Lack of technical expertise and skills • Unavailability of technical staff
Risk	• Lack of risk identification • Lack of risk measurements • No risk management personnel identified • Lack of internal stakeholder's involvement in risk identification • Lack of external stakeholder involvement in risk identification • Unavailability of risk mitigation strategy
Environment	• Macro environmental factors • Micro environmental factors • Excessive stakeholder involvement
Complexity	• Involvement of a high number of contractors and vendors • Involvement of a high number of internal functions and departments • High number of Work Breakdown Structure (WBS) levels • High degree of product/system customization • The variety of distinct knowledge bases
Communication	• Lack of formal communication plan • Traditional, non-internet-based communication methods • Unsupportive environment for free and open communication • Lack of communication with affected parties

Uncertainty	• High technological novelty • Frequent change in customer requirements • Lack of involvement of suppliers in the design phase • Lack of involvement of customers and users in the design phase • Lack of clarity of project goals and requirements • High degree of embedded software • High degree of regulatory compliance

Additionally, the authors studied the commonality of stakeholders' views of factors identified in the Table 6 above among the four studied stakeholder groups. In this regard, they found convergence in opinions at the "PMO-consultant" intersection, as both mentioned similar causes of scope creep, such as frequent customer-requested changes, environmental conditions, and a high level of uncertainty. On the other hand, the intersection of "project team—clients or customers" shared a common view of tasks as the major contributing factor to project scope creep. In addition, the comparison between the views of "PMO—project team—consultants", reported technicality, risk, and complexity as the main issues in project scope management. Finally, all four stakeholder groups PMO, project team, consultants, and clients and customers shared the same view of the project manager's communication abilities as the factor influencing the dialogue with stakeholders and consequently, affecting the overall outcome of a project. Therefore, they interpret it as evidence that poor communication is one of the major causes of scope creep, which should be addressed by project managers efficiently and in a timely manner during the project lifecycle. Hence, the commonality of stakeholders' views on causes of project scope creep is shown in Figure 3.

Hence, the authors recommend that project managers can benefit most from the application of Figure 3 to their projects by focusing on the factors that have been mentioned by more than one stakeholder group. Although, for the highest benefit, they should take into consideration the factors identified by all stakeholders, like poor communication issues. In this regard, they mention that the next causes of scope creep that were reported by the PMO, project team, and consultants and should be taken care of are risk, technicality, and complexity. Next, factors reported by two groups and even single stakeholder groups should be addressed, as various stakeholders

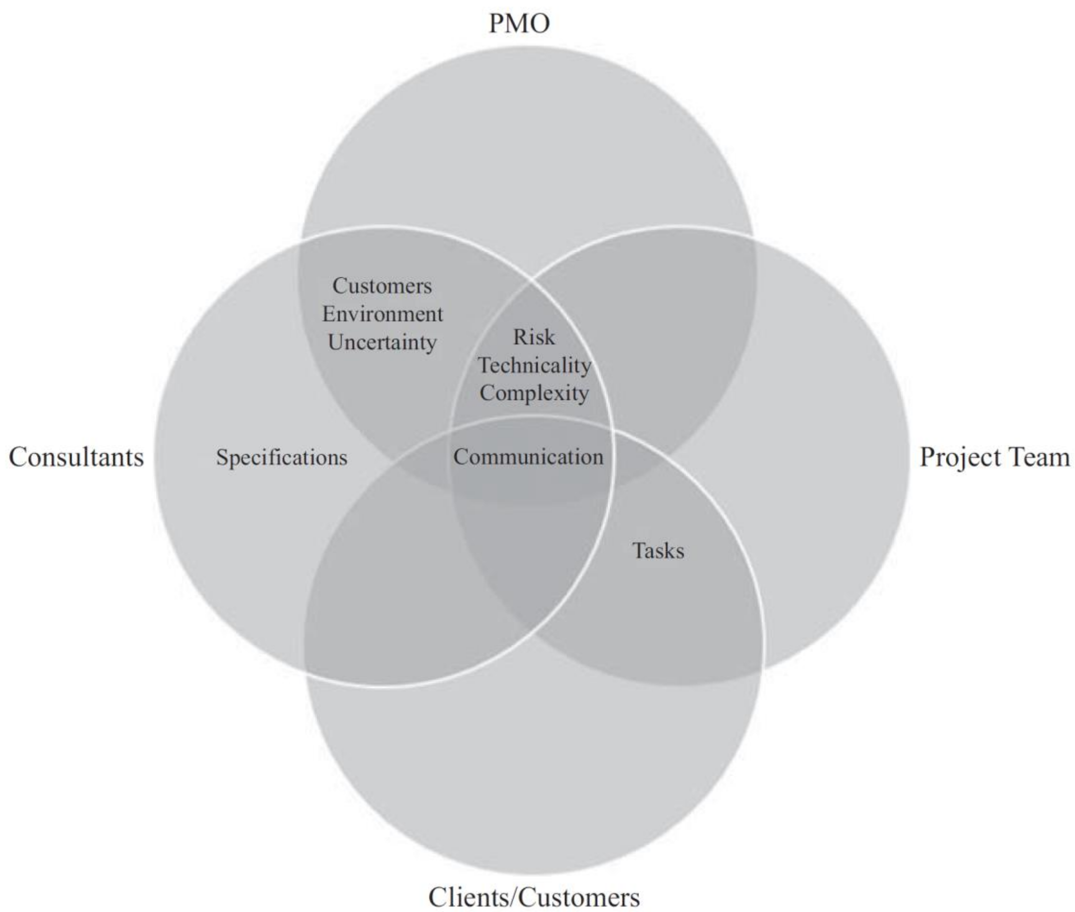

Figure 3 Implications of stakeholder's theory – commonality in stakeholders' view (Ajmal et al., 2020, p.495)

have different roles in projects and, therefore, their needs and expectations differ, which requires adjusting the benefits and costs of one solution over the other. Of course, they mention that to ensure the effectiveness of this framework (Figure 3), the project managers should first analyse the current state of the scope of their project and ensure the comprehensiveness of the scope in comparison with the identified factors so that the aspects that need more improvement can be identified.

Although helpful in identifying and structuring some of the causes of scope creep in projects based on the perspectives of stakeholder groups, their study does not investigate the influence strategies used by various stakeholders to impose their expectations, nor the role of new methods such as BIM in addressing the aforementioned issues. Also, as the authors mentioned, the identified factors need to be quantified to understand their significance, and further investigations should be done to identify similar factors in other countries like the UK. Plus, the interrelationships between the identified causes of scope creep should be investigated and their validity explored.

In another study, Ajmal et al. (2022) investigated the contributing factors to the occurrence of scope creep in construction projects. They used brainstorming with stakeholders to gather causes of scope creep and executed a survey of large-scale construction projects in the United Arab Emirates (UAE). Also, confirmatory factor analysis (CFA) and exploratory factor analysis (EFA) were used for data analysis. In conclusion, they identified and validated the top 5 causes of scope creep in projects, among which tasks or specifications and complexity or uncertainty have the highest and lowest impacts on projects, respectively.

Primarily, the authors used brainstorming and semi-structured interviews to identify the causes of scope creep based on the stakeholder management theory, which includes factors such as communication, technical complexities, specifications, and environmental uncertainties. Then, they investigated the identified factors by undertaking a survey questionnaire on 10 public construction projects in the UAE, which received 155 responses from practitioners. Hence, they identified five contributing factors to the occurrence of scope creep, such as complexity and uncertainty, tasks and specifications, risk, communication, and customers.

Project complexity and uncertainty: Ajmal et al. (2022) state that complexity is identified as one of the main causes of project failure and that it grows exponentially as construction projects get bigger. They add that despite the efforts to frame the concept of complexity, it has remained a vague concept. However, various authors have categorised complexity into six groups: environmental, socio-political, organisational, technological, infrastructural, and scope complexity (Bosch-Rekveldt et al., 2011; Nguyen et al., 2015; Ajmal et al., 2022).

Ajmal et al. (2022) mention the role of uncertainty in characterising the complexity of projects, arguing that as complexity increases, the level of uncertainty increases as well. In this regard, it is argued that sources of uncertainty can be related to cost estimation, the required time and quality of planned activities, the existence of multiple stakeholders with different objectives and motivations, and different phases of the project life cycle (Atkinson et al., 2006; Ajmal et al., 2022). According to Um and Kim (2018), when the level of project uncertainty is high, opportunism serves as an obstacle to project performance, while collaboration acts as its driver.

Tasks and specifications: According to Ajmal et al. (2022), this step aims to define, analyse, and document the main business needs of the project that will guide the specification step. These needs will then be formally documented so that they can be communicated to the relevant parties. Using the findings from projects in the software industry, Ajmal et al. (2022) explain that requirements can be categorised into functional, non-functional, and technical requirements. The functional user requirements include those addressing what the output of the project will do and what is applicable for its enhancement, while the non-functional group contains a summary of how the project must address performance and quality measures. In addition, the technical requirements are the physical implementation requirements, such as tool support and team skills (Dekker and Forseluius, 2007; Ajmal et al., 2022). Hence, it is claimed by Atkinson et al. (2006) that a lack of well-defined specifications, which sources from inefficiencies during the early stages of design and planning, can lead to adverse effects on project time, cost, and quality (Ajmal et al., 2022). Additionally, Kumari and Pillai (2014) identified other reasons behind poor project requirements and specification definition as lack of a clear organisational business strategy, lack of clear goals, inability to pursue the set goals, and lack of skills for achieving organisational goals (Ajmal et al., 2022).

Risk: It has been determined that failure to establish a proper risk assessment and planning process for foreseeing and dealing with potential events in a business environment could have detrimental effects on the entire project (Nguyen et al., 2015; Ajmal et al., 2022). Moreover, scholars claim that as a result of not integrating all stages of a project's life cycle, common risk management practices commonly fail to identify the sources of problems in the project (Tsiga et al., 2017; Ajmal et al., 2022).

Communication: Emphasising the important role of communication in project success, Ajmal et al. (2022) claim that it can also be challenging as communication is associated with human behaviour. Accordingly, scholars argue that the gap in communication between project teams and other stakeholders can result in poor definition of requirements and scope creep in projects (Phua, 2005; Bjarnason et al., 2012; Ajmal et al., 2022). Furthermore, one of the contributing factors to delays in projects is the problems in coordination between stakeholders (Mpofu et al., 2017; Ajmal et al., 2022). It is further stated that the lack of communication with stakeholders may affect the overall success of the project, as their input is neglected, and they are not regularly updated on the key developments in the project (Kumari and Pillai, 2014).

Customers (end-users): An end-user's or customer's clear understanding of the project's objectives plays a critical role in the success of a project and in ensuring that the project's requirements are comprehensive (Kumari and Pillai, 2014). Also, if stakeholder expectations and priorities are not clarified early on in the project, it can lead to a poorly defined project scope (Ajmal et al., 2022). Moreover, the insufficient involvement of end-users is identified as one of the reasons behind project failure (Ajmal et al., 2022). In addition, dominating the inputs of one or more stakeholders and omitting the inputs of others can cause an incomplete project definition (Sharma and Lutchman, 2006). Client demands or a contractor's failure to perform based on client expectations are two variables that influence project scope, resulting in scope evolution and, finally, scope creep (Dicky et al., 2011). Moreover, inadequate stakeholder engagement and failure to address their needs and expectations can lead to disputes about the execution of a project (Fageha and Aibinu, 2013; Ajmal et al., 2022).

In regards to tasks and specifications, they claim that the overlap between tasks and the variation in task requirements have a direct influence on the scope of the project. In contrast, they report that "complexity/uncertainty" has the lowest impact among the identified factors, but it is still a significant factor. In addition, they justify its low impact by explaining that, usually, project managers are aware of the complexity of construction projects and their associated issues. Moreover, they point to the importance of change management and evaluation of the impacts of any requested change to assess whether or not it is within the scope of defined project requirements.

In addition, Ajmal et al. (2022) claim that a lack of proper scope planning is the result of an unclear or incomplete scope, a lack of finalising the scope documents, and a lack of sharing the scope statement, all of which can lead to mismanaged scope. In this situation, scope creep will occur as a result of scope changes and their negative impacts on time, cost, quality, and risks in projects (Ajmal et al., 2022).

Hence, one issue with this study is that it only included public construction projects. Although these authors provide a list of contributing factors to scope creep in projects gathered from literature, their identified causes seem to be generic and mostly about the reasons behind the failure of projects and not specifically related to scope management.

2.3.2.1 The Overall Causes of Scope Creep

In order to effectively address scope creep in construction projects, it is essential to have a deep understanding of its root causes. This understanding can lead to improved organizational performance and ultimately enhance competitive advantage, as emphasized by several scholars (Martens et al., 2018; Ajmal et al., 2022). The table 7 below provides a summary of findings from a literature review on the most important causes of scope creep in construction projects, as discussed in the previous section.

Table 7 The identified causes of scope creep from the literature review

Author	Cuase of Scope Creep
Cho and Gibson (2001); Gibson and Gebken (2003);	• Poor scope definition

Sharma and Lutchman (2006)	
Fageha and Aibinu (2013)	• Change requests are the result of differentiation in stakeholders' perspectives

Moustafaev (2014)	• Scope elicitation issues
	    o Lack of communication between clients and the project team
	    o Lack of access to the higher authority
	    o The inability to see the entire project
	    o Lack of requirement prioritisation
	• Lack of skills
	    o Poorly trained requirements professionals technical and requirements experts
	    o Lack of stakeholder education
	• Project management issues
	    o Teams under pressure
	    o An excess of scope
	    o Quick de-scoping at the end of the project
	• Documentation issues
	    o Undocumented requirements
	    o Vague scope
	    o Lack of measurability
	• Scope management issues
	    o Customers having direct access to the technical people
	    o Frequent scope creep

Ye et al. (2014)	• Unclear and ambiguous project process management (Project Process Management)

	• Poor quality of construction technologies used (Contractor Field Management) • Use of poor construction materials (Contractor Field Management) • Active rework made by the contractors to improve quality (Changes for Quality Improvement) • Design error/omission because of too many design tasks and time boxing (Design Management) • Poor coordination of design team members (Design Management) • Project scope change after work had been undertaken/completed (Project Scope Management) • Lack of constructability of design solutions (Design Management) • Poor communication path of project instructions (Project Communication Management) • Lack of supervision of admission materials/equipment (Contractor Field Management)

Fageha and Aibinu (2016)	• Insufficient involvement of stakeholders
	• Changes originating from variations in stakeholders' perspectives
	• Incomplete project scope definition
	• Poor understanding of the work
	• External factors
	  ○ Price fluctuations
	  ○ Unpredictable economic cycles
	  ○ Corruption
	  ○ High levels of competition

Yap et al. (2017)	• Client-related changes ○ Extra requirements with added features

	◦ The desire to use new materials or technology ◦ Market demand or sales • Consultant-related ◦ Poor understanding of the client's requirements ◦ Design improvements through modifications • Contractor, site, and external factors ◦ Improving buildability ◦ Unforeseen ground conditions ◦ Changes in government regulations, laws, and policies
Shirazi et al. (2017)	• Poor scope definition and documentation ◦ Inexperienced experts involved in defining the scope ◦ Misinterpretation of the business needs ◦ Inadequate understanding of the client's requirements in defining the scope ◦ Unrealistic project objectives ◦ Variations in the size and level of detail in the scope statement without third-party validation ◦ Unclear definition of system boundaries • Poor change control ◦ Inadequate expertise in defining project procedures ◦ Exclusion of the project team in the procedure definition ◦ Lack of third-party verification for procedures • Poor information transformation ◦ Lack of configuration management plan. ◦ Lack of communication

	• External changes ○ Lack of risk management process
Amoatey and Anson (2017)	• Client changes • Unanticipated risks • Unclear scope • New laws • New insight • New technologies • New economic situation
Yu et al. (2019)	• Faulty precast components • Mistakes by workers • Ineffective quality inspection and testing • Stakeholders influence, particularly contractors
Ajmal et al. (2020)	• Poor communication • Risk • Technicality • Project complexity • Tasks • Customer change requests • Environment • Uncertainty

Ajmal et al. (2022)	• Complexity and uncertainty
	  ○ Environmental
	  ○ Socio-political

- Organisational
- Technological
- Infrastructural
- Scope complexity

- Tasks and specifications
- Risk
- Communication
- Customers

Several authors (Cho and Gibson, 2001; Gibson and Gebken, 2003; Sharma and Lutchman, 2006; Shirazi et al., 2017; Fageha and Aibinu, 2016) mention poor scope definition as a cause of scope creep. This refers to the inadequate or unclear definition of project boundaries, objectives, and deliverables, leading to ambiguity and confusion during the project execution, which may result in scope creep.

Fageha and Aibinu (2013) and Fageha and Aibinu (2016) both point out that changes in stakeholder perspectives can cause scope creep. This can occur when stakeholders have different expectations or views about the project, leading to disagreements and additional requirements that were not initially included in the project scope.

Moustafaev (2014) and Ajmal et al. (2020) both highlight various project management issues as contributing factors to scope creep. These issues can include ineffective communication, poor risk management, lack of proper oversight, and unaddressed complexities in the project.

Moustafaev (2014), Shirazi et al. (2017), Ye et al. (2014), and Ajmal et al. (2020, 2022) all emphasize the role of poor communication as a cause of scope creep. Ineffective communication among project stakeholders, such as clients, project managers, designers, and contractors, can lead to misunderstandings, incorrect interpretations of requirements, and ultimately, scope creep.

Yap et al. (2017) and Amoatey and Anson (2017) both mention client-related changes as a cause of scope creep. These changes can arise from clients adding extra requirements, desiring to use new materials or technologies, or reacting to market demands. Such changes may not have been initially planned or accounted for in the project scope, leading to scope creep.

Fageha and Aibinu (2016) and Ajmal et al. (2022) both discuss the impact of external factors on scope creep. These factors can include changes in economic conditions, laws and regulations, technology, and other environmental or socio-political factors that were not anticipated during the project planning stage. These external factors can force the project to adapt and change its scope, leading to scope creep.

2.3.3 Scope Management Tools and Techniques

Through reviewing previous works published in scientific journals, several tools and techniques for better management of scope in projects are identified. The main aim in this stage is to identify the most reliable, valid, and comprehensive tools, to analyze and synthesize their most relevant steps and processes that meet current research criteria for the development of a new practical framework. A selection of these tools is presented in Table 8.

Olsson (2015) conducted a research to investigate the management of possible reductions of railway infrastructure investment projects. For doing this, the author considered the reduction lists of Norwegian ministry of finances which is part of their quality assurance program (QA) for large government investment projects from defense to railway, transport building and IT projects. Olsson (2015) discusses that the QA program came to picture as a response to cost overruns in public projects like railway projects which incorporates a quality-at-entry regime by assigning pre-qualified external consultants to carry out quality assurance of projects including evaluation of potential scope reductions. The author explains that the QA scheme contains two external reviews during the planning process such as QA1 which covers choice of concept before starting the pre-project by the Cabinet and QA2 which reviews the cost estimates and project maturity before submission of project to the parliament for funding and approval. Pre-qualified consultants review the cost estimates and to avoid cost overruns provide recommendations on two types of measures such as reduction lists and project contingencies. The QA advisors provide cost estimates with related probabilities and a size of project contingency. Additionally, they review the feasibility of potential reductions which may be undertaken if other parts of project turn out to be more costly than planned and provide a list of potential reductions. Thus, the reduction lists contain parts of project scope that can be taken out if required which do not jeopardize the basic functionality of the project. The reductions and calculated potential cost reductions are described in a QA2 report together with due dates for resolution of various reductions to realise the cost savings. In continue, Olsson (2015) argues that value engineering approach has similarities with the logic behind the reduction lists as it reduces costs and improves the value of construction projects taking out the functionality which is not essential for achieving the core functionality. Another similar approach to reduction lists, is the target cost contracts (TCC) in which the scope of project is adjusted by the agreements between the contractor and client and results in shared incentives for both parties. Also, the design-to-cost approach is a continuous process which shares similar features with reduction lists but these approaches are not based on predefined reduction lists. In conclusion, the author claims that from the investigated case studies, the reduction lists represented only between 1.6% to 4% of the project budget and these reductions only get partially performed (Olsson, 2015). Albeit, the findings showed that additional saving can be obtained by implementing scope reductions not listed in the reduction lists but still it only amounts to 4.2% of the budget. This is lower than the savings reported from using value engineering technique (30% of project cost, 10% of project budget) in other studies. However, Olsson (2015) claims that efficient project implementation requires sufficient level of project maturity and therefore, the size of saving depends on maturity and time of review. Thus, larger amount of savings may be an indication of low project maturity. Besides, Olsson (2015) discusses the issues with reduction lists such as affecting the quality and functionality of deliverables, decision makings about reductions in early stages when the cost overrun is not occurred and representing a relatively small amount of budget. Additionally, projects usually take into consideration working on optimisation of involved elements regardless of reduction lists. But Olsson (2015) mentions that reduction lists are still helpful in reducing cost overruns and contribute to cost-consciousness. Although, Olsson (2015) argues that reduction lists are one sided towards reductions and focusing on opportunities and improvements is one alternative approach. Also, further studies are needed to investigate using reduction lists in other types of projects. Furthermore, Olsson (2015) claims that reductions need full support of relevant stakeholders and must be contractually and technically possible to execute in late phases of the project and identifying potential reductions in early stages is a difficult task which cannot replace the contingencies as a method and instrument for controlling cost. As the author mentioned, the access was provided to only one of case study projects' detailed reductions made using reduction list and such information was not available for other six projects in this case study and this hinders the reliability and validity of their research. Although the reduction lists provide a gateway at the time of trouble for the project, but it seems that the downside of this method is missing potential opportunities and reduced quality of project deliverables. Besides, further studies are needed to test the findings within UK construction industry.

Table 8 Tools and techniques for scope management.

Author	Name of Tool/ Method/ Technique	Definition
Kamara et al. (2000)	- The Client Requirements Processing Model	Describes a process model for processing client requirements, which was developed in response to the need for an appropriate framework for client requirements processing in construction. The model, which is represented using the IDEF-0 modelling method. Four diagrams are specified in the node index: the context diagram, the define client requirements diagram; the analyse client requirements diagram; and the translate client requirements.
Delgado-Hernandez et al. (2007)	- Quality Function Deployment (QFD) - House Of Quality (HOQ)	Is a system for translating customer requirements (government regulations, operating conditions and buyer expectations) into suiTable technical characteristics and ensuring that important ones are prioritized in the design.
T.W. et al. (2010)	- Value Management Framework	Is established by identifying the problems related to the project briefing process. The main purpose of this framework is to facilitate the systematic identification and clarification of client requirements.
CII (2013)	- Project Definition Rating Index (PDRI)	In order to address the issue of the poor project definition. The definition completeness can be evaluated by using this tool.
Olsson (2015)	- Scope Reduction List - Value Engineering	The reduction lists consist of scope reductions that are not desirable, but that can be implemented if there is a risk of cost overrun.

2.4 Stakeholder Management

Bourne and Walker (2005) point out that prior to the definition of stakeholders' requirements or impacts achieving the understanding of what the term 'Stake' really means to the stakeholders may be necessary. Hence, Carroll and Buchholtz (2000)determined three definitions of stake which consider it as an interest, right, or ownership. Some of the project stakeholders will have ownership when they possess a legal title to a property or an asset like shareholders of an organization; many will have a right which can be a moral right or a legal claim to be treated in a certain way like disable people or citizens with the right of privacy, and most of them will have an interest which is a situation where individuals or groups are affected by a decision. Accordingly, Bourne and Walker (2006) defined the stakeholder for the purpose of researching in the area of relationships as 'individuals or groups who have an interest or some aspect of rights or ownership in the project, and can contribute to, or be impacted by, the outcomes of the project'. Also, Olander (2007) describes a project stakeholder as a person or group of people who have a vested interest in the success of a project and the environment within which the project operates. There are essentially two categories of stakeholder: external stakeholders who comprise groups or individuals affected by the project (e.g. local authorities, the general public, neighbours, local community), and the internal stakeholders who are mandated with the task of executing the project (e.g. suppliers, employees, costumers, owners) (PMI, 2017). However, other scholars have introduced different categories of stakeholders as well. Briner et al. (1996) classified stakeholders into four groups of project leader's organisation, client, invisible team members, and outside services.

2.4.1Stakeholder Management Methodologies

PMI (2017) defines stakeholder management as a process for identifying individuals or groups who could impact or be impacted by the project, analyzing their expectations and impact and developing appropriate strategies for engaging them in project decisions and execution. A selection of methodologies for identifying and managing stakeholders developed by government bodies, companies, individuals, and universities is presented in Table 9. In summary, it can be concluded that stakeholder identification, analysis, strategy development, and performance control are four essential and mutual steps among these procedures and the aforementioned areas of stakeholder management studies.

Table 9 Selection of methodologies, processes and approaches for stakeholder management (Yanga et al., 2011).

Authors	Process Models and Approaches
Cleland (1997)	Four stakeholder management steps:

	-Stakeholder identification, classification, analysis and strategy development
Savage et al. (1991)	Definition of categories of stakeholders: -Four generic types — supportive, mixed blessing, no-supportive, marginal
Briner, Hastings and Geddes (1996)	Stakeholder identification, assessment, and engagement: -Focus on communication as an important part of stakeholder management
Mitchell, Agle and Wood (1997b)	Definition of categories of stakeholders: -Eight-part stakeholder typology based on assessments of the strengths of three attributes of power, legitimacy, and urgency
Rowley (1997)	Social network analysis (SNA): -Considering structural characteristics of the stakeholder network and the interactions among multiple stakeholders
Cleland (1999)	-Identify stakeholders and their interest, measure this interest, attempt to predict stakeholder's future behavior and its impact on the project and project team
Jergeas et al. (2000)	Stakeholder management activities: -education, communication, mitigation and compensation
McElroy and Mills (2000)	-Stakeholder classification model: Considers stakeholder attitude towards a project by distinguishing whether a stakeholder is an advocate or adversary of the project in five levels of "active opposition", "passive opposition", "not committed", "passive support" and "active support"
Veil and Turner (2002)	-A more holistic process of identification, assessment of awareness, support, influence, culminating in the development of a stakeholder knowledge base
Karlsen (2002)	-Identification of stakeholders, analyzing the characteristics of stakeholders, communicating and sharing information with stakeholders, developing strategies, and following up.
Elias, Cavana and Jackson (2002)	-Developing a stakeholder map of the project, preparing a chart of specific stakeholders, identifying the stakes of stakeholders, preparing a power versus stake grid, conducting a process level stakeholder analysis, conducting a transactional level stakeholder analysis, determining the stakeholder management capability of the R&D projects, analysing the dynamics of stakeholder interactions.

Fletcher et al. (2003)	-A process for mapping stakeholder expectations based on value hierarchies and key performance areas (KPA) -An analysis of ways organizations can plan their stakeholder management strategies, rather than response strategies
Bourne and Walker (2005)	- Stakeholder Circle Visualisation: -Continual process for identification, prioritization, engagement strategy for developing long-term relationships
Young (2016)	-Identifying stakeholders; gathering information about stakeholders; analysing the influence of stakeholders.
Olander (2006)**adopted** Cleland (1999)	-Identification of stakeholders, Gathering information on stakeholders, Identifying stakeholder mission, Determining stakeholder strengths and weaknesses, Identifying stakeholder strategy, Predicting stakeholder behaviour, Implementing stakeholder management strategy.
Bourne and Walker (2008)	-Identifying stakeholder, Prioritizing stakeholders, Visualizing stakeholders, Engaging stakeholders, Monitoring the effectiveness of communication.
Jepsen and Eskerod (2009)	-Identification of the (important) stakeholders, characterization of the stakeholders pointing out their (a) needed contributions, (b) expectations concerning rewards for contributions, (c) power in relation to the project; the decision about which strategy to use to influence each stakeholder.
Project Management Institute (2017)	-Identify stakeholders, Plan stakeholder engagement, Manage stakeholder engagement, Monitor stakeholder engagement.

Despite the extensive works done by the authors, some of these methodologies suffer from a lack of consistency and neglecting stakeholders' interrelationships and social networks as evaluation of individual stakeholders is insufficient to add value to projects. Also, the absence of performance control in Cleland (1997) and lack of classifying stakeholders in Karlsen (2002) models show these processes and models are not entirely consistent. In another example, the weakness of the Stakeholder Circle Tool (Bourne and Walker, 2005) is that although it recommends consideration of the level of stakeholders' interest and support, but it does not visualise the stakeholder attitude or reflect how they perceive the project in terms of negatively or positively. On the other hand, stakeholder management processes are unsatisfactory as they are characterized by spontaneity and casual actions (Smyth and Pryke, 2006). Furthermore, the fragmented and informal process is insufficient to manage the complicated interfaces involved in major construction projects. Consequently, there is a serious need for developing and synthesizing a formal process model for stakeholder management. Also, the plurality and diversity of available methods for stakeholder analysis may lead to confusion of project managers. Another issue in contemporary stakeholder research is putting abstract research philosophy into project management practice. In this regard, scholars (Wei-Skillern, 2004; Agle *et al.*, 2008) point out that stakeholder theory is not fully integrated into project management practice and developed approaches in this area cannot be easily comprehended by construction practitioners. Therefore, this is the point where this study can help to obtain such understanding by investigating the stakeholder influence on the scope of projects and how BIM can bring forth a solution for that. Accordingly, the majority of processes and approaches presented in Table 9 consider stakeholders and relevant approaches in a generic way. Therefore, the effort will be made in this research to address the aforementioned issues and weaknesses by developing a comprehensive, integrated, and consistent 'practical framework' in which stakeholder theory is tied up to other project management processes like scope, communication and risk management and by specifying the purpose of using stakeholder theory and approaches during construction management implementation.

2.4.2Stakeholder Management Challenges

Some of the most important challenges which stakeholder management confronts during complex construction projects are gathered and presented in Table 10. In summary, the challenges of stakeholder management presented in Table 10 can be categorised as :

- Stakeholder identification and prioritisation
- Stakeholder involvement and engagement
- Stakeholder impacts
- Coordination and collaboration of stakeholders

Analysis and management of different needs and concerns of stakeholders are one of the most problematic challenges for project managers in the construction sector, as stakeholder groups possess a natural inclination to influence the execution of projects caused by their individual needs and concerns (Olander and Landin, 2005). So, the implementation of construction projects can be severely obstructed by a negative tendency of stakeholders and this would result in delays and cost overruns caused by controversies and conflicts about project implementation and design (Olander and Landin, 2005). Therefore, identifying the valid and legitimate needs of stakeholders and understanding their influence and power is crucial for managing stakeholders' potential impact on projects.

Then, any negative influence of stakeholders can be minimized while the positive ones will be maximized through formulating and approving suitable strategies.

Empirical studies reveal that conflicts involving project managers and external stakeholders arise mostly from the difference in the perceptions of these two players (Olander and Landin, 2005; Aaltonen and Sivonen, 2009). Failure to acknowledge the concerns of the various external stakeholders breeds a relationship filled with distrust. Project managers should, therefore, conduct a stakeholder analysis to identify possible trade-offs between developers and the various stakeholder without compromising the objective and purpose of the construction project. Therefore, an effective stakeholder analysis should be able to determine the extent to which various concerns and needs of the external stakeholders can be assimilated into the project. However, finding a suitable trade-off that ensures that all the stakeholder's concerns and needs are satisfied is very challenging (Aaltonen, Jaakko and Tuomas, 2008). In addition, the impacts of stakeholders on the project should be evaluated in terms of their interest and power to impose their influence. So, appropriate strategies and responses can be developed to reduce their negative influence and increase their engagement and positive impact. Hence, in this research, it will be tried to propose a holistic solution for these challenges together with improving collaboration among stakeholders by using Building Information Modelling (BIM) guidelines and through developing a process framework which will be discussed in the following sections and chapters.

Table 10 Stakeholder management challenges in construction projects.

Authors	Challenges
Jepsen and Eskerod (2009)	-Ambiguous instructions in stakeholder prioritization and insufficient inquiring skills
Yang et al. (2011)	-Challenges in the processes of identifying stakeholder and their needs -Assessing stakeholder impacts and their relationships -Formulating appropriate engagement strategies
Mok, Shen and Yang (2015)	-Decreased accuracy of assessment and judgment of project managers as the project grows in size and complexity -Lack of strong foundation for stakeholder identification and prioritization

	-limited cognition of project managers and incomplete stakeholder boundary
Yeo (1995)	-Complex stakeholder interrelationships and conflicting interests -The dynamics and growing capacity leading to high project uncertainty -High public attention and controversies
Timothy and Karen (2010)	-Late involvement of major stakeholders -Discrepancy in their relationship intentions
Emuze and Smallwood (2011)	-Inadequate skills of public sector departments in collaborating with stakeholders
Jha and Iyer (2006)	-Conflict, indecisiveness and inadequate coordination of project stakeholders

2.4.3 Stakeholder Influence Strategies

The literature review provides a comprehensive overview of stakeholder management research in major construction projects. The research can be grouped into four main areas: (1) stakeholder interests and influences, (2) stakeholder management process, (3) stakeholder analysis methods, and (4) stakeholder engagement. While there has been significant research on stakeholder management processes and a recent growth in interest in stakeholder engagement, the focus on stakeholders' interests and influences has been limited.

The behaviour of stakeholders has been a key area of study, with many researchers identifying the various mechanisms through which stakeholders shape their salience or influence construction organizations. The factors affecting the selection of influence strategies by stakeholders have also been analysed in various scholarly texts. Frooman (1999) introduced the concept of stakeholder influence strategies as the means by which stakeholders achieve their goals and objectives. He further explained that each stakeholder would choose a different strategy based on the nature of the resource relationship between the firm and the stakeholder. Frooman (1999) identified four types of influence strategies that stakeholders typically employ based on the resource relationships: direct and indirect withholding and direct and indirect usage.

It is important to note that effective stakeholder management is critical for the success of construction projects. A comprehensive understanding of stakeholders' interests and influences, as well as effective stakeholder management processes and engagement strategies, can help construction organizations to mitigate potential risks and enhance project outcomes.

This scholarly discourse delves into stakeholder management research in major construction projects, highlighting the various stakeholder influence strategies and the contextual factors that influence the choice of these strategies. The research can be categorized into four areas, namely stakeholder interests and influences, stakeholder management process, stakeholder analysis methods, and stakeholder engagement.

Stakeholder influence strategies are classified into two categories, withholding and usage strategies. Withholding strategies are employed by stakeholders to stop providing certain resources to a company to change its stance towards a particular issue. For example, workers can use strikes to demand better wages. On the other hand, usage strategies involve continuing to provide resources to the firm but with certain constraints attached to the supply terms. These strategies can be applied either directly by overtly manipulating the supply of resources to the company or indirectly using another person to achieve the same goal (Frooman, 1999).

Frooman (1999) identified four stakeholder influence strategies, namely direct and indirect withholding, and direct and indirect usage. Hendry (2005) empirically tested and confirmed these four strategies and added communication as a strategy that is vital in influencing organizational behavior. She also identified other techniques that stakeholders use, such as stakeholder litigation, lobbying, boycotts, blockades, stakeholder allying, letter-writing campaigns, and dialogue with multi-stakeholders.

Hendry (2005) identified three determinants that influence the selection of each of the strategies, namely the opportunity available for a particular strategy, expertise or personal experience with a strategy, and the possibility of an alliance in support of a particular strategy. Aaltonen and Kujala (2010) also identified two project-specific characteristics, namely the uniqueness of the project and irreversibility of decision-making, as factors that influence stakeholder salience (prioritization of stakeholder requests in the decision-making process) and capability of stakeholders for mobilizing and using different influence strategies.

Contextual factors play a crucial role in the choice and ability of secondary stakeholders to apply various influence strategies. For instance, a secondary stakeholder who does not have influence attached to any resource may exploit other avenues such as acting through an ally or any other indirect strategies with the power of influencing the focal project. Using the resource dependence theory, Frooman (1999) outlined the various reasons that determine the choice of influence strategy. The theory suggests that the behavior of firms is affected externally since the focal company must review the demands of stakeholders who provide essential resources. Therefore, the type of path chosen is determined by the level of the firm's dependence. Firms also engage more with stakeholders who have valuable resources. As a result, the stakeholders will prefer indirect strategies to pressure the firms to agree to their demands. Secondly, the level of the stakeholder's dependence determines the type of the chosen resource control. An increase in the degree of dependence of the focal firm makes them heavily reliant on its resource providers. As a result, the stakeholder will rely on usage strategies.

Aaltonen and Kujala (2010) conducted a case-study based research to enhance the understanding of how opposing secondary stakeholders can take action and influence decision-making during a project's lifecycle. The researchers built upon Mitchell et al.'s (1997) work, which asserts that stakeholders' ability to influence project decision-making is determined by their salience. However, Aaltonen and Kujala (2010) note that stakeholder salience is not fixed throughout all project phases, and project characteristics can impact the salience of secondary stakeholders and their influence on project management decision-making. Furthermore, the researchers argue that secondary stakeholders may utilize different influence strategies and engage in various activities to increase the likelihood of their claims being considered by decision-makers. In this regard, the researchers conducted a comprehensive literature review to identify and summarize the various stakeholder influence strategies in the project context, which are presented in Table 11.

Table 11 Summary of stakeholders' strategies (Aaltonen and Kujala, 2010).

Stakeholder Strategy	Description
Direct usage or withholding strategy	A strategy whereby stakeholders, internal and business-related, such as subcontractors, government or financiers agencies prevent the project from using crucial resources which they control for example governments refusing to grant permits.
Indirect usage or withholding strategy	These strategies are common among secondary stakeholders to influence the ability of the project to access resources that are controlled by other business-related stakeholders. The strategy of indirect usage has the secondary stakeholder imposing additional restrictions for the use of resources.

Resource building strategy	Here, business-related stakeholders access essential resources to the implementation of the project. Also, secondary stakeholders gain access to crucial material and non-material resources such as labour, computers, consensus, leadership, and moral engagement. Given that each project is unique, stakeholders normally do not have access to adequate resources at the early stages of the project implementation.
Coalition building strategy	The strategy involves the stakeholders trying to obtain an advantageous position in the network of the project by forming alliances with other stakeholders of the project.
Conflict escalation strategy	The strategy is employed by stakeholders in an attempt to partner with other ones in a particular conflict so as to increase the project management salience to their claims. In some cases, the stakeholders escalate the conflict beyond its initial direction. For instance, making the conflict a political affair and using the projects as political battlegrounds.
Communication and credibility building strategy	The strategy involves the stakeholders trying to legitimize their claims by making use of the various forms of media to communicate the legitimacy of their claims and in the process also acquire resources.
Direct action strategy	The strategy involves the organization of boycotts, protests, road blockades and demonstrations by the various stakeholder groups.

Aaltonen and Kujala (2010) note that the project lifecycle is comprised of three main phases: investment preparation, project execution, and operation. They argue that each of these phases affects the possibility of stakeholders engaging in influence activities and the management's willingness to respond to their claims. Their research findings suggest that although the salience of secondary stakeholders is highest during the investment preparation phase and they have the best opportunity to influence decision-making, in practice, the temporary and unique nature of projects may limit their ability to act and use influence strategies during the early stages. In other words, while early-stage influence may be most acceptable from a project management perspective, there is a low likelihood of secondary stakeholders taking action and expressing their opinions.

Furthermore, Aaltonen and Kujala (2010) found that the salience of secondary stakeholders decreases as the project moves from the investment preparation phase into the project execution phase, while the probability of secondary stakeholders using influence strategies increases as the project progresses. This mismatch in timing between the possibility and capability to influence can lead to conflict escalation during the execution phase.

Despite being a noteworthy contribution to this field, the researchers suggest the need for further investigation into the influence of stakeholders in multiple projects, particularly the salience and influence of other types of stakeholders, including internal stakeholders. Such studies would contribute to a more comprehensive understanding of stakeholder dynamics in project management and help project managers better anticipate and manage stakeholder conflicts throughout the project's lifecycle.

2.4.4 Available Solutions and Strategies for Addressing Scope Creep and Responding to Stakeholder Influence

Scope creep and stakeholder influence are critical challenges that project managers face throughout a project's lifecycle. Fortunately, several available solutions and strategies can help project managers address scope creep and respond effectively to stakeholder influence. One of the most important solutions is establishing a robust change management process. A well-designed change management process can help project managers identify and respond to scope creep and stakeholder influence promptly. This process should include a formal procedure for reviewing and approving scope changes, as well as a clear communication plan to keep stakeholders informed of any changes. Additionally, project managers can use tools such as a scope management plan and a change control log to keep track of scope changes and ensure they align with the project's goals and objectives (PMI, 2017).

Another effective strategy is stakeholder management. Project managers should identify all stakeholders and assess their level of influence and interest in the project. Then, they can develop a stakeholder management plan to ensure that all stakeholders' concerns are heard and addressed. This plan should include regular communication with stakeholders, as well as a process for escalating issues to senior management as needed. Furthermore, project managers can implement agile methodologies, which prioritize flexibility and adaptability. By using agile methodologies, project managers can respond to changes quickly and efficiently, reducing the risk of scope creep and stakeholder influence. Agile methodologies also emphasize collaboration and communication, which can help foster positive stakeholder relationships and improve project outcomes.

Finally, project managers can leverage risk management strategies to identify potential scope creep and stakeholder influence risks early on. By identifying potential risks, project managers can develop proactive mitigation strategies and contingency plans to minimize the impact of these risks on the project.

2.4.5 Uncertainty, Risk and Defence System of the Firm

In this research, scope creep is taken into account as uncertainty caused by stakeholders, which may result in risks affecting project objectives. In the next section, the fundamental concepts of uncertainty and risk are discussed together with the available strategies for the firms in responding to the stakeholders' risks and influence strategies.

2.4.5.1 Uncertainty and Risk in Projects

Any type of project may suffer or benefit from the negative or positive effects of uncertainty. Traditionally, most project managers still pay too much attention to conformance with time, budget, and scope limitations instead of reflective learning, costumer centric thinking and continues improvement; this results in the project becoming less flexible and unable to gather experience and knowledge for dealing with uncertainty (Perminova, Gustafsson and Wikström, 2008). The origin of risks is uncertainty which exists in different degrees in all projects. PMI (2017) has defined risk as ‘‘an uncertain event or condition that, if occurs, has a positive or a negative effect on at least one project objective, such as time, cost, scope, or quality’’. Perminova, Gustafsson and Wikström (2008) state that although PMI (2017) used the concept of uncertainty to describe risk, but it does not provide any definition of "uncertainty" as a term. In this regard, they explain that according to this definition it can be concluded that risk is uncertainty, while these two terms are not synonyms. Hence, the authors have depicted them as "cause" and "consequences". The main reason for distinguishing risk from uncertainty is the importance of explanation of their influence on the project performance. Scholars in the area of risk management believe that unlike common perception about the negative impact of uncertainty on outcomes and objective of projects, it can bring unique opportunities into the project (Ward and Chapman, 2003). Therefore, in contrast with the traditional view, risk is appreciated as one of the implications of uncertainty. Hence, Jaafari (2001) has defined uncertainty as "the probability that the objective function will not reach its planned target value or an unknown probability of an event's occurrence". Considering this viewpoint, there is a close relationship between uncertainty and the measures for project performance like time, budget, quality, and scope (Perminova, Gustafsson and Wikström, 2008). Consequently, to emphasise on dual nature of uncertainty, it can be defined as opportunities in form of events having a positive impact on project performance or events which can exert a negative impact on the outcomes of projects. But one may ask what is the purpose of conducting such discussion for the current research? As it is obvious, construction projects can not exist in a vacuum and they are always changing from inception to execution. Therefore, changes in construction projects are inevitable including the changes in the scope of projects. But the important point in this regard is that not all of the scope changes result in scope creep or risk, in fact, some changes in the scope of construction projects may result in not only increased quality but also they may reduce time or the costs of project delivery. The subtle point is adjusting plans, evaluating impacts and engaging stakeholders in a way that these deviations from scope deliver maximum benefits while their negative impacts are reduced. Hence, deviation from scope can be deemed as uncertainty which may cause positive impacts or risk and negative impacts in construction projects.

Several scholars like Perminova, Gustafsson and Wikström (2008) believe that unlike risks and certainties, uncertainties can be managed in the same way. Although tools like planning, monitoring, and controlling from traditional risk management perspective are successful in preventing risks, but these are not sufficient for managing uncertainties as it has been defined encompassing risks and opportunities both together. On the other hand, another weakness with traditional risk management tools is the existence of a gap between monitoring and controlling tools that aim to reflect the past and risk analysis and planning for grasping the future (Nikander and Eloranta, 1997). However, the tools and procedures of risk management for predicting the future are not iterative and will not be applied at each and every stage of the project; conversely, they are deemed as a life cycle process. Besides, methods related to controlling as a source of historical data, indicate that the problem has already happened and even precautionary methods will not be effective in removing them. Consequently, the aforementioned issues will result in the organisation losing its flexibility in responding to various issues and problems.

Ward and Chapman (2003) state the main reason for applying uncertainty management in large-scale projects is concerns regarding logistics and design issues. However, objectives and relationships between key stakeholders, especially internal stakeholders and within the project owner organisation are causes of the most important issues.

Also, where the fundamental aspects of the project are controlled by more than one organization like multi owned projects such as joint ventures or intergovernmental projects, the particular challenge or key issues are governance arrangements and allocating risks and rewards in the way that incentives for cooperative behaviour will be created and maintained (Millar, 2007).

Crawford, Pollack and England (2006) developed a seven-dimensional hard-soft framework as it will be useful to investigate the features and characteristics of projects in terms of hard or soft features where uncertainty management is being applied for the first time. Table 12 presents a summary of this framework. In this framework, higher levels of ambiguity and uncertainty will be indicated by projects with softer attributes and this increases the role and importance of stakeholders as they are the main contributors to uncertainty in projects. Linked confusion, poor understanding by different stakeholders, conflicting and multiple interpretations and excessive optimistic interpretations regarding problems and project outcomes are the implications of this uncertainty and ambiguity. In the authors’ opinion, ongoing sense-making, exchanging views between stakeholders and clarifying situations and issues are the essential efforts warranted for managing such ambiguity and uncertainty.

Table 12 Hard and Soft projects (Crawford and Pollack, 2006).

‘Hard’ end of dimension: completely ‘hard’ features	Attribute dimension	‘Soft’ end of dimension: completely ‘soft’ features
- Clearly defined	- Goal clarity	- Highly ambiguous
- Physical artefact	- Goal tangibility	- Abstract concept
- Owned only caught quantitative	- Success measures	- Only qualitative
- No external influences	- Permeability of project boundary	- Many external influences
- Refinement of a single solution	- Number of solution options	- Exploration of many alternatives
- Experts’ involvement, little stakeholder Participation	- Participation and practitioner role	- Facilitated practitioners and high stakeholder participation
- Concern for technical performance, efficiency, control	- Stakeholder expectations	- Concern for relationships, culture,
		- management by negotiation and discussion

Also, Ward and Chapman (2008b) believe that stakeholders are major sources of uncertainty in projects. Uncertainty related to the stakeholders includes the identification of relevant stakeholders, how they can exert their influence on the project at any stage, their motives in accordance with the project and the implication of stakeholders’ relationships. They created a generic risk management process framework in order to provide structure to place different methods of stakeholder identification and management in an inclusive framework that connects all sources of uncertainty in a systematic way. This process framework is called SHAMPU (shape, harness and manage project uncertainty) and encompasses 9 phases(Ward and Chapman, 2003). Table 13 presents these nine phases together with a brief description of each phase. Despite its useful general structure for managing uncertainty, Ward and Chapman (2003) do not provide any solutions for dealing with the uncertainties or the analysis of the origins of occurred issues.

Table 13 The shape, harness and manage project uncertainty (SHAMPU) process (Chapman And Ward, 2003).

Phases	Purposes and Tasks in Outline
Define the Project	Consolidate relevant existing information about the project at a strategic level in a holistic and integrated structure suitable for risk management. Fill in any gaps uncovered in the consolidation process, and resolve any inconsistencies.
Focus the Process	Scope and provide a strategic plan for the risk management process. Plan the process at an operational level.
Identify the Issues	Identify sources of uncertainty at a strategic level in terms of opportunities and threats. Identify what might be done about it, in terms of proactive and reactive responses. Identify secondary sources of uncertainty associated with responses.
Structure the Issues	Complete the structuring of earlier phases. Test simplifying assumptions. Provide more complex or alternative structures when appropriate.
Clarify Ownership	Allocate both financial and managerial responsibility for issues (separately if appropriate).
Estimate Variability	Size uncertainty is usefully quantified on a first pass. On later passes, refine earlier estimates of uncertainty where this is effective and efficient.
Evaluate Implications	Assess statistical dependence (dependence not modelled in a causal structure). Synthesize the results of the Estimate phase using dependence assumptions that are fit for purpose. Interpret the results in the context of all earlier phases. Make decisions about proactive and reactive responses, and about refining and redefining earlier analysis, managing the iterative nature of the process as a key aspect of these tasks.
Harness the Plans	Obtain approval for strategic plans shaped by earlier phases. Prepare detailed action plans. These are base plans (incorporating preventative responses) and contingency plans (incorporating reactive responses with trigger points) ready for implementation within the action horizons defined by appropriate lead times. Commit to project plans which are fit for implementation.
Manage Implementation	Manage the planned work. Develop action plans for implementation on a rolling basis. Monitor and control (make decisions to refine or redefine project plans as required). Deal with crises (unanticipated issues of significance) and be prepared to cope appropriately with disasters (crises that are not controlled).

PMI (2017) defined the risk management as "…the processes of conducting risk management planning, identification, analysis, response planning, response implementation, and monitoring risk on a project." The aims of managing project risks are to enhance the likelihood and/or consequence of favorable risks and to diminish the likelihood and/or consequence of unfavorable risks, with the purpose of maximizing the likelihood of project accomplishment (PMI, 2017). Accoording to PMBOK GUIDE (PMI, 2017), the risk management processes include plan risk management, identify risks, perform qualitative risk analysis, perform quantitative risk analysis, plan risk responses, implement risk responses, and monitor risks. Accordingly, the plan risk management process includes specifying how to execute risk management activities in a project. The "identify risks" process is identification of particular project risks, origins of total project risk, and documentation of their attributes. Also, the PMBOK GUIDE (PMI, 2017) defines "perform qualitative risk analysis" as prioritizing particular project risks for further study or action by evaluating their likelihood of occurrence, effect, and other factors. In addition, "perform quantitative risk analysis" involves analyzing quantitatively the aggregate impact of recognised individual project risks and other sources of uncertainty on the overall project goals. Also, "plan risk responses" is the process of generating alternatives, choosing strategies, and reaching consensus on actions to manage both the general risk exposure of the project and individual project risks. According to PMI (2017), "implement risk responses" includes the process of executing risk response strategies that have been agreed upon. Finally, "monitor risks" refers to the activity of overseeing the execution of previously agreed-upon strategies for mitigating risk, as well as tracking and assessing any newly identified risks, and evaluating the efficacy of the risk management process throughout the project's duration. The overall process of risk management and its outputs are captured according to PMBOK GUIDE (PMI, 2017) processes and guidelines in the Figure 4.

2.4.5.2 Other Organisational Response Strategies, Tools and Techniques

Also, projects managers have various options for responding to the pressure from stakeholders. Current literature on stakeholders' influence provides different types of shaping schemes and engagement models such as the power/interest matrix (Olander and Landin, 2005) which provides guidelines on whether the project manager should consider the claims of a certain group of stakeholders or ignore it. This tool is presented in Figure 5. The power/interest matrix depicts that the project manager should respond to stakeholder's demands only if they have the power to advance their interests. Most of the current literature shows that the majority of project systems nowadays are proactive towards influence and pressure from external stakeholders (Aaltonen and Sivonen, 2009).

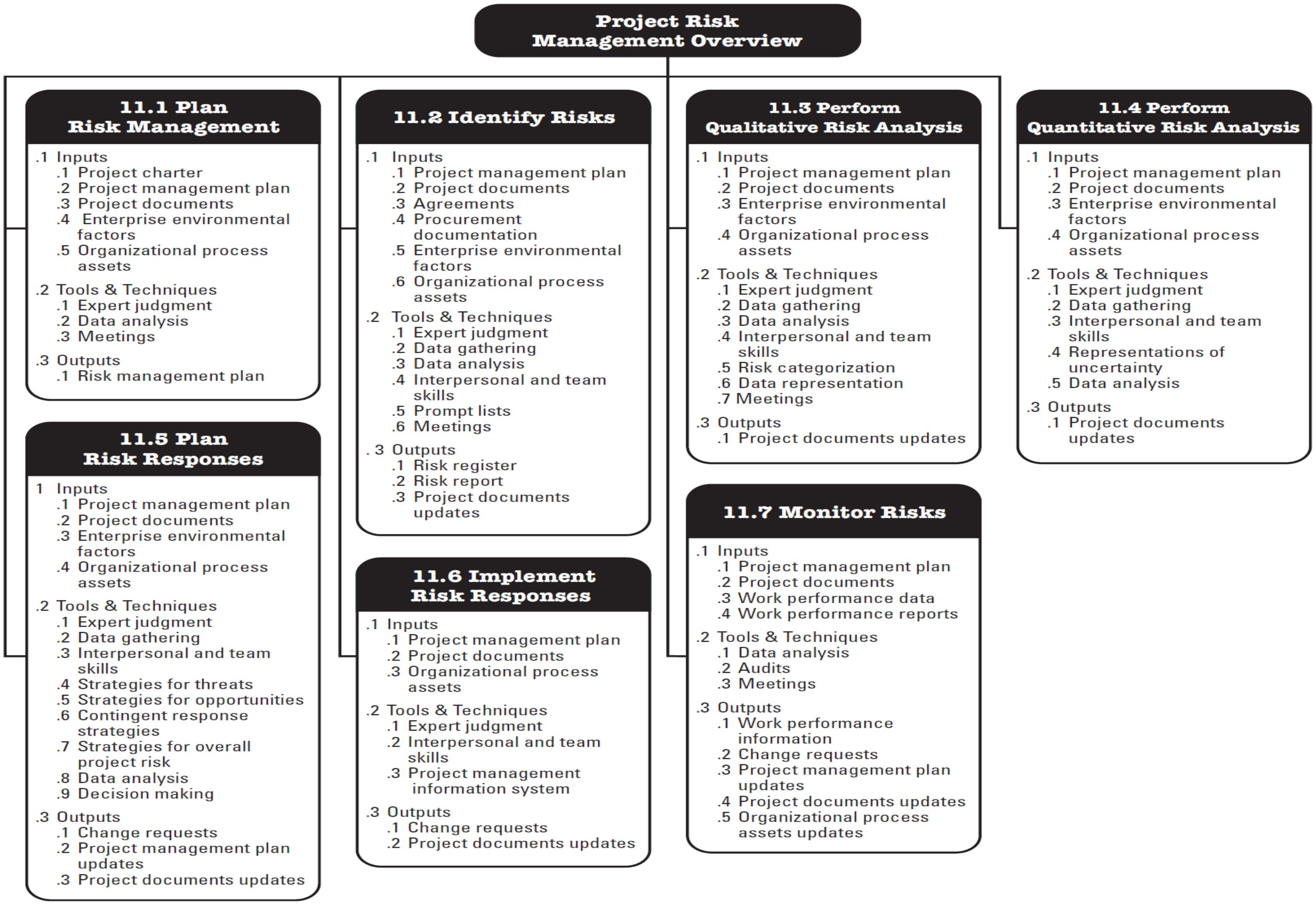

Figure 4 Overal risk management process captured from PMI(2017, p.396).

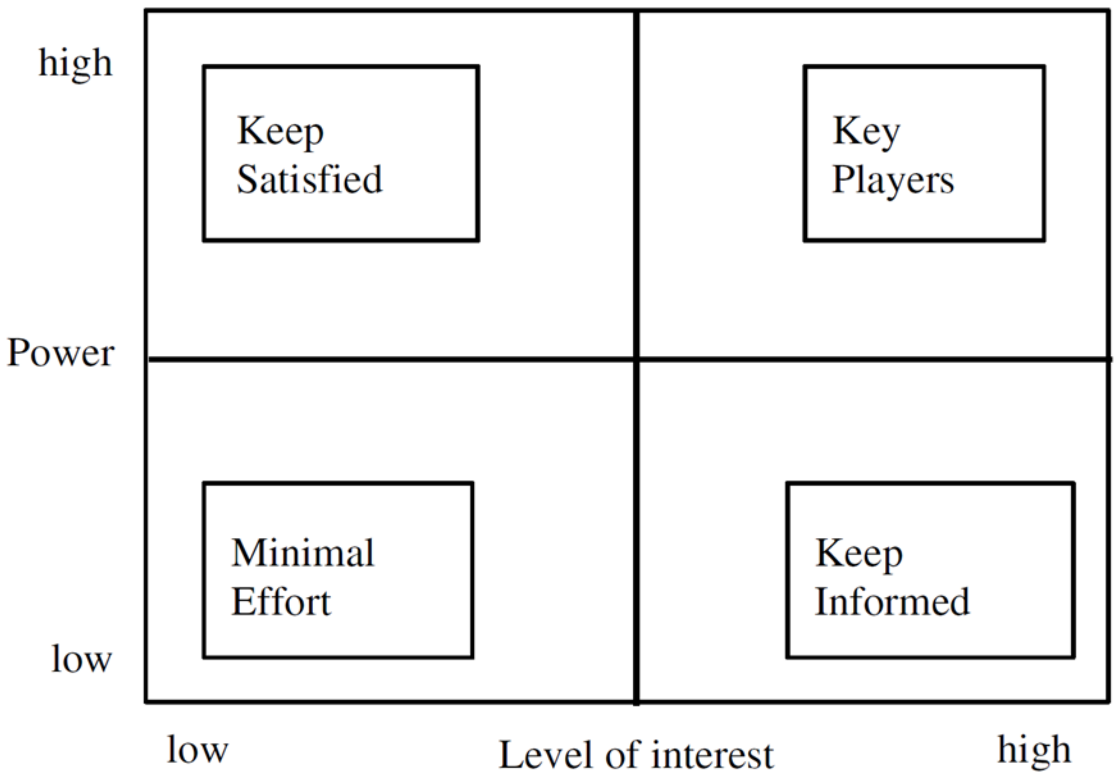

Figure 5 Power/Interest matrix for stakeholder mapping (Olander and Landin, 2005, p.322).

There are five categories of response strategies that project managers use. These strategies are (1) Compromise, (2) adaptation, (3) dismissal, (4) influence, and (5) avoidance as presented in Table 14 (Aaltonen and Sivonen, 2009).

Table 14 Response strategies (Aaltonen and Sivonen, 2009).

Response Strategy	Description
Adaptation	Obeying the demands and rules that are presented by stakeholders. It is considered that to cope with the demands and to achieve the objectives of the project, it is better to adjust to the external stakeholder pressures.
Compromising	Negotiating with the stakeholders, listening to their claims related to the project, and offering possibilities and arenas for dialogues. Making reconciliations and offering compensation. Opening the project to the stakeholders.

Avoidance	Loosening attachments to stakeholders and their claims, to guard and shield oneself against the claims. Transferring responsibility of responding to the claims to another actor in the project network.
Dismissal	Ignoring the presented demands of stakeholders. Not taking into account the stakeholders' related pressures and their requirements in the project execution.
Influence	Shaping proactively the values and demands of stakeholders. Actively Sharing information and building relationship with stakeholders.

The choice of a response strategy is formed from a sequence interaction between a project and a stakeholder rather than a dyadic interaction between a construction firm and the stakeholder. Furthermore, salience and the stakeholder’s demands constantly change; hence, there is a need for a dynamic response strategy (Aaltonen and Sivonen, 2009).

As mentioned before, Mitchell et al. (1997) developed a framework for identifying the salience of stakeholders’ demands. The framework belongs to those that offer guidance to understanding the circumstances under which companies are more likely to react positively to the influences and requests of secondary stakeholders. The framework identifies three key attributes of stakeholders which are the determinants of their salience to project management. These are power, urgency, and legitimacy. Salience is the extent to which project management will prioritize the various competing stakeholder claims (Mitchell et al., 1997). The higher the legitimacy, power, and urgency of external stakeholders, the greater the management saliency of stakeholder’s demands. In this regard, stakeholders can be categorized according to their possession of the three key attributes identified by Mitchell et al. (1997). From the above definition of stakeholder salience, using the attributes identified by Mitchell et al. (1997), Table 15 shows various classes of stakeholders. These categories will help project managers to prioritise the stakeholders’ claims and requests in order to plan their response strategies during project execution.

Table 15 Classes of stakeholders (Mitchell, Agle and Wood, 1997).

Class	Description
Dormant stakeholders	Possess power attribute they can use to impose their will, however, they lack legitimate and urgent claim hence their power is dormant.

Discretionary stakeholders	Have the attribute of legitimacy but lack power and urgent claim. Therefore, they do not exert any absolute pressure for project management, although they may decide to actively do so.
Demanding stakeholders	They have urgent claims but lack power or legitimate relationship. Therefore, although they may bother management, their claims do not warrant more than passing management attention.
Dominant stakeholders	Have power and legitimate attribute and their expectations clearly matter to managers.
Dangerous stakeholders	Lack of legitimacy but have both urgency and power. They are coercive and sometimes violent which makes them 'dangerous'.
Dependent stakeholders	Have claims that are legitimate and urgent but lack the attribute of power.
Definitive stakeholders	Possess both legitimacy and power and may already be members of a dominant coalition of the firm. When their claims become urgent, managers must immediately prioritize and address their claims.

Also, the three stakeholder attributes of power, legitimacy and urgency which constitute the stakeholder salience, are discussed in the next sections.

2.4.5.3 Power

The resource dependency theory emphasizes that organizations must acquire resources crucial to their normal operations and ultimate survival. Therefore, (Eesley and Lenox, 2006) define stakeholders' power as having relative access to resources. This definition implies that the power of the stakeholder goes both sides since the stakeholder's power depends both on the focal company and the resource base of the various stakeholder. Therefore, the power of the stakeholder should be more of a partnership attribute between the stakeholders and the firms than a one-way stakeholder attribute. Consequently, the more powerful the stakeholders are, the more chances they have of sustaining costly actions against firms given their relative access to resources. The probability of the firm responding positively to the request of the stakeholders is increased if the stakeholder possesses greater resources given the point that the firm's resources will be depleted by the actions of the stakeholders (Aaltonen, Jaakko, and Tuomas, 2008). However, if the firm's resources are greater, then the probability of a positive response to stakeholder's demands is very low.

Also, the theory of social movement suggests that stakeholders who are rich in terms of resources are more likely to influence positive responses (McCarthy and Zald, 1977). Furthermore, according to the theory of resource mobilization, the difference in the levels of resources is the major drive for any change in the levels of social movement activities (McCarthy and Zald, 1977). Not all groups will be fully satisfied even though certain actions are hindered by access to resources. Hence, stakeholder groups rich in resources can exert greater pressure on companies, and the firms which have abundant resource base are in a better position of resisting any form of pressure from the stakeholders. These firms can repair any damages that may be caused by the stakeholders including rebuilding their image as well as support staff that is solely dedicated to legal and public relations issues. For instance, the financial position of a firm can influence the outcomes of corporate lawsuits (Bhagat et al., 1998).

2.4.5.4 Legitimacy

The legitimacy of the stakeholder's claims and demands is another determinant as to how the firm will react (Mitchell et al., 1997). The more legitimate the demands of the stakeholder groups are the more likely the firm will react positively. Mitchell et al. (1997) defined legitimacy as a generalized assumption or perception of an entity's actions being appropriate, proper, or desirable to socially constructed definitions, beliefs, values, and norms (Suchman, 1995). Mitchell et al. (1997) describe legitimacy as being the characteristic of a group of stakeholders. Therefore, having a greater legitimacy gives a group of stakeholders a more credible threat that will highly influence the ability of the various firms to access resources from crucial stakeholders such as customers or supply of labour (Rowley, 1997).

Eesley and Lenox (2006) propose that legitimacy is to be granted not only to the group of stakeholders but also to the issues that they championed. For instance, issues regarding environmental concerns are normally complicated and are often disputed. A call for action for a particular firm to address a pollution concern that is affecting local communities will be more legitimate in the eyes of the public in comparison to a call of action to address a global environmental pollution issue as it seems more distant. This tendency explains the reasons why conservation groups have in the past received more support from the public than environmental movements with broader agendas (Mertig and Dunlap, 2001).

2.4.5.5 Urgency

Mitchell et al. (1997) defined urgency as "the degree to which stakeholder claims call for immediate attention." Urgency includes both time and criticality sensitivity in that it puts a timeline to which a managerial delay is considered unaccepTable while also emphasizes the significance of a stakeholder's claim. The inference by Mitchell, Agle, and Wood (1997) that the urgency of a stakeholder group incites a positive response from the firm has received strong support from other empirical works (Eesley and Lenox, 2006). Urgency, according to Mitchell et al. (1997), is unique to a particular group of stakeholders. However, it changes if the members of that particular group of stakeholders are changed. It should be noted that just because a group of stakeholders is deeply concerned with a particular issue and are adamant for prompt action, a targeted firm will not be moved to positively respond. Although urgency may correlate with how persistent a group of stakeholders is, in the end, the stakeholder group's attribute of power appears more relevant (Aaltonen, Jaakko, and Tuomas, 2008).

Eesley and Lenox (2006) add that a better and more effective approach would broaden urgency and make it universal in the sense that it should be determined whether a stakeholder claim is meant to halt or change a current or a future action by the firm (Aaltonen, Jaakko, and Tuomas, 2008). Also, the authors claim that a stakeholder with the intention of influencing the current revenue stream of a firm is probably more salient than the stakeholder group whose actions target potential and future revenue stream (Aaltonen, Jaakko, and Tuomas, 2008). A firm will be more motivated to positively respond to action calls that affect its immediate operations and the ones which require it to stop future operations will most likely be ignored. The psychology literature also supports this theory in the sense that the urgency of a request influences the probability of response. In particular, time pressure has been shown to make decision-makers more prone to take action (Dror, Basola and Busemeyer, 1999).

2.4.5.6 Stakeholder Circle

Bourne and Walker (2006) have developed a tool which is called the Stakeholder Circle™ to identify, measure, and visualize the power and impact of each stakeholder in the projects by investigating two case studies. This tool has been developed utilizing stakeholder and project management theories and emphasizes a deeper understanding of the impacts exerted to the projects by stakeholders which excavates the importance of customer relationship and risk management implications in this sector.

In this tool the distance of stakeholders from the project delivery entity is indicated by concentric lines, homogeneity of stakeholders is indicated by specific patterns like solid shade and patterning or shading for indicating heterogeneity of interest; the scope and scale of influence are shown by the relative area and size of the block; while the degree of impact can be designated by the radial depth (Bourne and Walker, 2005). Project managers can use this tool to understand the nature of stakeholder impact and remain perceptive about it. The authors state that the stakeholder circle tool is an iterative process because stakeholders of a company or project may change within the organization or leave and their relative importance, power, and influence change as well. Therefore, this methodology should be repeated at different points during the project lifecycle.

The Stakeholder Circle™ consists of three steps which are identifying stakeholders, prioritising stakeholders, and developing a stakeholder engagement strategy. The first step is the identification of the stakeholders and grouping them into relevant categories including the definition of what they need from the project and their significance to the project. For this purpose, they recommend conducting workshops with individuals who are familiar with project constraints, deliverables, and organisational structure.

The second step of this methodology is prioritising stakeholders. The authors have used a notion similar to the work done by Mitchell et al. (1997), except that they replaced the 'legitimacy' phrase with proximity. In this regard, for defining the relative importance of stakeholders they suggest considering three factors of proximity, power, and urgency. The proximity factor defines if stakeholders are either closely or remotely associated with the project and it is suggested that the team should rate stakeholders on a scale of 1-4 where 4 means directly working in the project and 1 is relatively remote from the project. The next factor defines whether a stakeholder's power to influence or kill the project is significant or limited and can be measured by conducting a workshop where participants will rate power on a scale of 1-4 where 4 is the high capacity to instruct change and 1 indicates the relatively low levels of power. Urgency as the third factor considers the preparation of stakeholders for going any length to achieve their outcomes. Likewise other factors, the authors recommend conducting workshops for rating stakeholders on a scale of 1-5, where 5 is defined as 'immediate action is warranted regardless of other work commitments' and 1 is 'little need for action outside of routine communications'.

The third step is developing a stakeholder engagement strategy which includes the identification of stakeholders engagement approaches tailored to the needs and expectations of the top 15 prioritised stakeholders. The authors claim that this process provides essential data on the role of the stakeholder, what the project needs from the relationship, and what that particular stakeholder obtains from supporting a successful project. For the first set of analysis, the interest of stakeholders should be identified at five levels differing from committed, through ambivalent, and antagonistic. Then, the levels of stakeholder support should be analyzed at five levels of Active support, non-committal and active opposition. Bourne and Walker (2006) mention that a separate engagement approach should be considered for stakeholders who are actively opposed and antagonistic. The next is defining the method of delivery in terms of formal, informal, written, or oral and clarifying who will deliver it, together with the frequency of the message. The final activity is to define the content of the message, for example, notification of issues or project updates, and ensuring that the content and tenor of the message is in accord with what the stakeholder requires from the project. The Stakeholder Circle tool is presented in Figure 6.

The calculation in this tool for the importance of each stakeholder is provided through assessments provided by the project team. However, it does not prevail over the cognitive limitations, even if the project team including the sponsor have investigated the impact of each stakeholder. Also, Yang et al. (2011) point out that in complex projects, the accuracy of this tool decreases, and Smyth and Pryke (2006) mentions that it still lays on traditional dyadic analysis. Also, there is a need for backup validation through the identification of the fundamental structure of relationships between participants.

Although their work provides a good foundation for mapping stakeholder influence, but it is limited in providing strategies for responding to the influence strategies of stakeholders and refers to the old response strategies proposed by PMI which include avoidance, transference, and mitigation. Besides, the authors have not clearly defined the strategies by which stakeholders impose their influence on the projects. Plus, the target of stakeholder influence strategies is rather vague and the impacts of these strategies on other stakeholders and different work packages and their relationships are neglected. Also, despite their emphasis on the importance of communication for managing stakeholder relationships, they do not suggest any structured approach for improving communications in projects. In conclusion, it lacks a comprehensive and practical approach to cover all the themes that they mentioned as important pieces of the stakeholder management puzzle including risk and communication management.

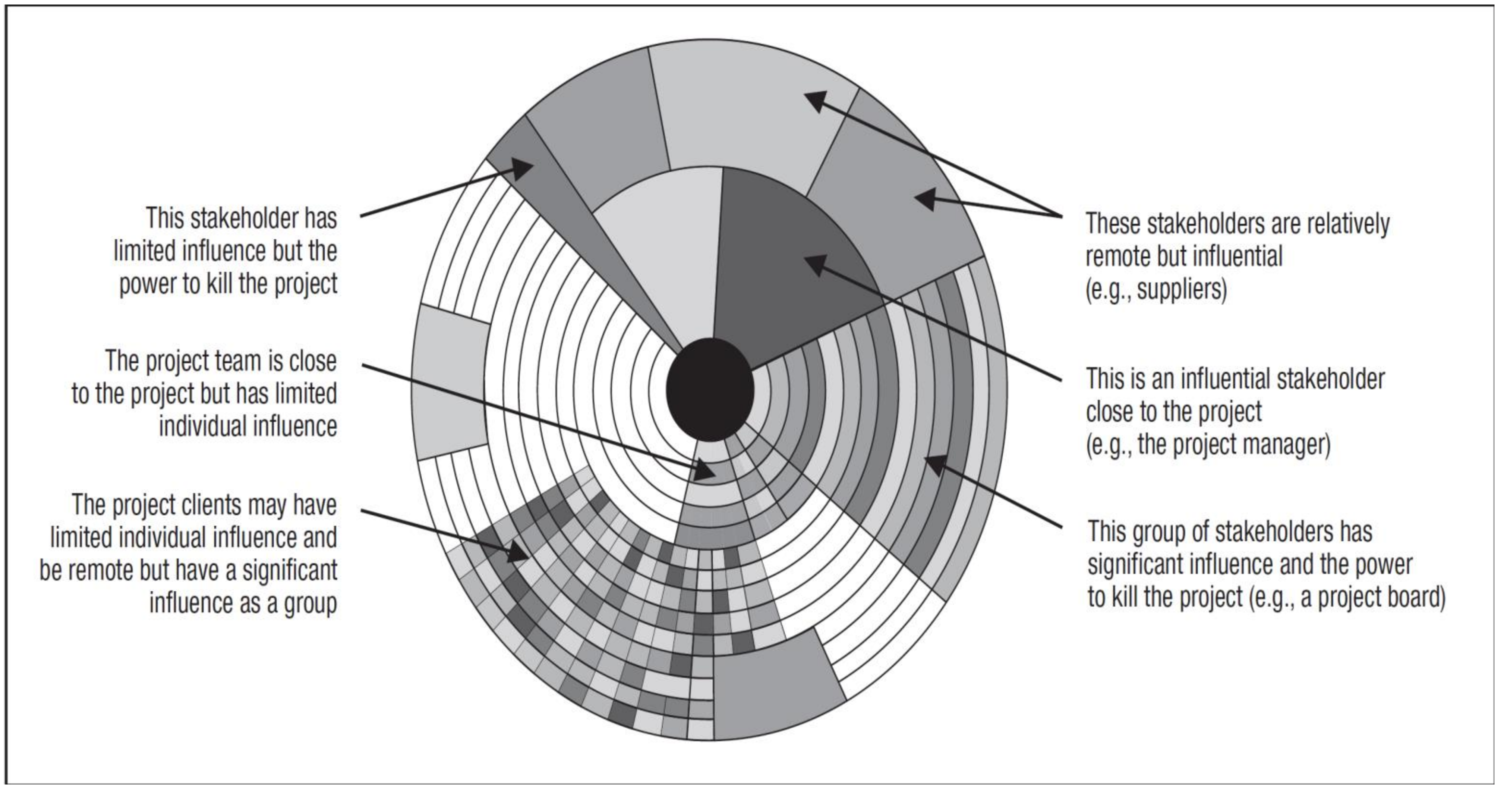

Figure 6 Visualising stakeholder influence (Bourne and Walker, 2006, p.10).

According to the PMBOK GUIDE (PMI, 2017), the processes related to stakeholder management assist the project team in evaluating stakeholder expectations, analysing their impact on the project, and devising suitable strategies to involve stakeholders in making project decisions and planning and executing project work. In this regard, PMI (2017) presents stakeholder management processes such as identifying stakeholders, planning stakeholder engagement, managing stakeholder engagement, and monitoring stakeholder engagement. The "identify stakeholder" process is defined as identifying project stakeholders on a regular basis and assessing and recording pertinent information about their interdependencies, interests, influence, participation, and possible effect on project success (PMI, 2017). The process of "plan stakeholder engagement" involves creating strategies and methods to engage project stakeholders by considering their interests, expectations, requirements, and potential influence on the project (PMI, 2017). Also, "manage stakeholder engagement" is a project management process that aims to facilitate effective communication and collaboration with stakeholders to satisfy their requirements, manage conflicts and concerns, and encourage active stakeholder engagement throughout the project lifecycle. According to the PMBOK GUIDE (PMI, 2017), "monitor stakeholder engagement" refers to the process of observing and evaluating project stakeholder interactions and adjusting engagement strategies and plans accordingly in order to maintain effective stakeholder relationships. The project stakeholder management processes are characterised as individual processes with distinct interfaces. However, in actual practice, these processes have overlapping and interacting components that cannot be exhaustively described in the PMBOK® Guide (PMI, 2017). Thus, the processes of stakeholder management will be further analysed in the next chapters to identify their interactions with each other and other project management processes like scope management.The overall process of stakeholder management is captured in the following Figure 7 according to PM BOKE GUIDE (PMI, 2017b):

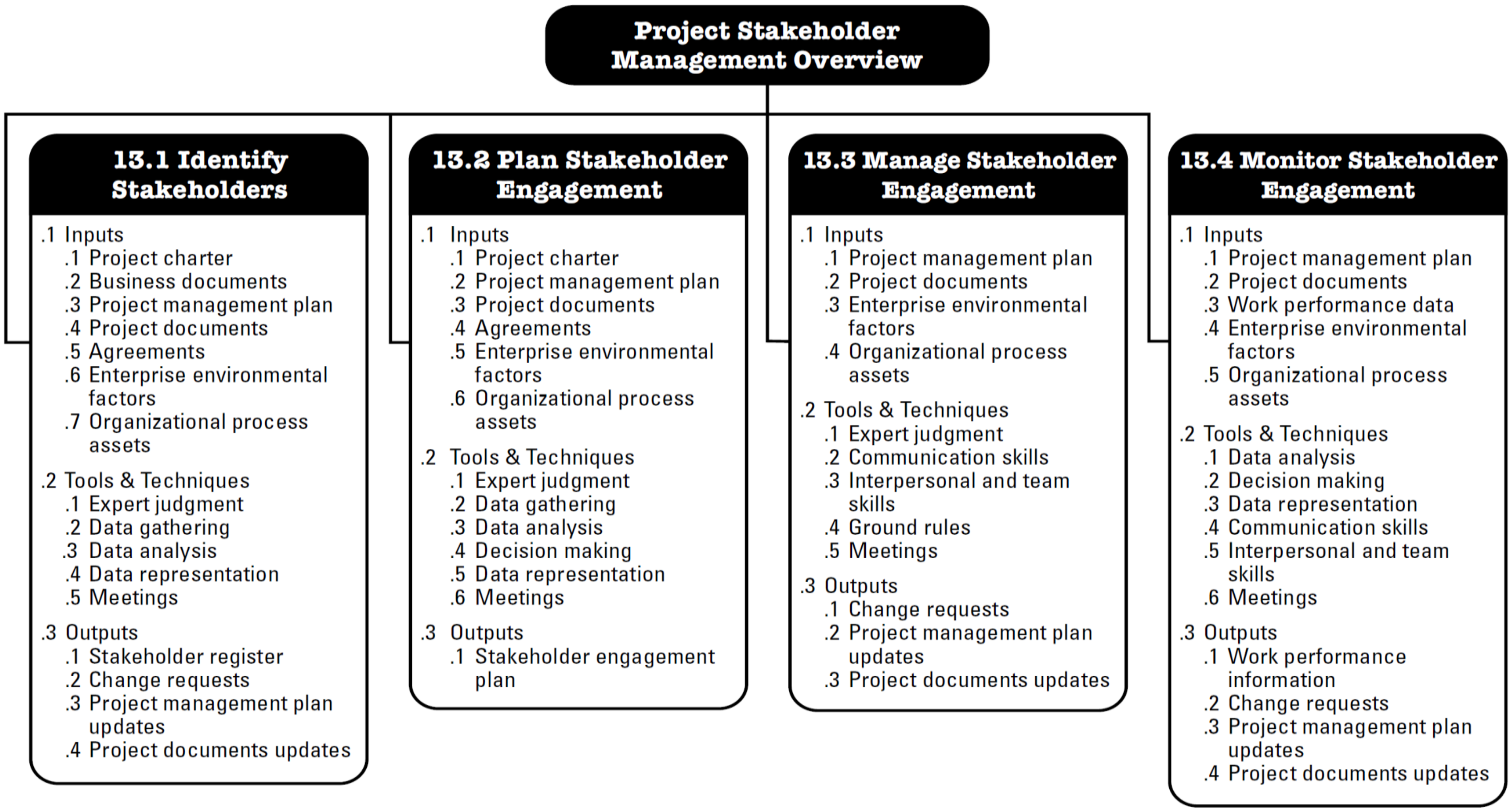

Figure 7 The overal Stakeholder Management Process (PMI, 2017, p.504).

2.4.6 Stakeholders' Communication and Relationship Management

According to PMBOK GUIDE (PMI, 2017b), communication management in projects includes processes to ensure appropriate and timely planning, collection, creation, distribution, storage, retrieval, management, control, monitoring, and ultimate disposition of project information. Communication management, on one side, is an essential part of stakeholder management and risk management in projects (Aaltonen and Kujala, 2010) which facilitates stakeholder engagement and management of their effects on the scope of projects, and on the other side encompasses different tools and methodologies such as Building Information Modelling (BIM). According to Landin (2000), the paid attention of decision-makers to the development of communication with stakeholders is a major aspect in satisfying stakeholders and the long-term performance of construction projects. Jergeas et al. (2000) mentioned communication as one of four essential activities for gaining stakeholder support during project implementation and making project activities issue-driven rather than stakeholder-driven. Also, effective communication possesses an important role in stakeholder engagement where the term 'effective' includes delivering the correct message to the appropriate stakeholders, using suitable means and clarifying project benefits and values (Bakens, Foliente and Jasuja, 2005). Besides, Nguyen, Skitmore and Wong (2009) emphasize the importance of stakeholder knowledge in evaluating stakeholder influence. They explain that limited influence can be exerted on the project from stakeholders with inadequate project knowledge even if they have the power while they can be more influential with gaining genuine project information instead of relying on rumours.

According to the PMBOK GUIDE (PMI, 2017), project communications management comprises two main components. The initial component entails devising a plan to guarantee communication efficacy with stakeholders, while the second component involves executing the necessary activities to implement the communication strategy. In this regard, the communication management processes include plan communications management, manage communications, monitor communications (PMI, 2017). "Plan communications management" refers to the systematic process of creating a suitable strategy and plan for communication activities in a project. This involves considering the information needs of every stakeholder or group, the available organizational resources, and the requirements of the project to determine the most appropriate approach to be used (PMI, 2017). "Manage communications" can be described as the systematic process of ensuring that project information is collected, created, distributed, stored, retrieved, managed, monitored, and disposed of in a timely and appropriate manner to meet project communication requirements (PMI, 2017). Finally, "monitor communications" is defined as the process of tracking, reviewing, and reporting the status and effectiveness of project communications to ensure that the information needs of the project and its stakeholders are being met (PMI, 2017). The overall process of communication management and its outputs are described according to PMBOK GUIDE (PMI, 2017b) in Figure 8.

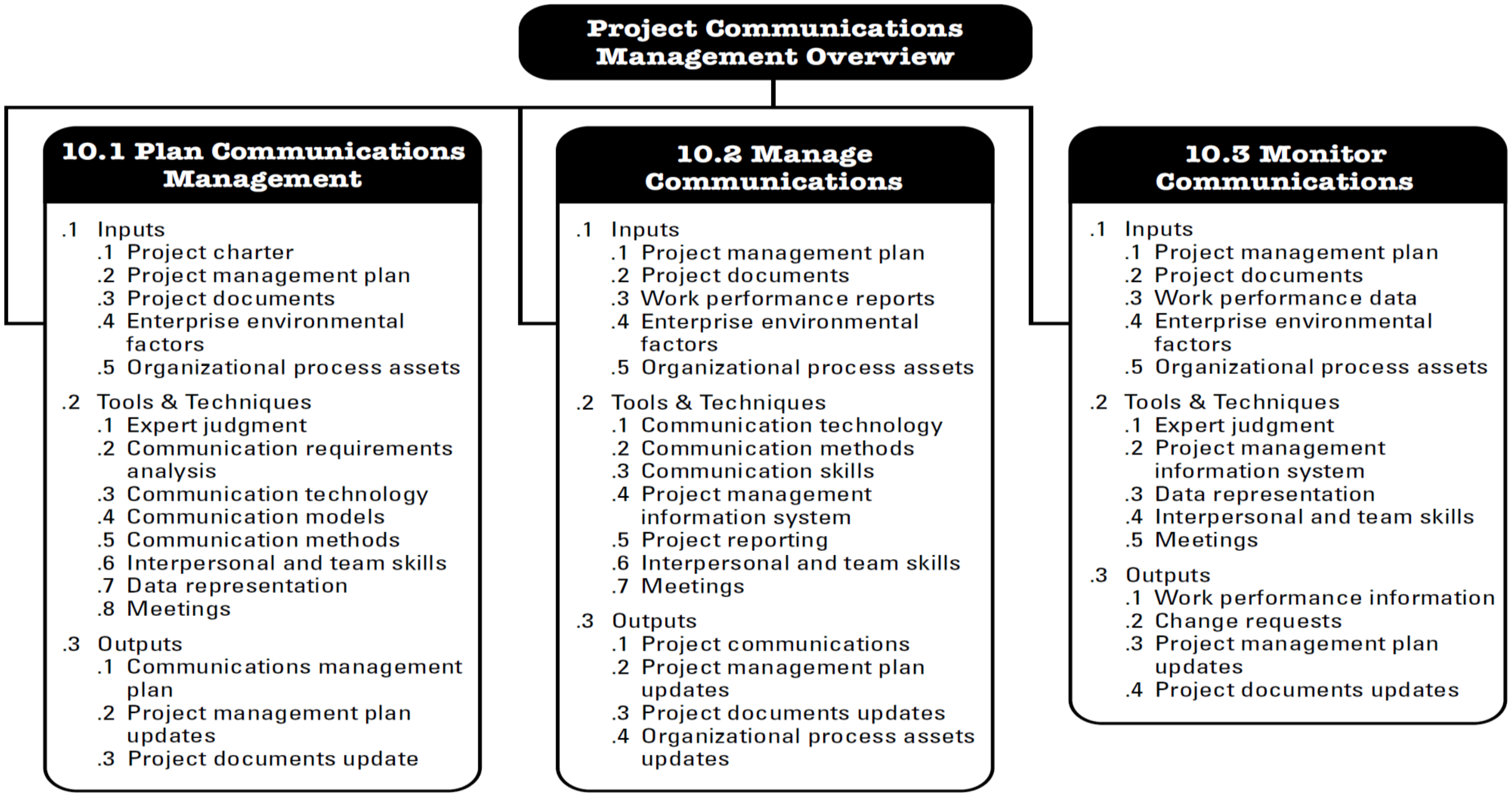

Figure 8 The overall Stakeholder Management Process (PMI, 2017, p.360).

Hence, communication management is utilised in this research as a channel which links project management processes to Building Information Modeling (BIM), because at one end it encompasses BIM as a methodology for managing the production, distribution and quality of construction information (British Standard, 2008) and at the other end it has a crucial role in stakeholder management and engagement.

2.5 Chapter Summary

This chapter investigated the literature on the scope and stakeholder management. Firstly, it looked at some of the foundational concepts of project management to obtain a deeper understanding of the importance of project scope. Then, the scope and scope management terms were defined and it was mentioned that scope can be segmented into two types of project scope and product scope. Additionally, it established the role of stakeholders in occurance of requests for change in requirements or final product and consequently uncertainty in projects. Also, the definitions of scope creep were reviwed and the main causes of scope creep were identified. In continue, the discussion was made on the recommended potential tools and techniques by other scholars for dealing with different aspects of scope creep. In the next section, it was defined that what a stake is, who the stakeholders are and how they are managed, together with identification of different types of stakeholders. Then, a selection of methodologies for identifying and managing stakeholders was presented in Table 9. Additionally, the Stakeholder influence strategies were defined and a selection of identified stakeholder influence strategies was presented in Table 11. Also, the factors that determine the choice of each stakeholder influence strategy were identified. In the next section, the uncertainty, risk and the available firms' response strategies to the stakeholder influence were discussed. Then the difference between uncertainty and risk was explained. Also, it was stated that in this research scope creep is taken into account as uncertainty caused by stakeholders, which may result in risks affecting project objectives. Several tools and techniques were identified for deciding whether or not the project manager should consider the claims of a particular group of stakeholders. Also, it was mentioned that communication management is utilised in this research as a bridge which links project management processes to Building Information Modeling (BIM).

Chapter 3 Building Information Modeling (BIM)

3.1 Introduction

This chapter reviews the literature on BIM to investigate its impacts on the four aforementioned project management processes of scope, stakeholder, communication, and risk management, together with collaborative working and integrated project delivery (IPD) approaches as two essential elements that strengthen BIM adoption in projects.

3.2 BIM History

The term "Building Information Modeling" (BIM) was initially conceived by Eastman in the mid-1970s as "Building Description Systems" (Cao et al., 2015). Its origins can be traced back to the Georgia Institute of Technology (Rokooei, 2015). Initially, the digital representation of buildings using predefined object classes was referred to as "Building Product Models," which eventually evolved into what is now known as BIM. The concept gained significant recognition in 1985 when the ISO's STEP (Standard for the Exchange of Product Data) standardization project was initiated. The STEP project aimed to address the data exchange requirements across various manufacturing industries (Howard and Bjork, 2008).

The term "Building Information Modelling" (BIM) was initially coined in 2002 to encompass virtual design, construction, and facilities management (Rokooei, 2015). However, according to Shoubi et al. (2015), the development of BIM actually took place in the mid-1980s but gained significant popularity only in recent years.

The UK Government released the Construction Strategy in May 2011 with the objective of lowering public sector asset costs by 20% before 2016. The strategy emphasizes the need for a significant transformation in the connection between public authorities and the construction industry. The goal was to ensure that the government consistently receives favourable outcomes while also providing the necessary long-term social and economic infrastructure for the country. Due to the announcement in 2010 by the UK government regarding mandatory use of Building Information Modeling (BIM) maturity level 2 by 2016 for all public construction projects, increasing pressure has been imposed on the UK construction industry.

3.3 Definition of BIM

The lack of a single agreed definition is one of the problematic issues regarding BIM in this sector. Accordingly, authors either focus on integrated delivery of the project and organizational information (Eastman *et al.*, 2011; O'Grady, 2013), or its technological elements like 3D modelling (Smith and Tardif, 2009; Saunders, M., Lewis, P. and Thornhill, 2012, 2019). However, providing a single centralized information pool for creating a collaborative design for all team members to access and work on, is the main requirement of BIM. Therefore, BIM is something beyond moving toward using 3D modeling like Autodesk Revit and Bentley Structural. Hence, since the basic issues of workflows and business processes have changed, BIM can depict changes to the way in which projects are managed and undertaken (Smith and Tardif, 2009). Also, scholars (Harty *et al.*, 2010) have mentioned that BIM is mostly about processes and people rather than technological elements. Table 16 provides a summary of some of the BIM definitions generated by scholars.

Table 16 BIM definitions gathered from the literature review.

Author	BIM Definition
Chen and Luo (2014)	As a tool for visualizing and coordinating AEC (architecture, engineering, and construction) work, avoiding errors and omissions, improving productivity, and supporting scheduling, safety, cost, and quality management on construction projects.
Xu, Ma and Ding (2014)	Is a new technique imitating buildings' actual information, through such tools as 3D geographic Figures and non-geographic Figures which include items such as the materials (for building components), weight, price, procedures, scale, and size.
Eastman et al. (2011)	Is considered as more than just a technical tool. BIM also supports multi-disciplinary, collaborative and integrated approaches and contributes to the development of business processes and work practices.

Smits, van Buiten and Hartmann (2017)	
Merschbrock and Munkvold (2012)	Emerging IT-based information systems which promote collaborative and integrated design, assembly, and operation of buildings. BIM can be best described as a platform of IT tools employed to design virtual models seeking to present all physical and functional characteristics of a building.
Ernstrom et al. (2006) Associated General Contractors of America (AGC) (2005)	A data-rich, object-oriented, intelligent and parametric digital representation of a facility, from which views and data appropriate to various users' needs can be extracted and analyzed to generate information that can be used to make decisions and improve the process of delivering the facility.
Arayici and Aouad (2010) Arayici, Egbu and Coates (2012)	As the use of ICT technologies to streamline the building lifecycle processes to provide a safer and more productive environment for its occupants, to assert the least possible environmental impact from its existence, and to be more operationally efficient for its owners throughout the building lifecycle.

But maybe the most reliable definitions in this regard is the one stated in **BS 1192:2007** (BRITISH STANDARD, 2008) as "methodology for managing the production, distribution, and quality of construction information, including that generated by CAD systems, using a disciplined process for collaboration and a specified naming policy".

3.4BIM Maturity Levels

Figure 9 displays the BIM maturity model, which illustrates the evolution from CAD to Level 3 BIM. The maturity levels of Building Information Modeling (BIM) are used to measure the technological advancement within the Architecture, Engineering, and Construction (AEC) sector based on the extent of collaboration and information exchange among project stakeholders.

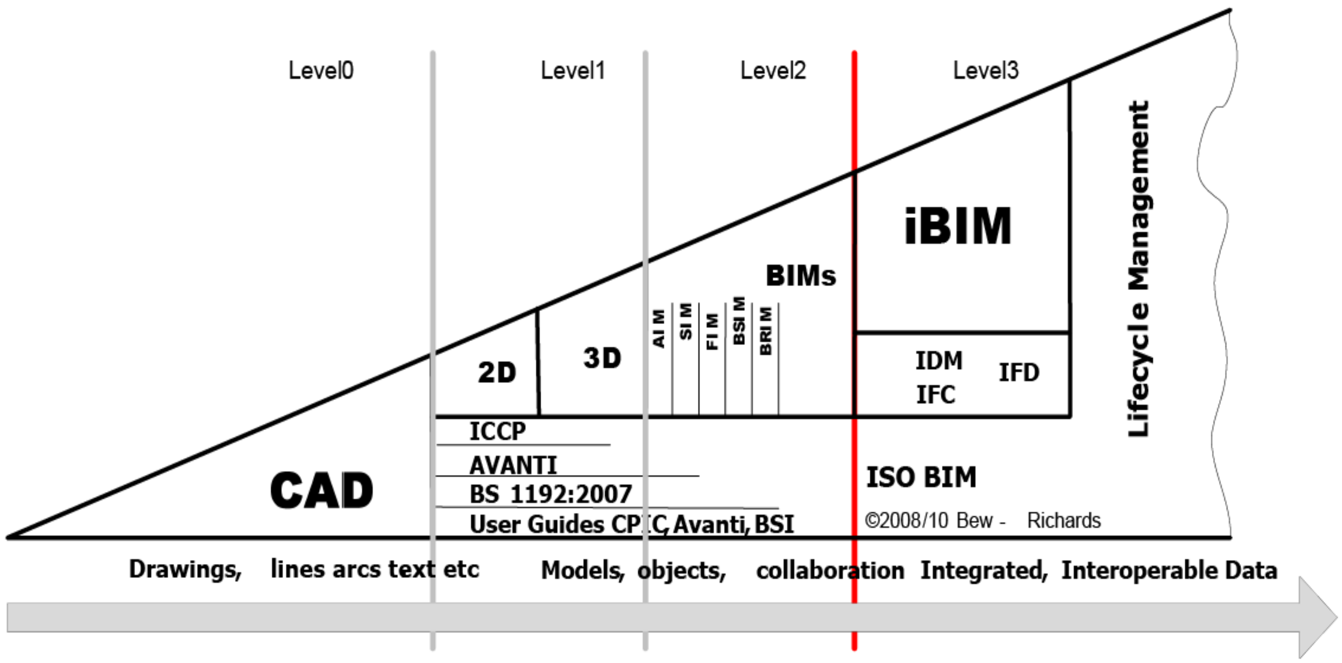

Figure 9 BIM maturity levels according to PAS 1192-2:2013 (BSI, 2013)

The PAS 1192-2:2013 (BSI, 2013) document defines four maturity levels, often referred to as "Levels of BIM Maturity."

Level 0: Unmanaged CAD: At this level, organizations primarily use 2D CAD drafting tools with no collaboration or data-sharing capabilities. BIM is not utilized, and information exchange typically occurs through paper-based or electronic documents.

Level 1: Managed CAD/BIM: At this level, organizations start utilizing basic 3D modelling tools and may begin to incorporate BIM elements. However, the collaboration is limited, and the information exchange is mainly through file-based systems, with no centralized data environment.

Level 2: Managed 3D Environment: Level 2 represents a significant shift toward collaborative working and integrated data sharing. Organizations use 3D modelling tools and work within a common data environment (CDE) to share information. Each party involved maintains their own model and shares information through a federated approach. While collaboration is a key aspect of BIM Level 2, it is not mandatory for all team members to work on the same CAD 3D models. In fact, each member has the flexibility to use their own individual CAD model, which can be stored in a common file format (such as an IFC file) specifically designed for exchanging BIM data. This file format encompasses all the necessary design information (references not provided).

Level 3: Integrated Process and Collaborative Working: Level 3 represents the highest level of BIM maturity. It involves the integration of all project information into a shared, single, and secure project model. All parties work collaboratively, using a centralized CDE and sharing information in real-time. Level 3 also supports the use of advanced technologies, such as cloud-based collaboration and data analytics.

3.4.1Digital Maturity Stages in ISO 19650 (2018)

The release of ISO 19650 (parts 1 and 2) in 2018 has given rise to new regulatory frameworks at the international, EU, and individual State levels. This standard has now become the primary point of reference for other existing standards. BS 1192 and PAS 1192-2 served as the foundation for the development of ISO 19650. ISO 19650 (BSI, 2018) incorporates and expands upon the principles and concepts established in BS 1192 and PAS 1192-2 to provide a global standard for managing information in construction projects using BIM. In particular, ISO 19650-1:2018 reintroduces and updates the concept of BIM Maturity.

The BIM maturity concept is categorized in this document into three stages as shown in Figure 10 (BSI, 2018):

- BIM Stage 1 involves the combination of 2D CAD deliverables and 3D BIM models, satisfying national regulatory requirements for effective project management.

- BIM Stage 2 focuses on integrating information models from different disciplines (such as structural, architectural, MEP systems, etc.) in accordance with the international standard ISO 19650. This stage ensures the cohesive management of the construction project.

- BIM Stage 3 introduces structured database systems for information models that are immediately quarriable. This stage promotes the adoption of OPEN BIM as a project management system and facilitates subsequent commissioning activities.

As the progression advances from Stage 1 to Stage 3, there is a growing level of data integration at both technological and informational levels. Specifically, in Stage 2, data sharing relies on the exchange of models and files. However, in Stage 3, there is a shift towards model management using structured platforms that facilitate the optimization of all BIM processes and enable direct interrogation of the models.

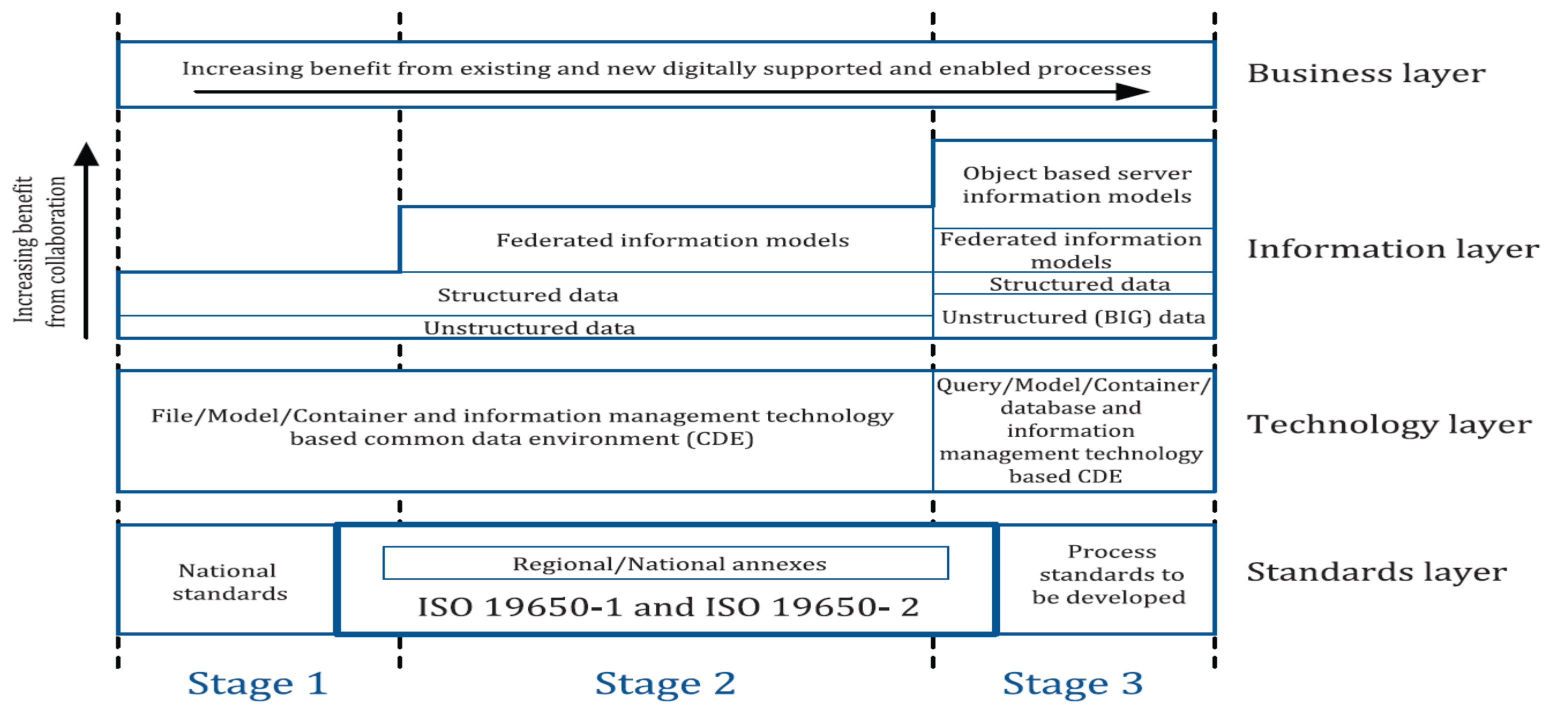

Figure 10 BIM maturity levels according to ISO 19650-1 (BSI, 2018)

3.5 The Information Delivery Cycle

Figure 11 in PAS 1192-2:2013 illustrates the information delivery cycle within the context of BIM. The information delivery cycle represents the flow of information and data throughout the lifecycle of a construction project, from inception to operation. It highlights the various stages and processes involved in managing information within a collaborative BIM environment. The information delivery and project management cycle depicted in Figure 11 outlines the generic procedure encompassing the identification of a project requirement, such as design services, construction, or the supply of goods. It encompasses the stages of procuring and awarding a contract, supplier mobilization, and the generation of production and asset information relevant to fulfil the specified need. This cycle is applied to all aspects of a project and includes the progressive refinement of design information during the seven project stages indicated in green.

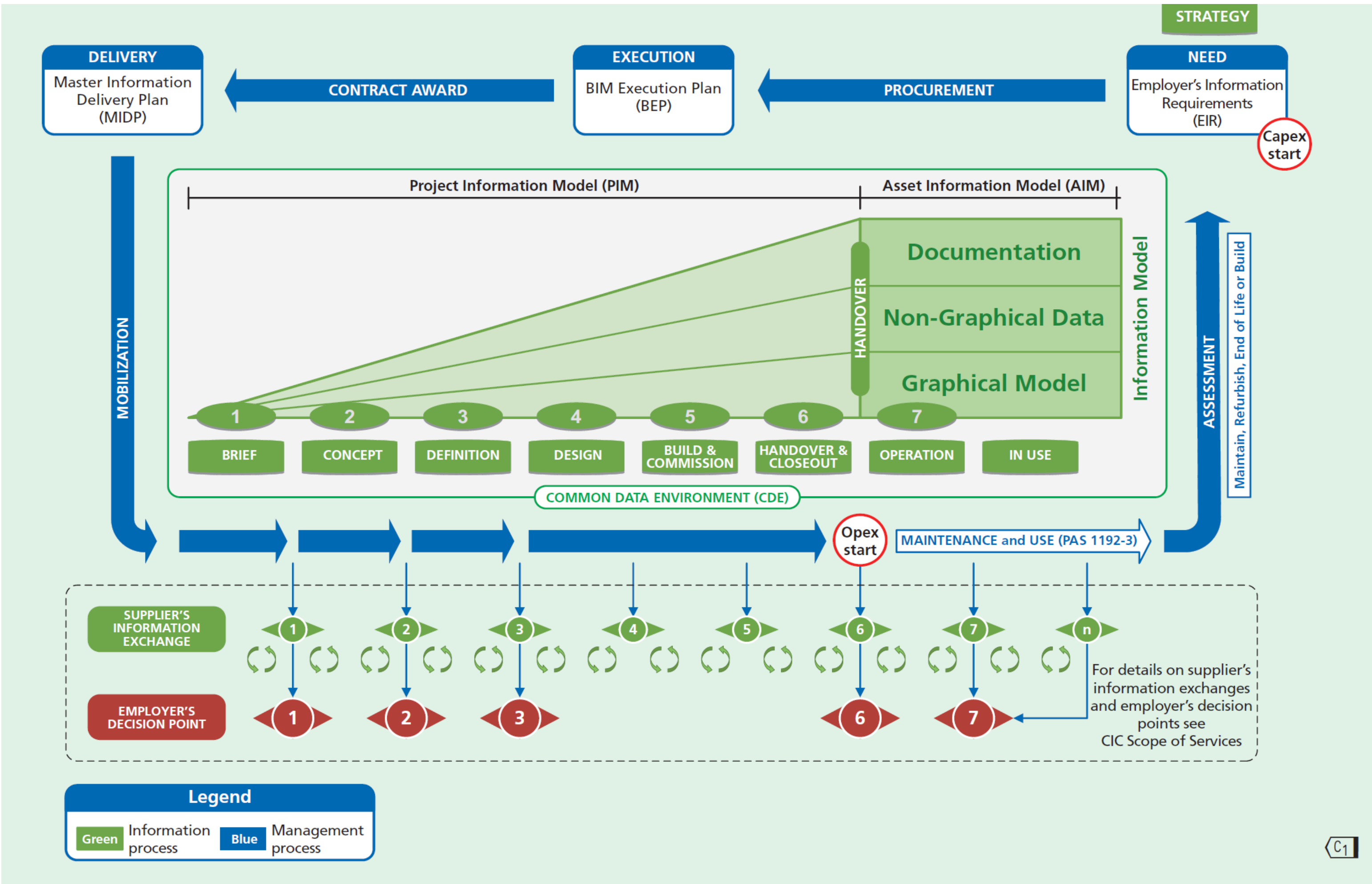

Figure 11 BIM information delivery cycle according to PAS 1192-2 (BSI, 2013)

The segments depicted in green within the diagrams symbolize the information delivery process referred to as the common data environment (CDE). The information delivery cycle, illustrated in Figure 11, offers two distinct entry points depending on the nature of the project. For independent new build projects, the starting point is the top-right box labelled "Need." On the other hand, for projects that are part of a larger portfolio or involve existing buildings and structures, the starting point is indicated by the right-hand arrow labelled "Assessment." In this case, relevant information from the existing asset information model (AIM) is utilized. It is anticipated that portfolio information will be accessed from both entry points to facilitate informed decision-making (BSI, 2013).

The numbered green ovals and labelled lozenges correspond to the stages outlined in the CIC Scope of Services. These elements serve as reference points for the different stages involved in the provision of services as defined by the Construction Industry Council (CIC). The exchange of information among members of the project team is represented by small green balloons, while the exchange of information between the project team and the employer is depicted by larger red balloons. The purpose of the larger red balloons is to address the inquiries posed by the employer in accordance with the Plain Language questions specified in the employer's information requirements (EIR).

The stages of the lifecycle, as indicated by the blue arrows in the information delivery cycle, can be summarized as follows (BSI, 2013):

-*Assessment and need:* The information delivery and project stages described in PAS 1192-2:2013 begin at "CAPEX start" and end at Handover. The term "CAPEX start" encompasses two possibilities: a project initiation without any pre-existing information, or a project that begins by assessing information derived from an existing asset portfolio. The assessment and need stage involves defining information exchange and collaborative working requirements through the Employer's Information Requirements (EIRs). These requirements align with employer decision points and project stages and provide sufficient information to address specific questions at each stage. The EIRs are incorporated into tender documentation, allowing suppliers to develop their initial BIM Execution Plan (BEP) for evaluation of their approach, capability, and capacity (BSI, 2013).

- *Procurement*: During the procurement stage, the employer requests bidders to provide details in their submissions regarding their approach to project information management. The pre-contract BEP serves to demonstrate the supplier's capabilities and the proposed approach, while the post-contract BEP confirms the supply chain's abilities and includes the agreed master information delivery plan. The supplier submits the BEP on behalf of the entire supply chain and provides a summary of their capabilities and responsibilities.

- *Post contract-award*: The purpose of the BIM Execution Plan (BEP) after contract award is to manage project delivery, ensuring compliance with contractual information exchange requirements and wider project deliverables. Suppliers must provide information to their supply chain partners at predefined stages during the project, and the Master Information Delivery Plan (MIDP) will specify project deliverables such as models, drawings, specifications, equipment schedules, and room data sheets, managed through change control (BSI, 2013).

- *Mobilization*: Mobilization is a crucial stage as it allows the project delivery team to validate the functionality of the information management system prior to commencing any design activities. This involves ensuring the preparation and consensus on essential documents, establishing effective information management processes, assessing the team's proficiency and capabilities, and verifying that the technology aligns with PAS 1192-2:2013 standards to facilitate efficient information management.

- *Production*: The Project Information Model (PIM) will be incrementally developed and provided to the employer through a sequence of information exchanges, as specified in documents like the CIC Scope of Services. These exchanges will align with significant stages that correspond to the employer's decision-making processes, as outlined in the Employer's Information Requirements (EIRs) and the CIC BIM Protocol (2013). In Level 2 BIM, the PIM is anticipated to consist of a collection of coordinated building information models rather than a single integrated model. It will also include relevant non-graphical data and associated documentation. The development of the PIM will adhere to the requirements outlined in the Master Information Delivery Plan (MIDP).

- *Asset information model (AIM maintenance):* The transfer of information during the asset lifecycle, particularly during the delivery phase, combined with commissioning data, will constitute the primary content for handover upon project completion. The recommended format for information exchange is COBie-UK-2012. If additional information such as proprietary geometric models (2D or 3D) or extra data attributes are required, employers and project delivery teams should explicitly specify these alternative formats in the Employer's Information Requirements (EIR) at the beginning of the project (BSI, 2013).

In conclusion, the BIM documents and notions utilisied during the BIM information delivery lifecycle are summarized in the following table:

Table 17 Definitions of BIM documents (The British Standards Institution, 2013)

Document/ Notion	Description
EIR (Employer's Information Requirements)	The EIR is a document that specifies the information and data requirements of the employer or client for a construction project. It outlines what information is needed, at what stage, and in what format. The EIR serves as a foundation for developing the BIM Execution Plan (BEP).
BEP (BIM Execution Plan)	Sets out how the project will be executed using BIM. It describes the standards, methods, procedures, and protocols that will be followed throughout the project lifecycle. The BEP outlines the responsibilities of the project team members and establishes the framework for collaboration, information exchange, and BIM implementation.
PIP (Project Information Protocol)	The PIP is a contractual document that defines the standards, procedures, and protocols for information management and exchange in a BIM project. It specifies how information will be produced, delivered, and coordinated among project participants. The PIP complements the BEP by providing detailed information on specific project requirements.
TIDP (Task Information Delivery Plan)	The TIDP is a component of the PIP that outlines the specific information deliverables required for each task or work package within a project. It specifies the information formats, levels of detail, and timelines for the delivery of task-specific information.
PIM (Project Information Model)	The PIM is the collective term for all the project-related information and models created and maintained during the design and construction phases. It includes 3D models, 2D drawings, schedules, specifications, and other relevant project data. The PIM is a dynamic and evolving representation of the project, capturing the collaborative efforts of the project team.
MIDP (Master Information Delivery Plan)	The MIDP is a document that provides an overview of all the information deliverables required for a project. It consolidates the TIDPs and other relevant information delivery requirements into a single plan. The MIDP ensures that all project participants are aware of their information responsibilities and facilitates coordinated information exchange.
CDE (Common Data Environment)	The CDE is a centralized digital platform or system that facilitates collaboration, information sharing, and version control in a BIM project. It serves as a single source of truth for all project-related information, ensuring that

	stakeholders can access the most up-to-date information. The CDE provides a controlled environment for managing and exchanging information among project participants.
AIM (Asset Information Model)	The AIM is the information model that represents the final as-built or as-constructed state of a facility or asset. It includes all the information and data necessary for the effective operation, maintenance, and management of the asset throughout its lifecycle. The AIM is typically handed over to the client at the completion of the project and serves as a basis for facility management and operations.

3.6 BIM Impacts on Project Management Processes

3.6.1 Generic Advantages and Challenges of BIM

Xiao and Noble (2014) have summarized the benefits of BIM to project management through an extensive literature review which are presented in Table 18. From the viewpoint of this research, these all can be taken into consideration as having remarkable effects on concepts investigated in current research for managing stakeholders, project scope and uncertainties caused by stakeholders. However, some disadvantages have been reported on BIM which the most important ones are software interoperability, primary software spending costs, legal issues about design liability and level of required training (Wood, Davis and Olatunji, 2011; Hardin and McCool, 2015).

Table 18 Potential benefits of BIM to project management (Xiao and Noble, 2014).

Potential BIM Benefits to Project Management	Rationale
1. Project programme and budget control	A BIM model can instantly update both the programme and budget when modifications are made to the design.
2. Design team collaboration	A BIM model can enable the impact of changes to be fully analysed and thus the scope can be monitored to enable the PM to liaise easily with the design team and clients.
3. Subcontractor control	Increased knowledge on clash detection changes, information requests, etc. results in sub-contractor work becoming more predicTable.
4. Request for Information (RFI) and change orders	The increased certainty brought about by BIM should result in a marked reduction in the number of changes and RFI's.
5. Progress monitoring	By utilising BIM, the PM has more tools available to understand and report on progress.
6. Client understanding	The client can understand a virtual model far easier than a 2D drawing, thus increasing understanding and satisfaction about the end product.
7. Project closure	BIM captures O&M information which can be used throughout the life of the building. This also saves significantly on administration costs as well as on-going management.
8. Mandatory BIM and growth	As clients increasingly request BIM, the PM firm can become skilled and grow faster than competitors.

Although O'Grady (2013)states that the indispensable requirement for implementing BIM is project-level change, but Xiao and Noble (2014) did not detect any major improvements in project performance in terms of cost, time and quality or the way in which projects adopting BIM were managed. Consequently, accepted and well-structured practices of construction management cannot easily change by BIM in a short time. Therefore, to attain improvements in project performance it is essential to align BIM tools with available project management practices (Davies and Harty, 2013; Smits, van Buiten and Hartmann, 2017). To encourage practitioners for adopting BIM, It has been suggested to implement elements of BIM which possess fewer obstacles to implement and provide short-term benefits (Jacobsson and Linderoth, 2010).

Considering the studies conducted by authors (Smith and Tardif, 2009; Xiao and Noble, 2014) investigating the experience of PMs who used BIM in their projects, several issues have been detected. Although communication within the project team can be improved through interlinking BIM and integrated project delivery (IPM) but there is no remarkable evidence of such change in this phase. Dossick and Neff (2010) point out that while connections between project team members have become visible by BIM, no development in closer collaboration of different companies has been observed. Also, because team members may come from different departments of a company or different companies and as they are physically separated; so the end model may be designed in collaborative way but the processes are not. Therefore, project manager will not confront any particular change and same issues are still arising in process of managing projects. Consequently, although deliverables are differentiated but project managers still have to pursue the updates and deadline in same way as current approaches.

Merschbrock and Munkvold (2012) reviewed the literature on Building Information Modelling (BIM) in the construction industry, highlighting its advantages and challenges. BIM's advantages include improved collaboration, increased design transparency, swift design visualization, enhanced decision support, and error-free design. BIM also facilitates effective information sharing among stakeholders and can potentially revolutionise organisational processes and improve construction site safety (Ahmad et al., 2010; Bansal, 2011). However, challenges in adopting BIM include the complexity of implementation, transition costs from 2D CAD, legal uncertainties, and data interoperability issues (Merschbrock and Munkvold, 2012). Researchers suggest using project Information Delivery Manuals (IDM) to address interoperability problems (Merschbrock and Munkvold, 2012). BIM adoption impacts daily work practices, organisational culture, and structure in construction companies (Merschbrock and Munkvold, 2012). Furthermore, advancements in 4D and 5D CAD applications can potentially enhance BIM's utility by connecting scheduling functions, cost estimates, and BIM models, enabling better evaluation of design alternatives and their financial impacts (Shen and Issa, 2010; Merschbrock and Munkvold, 2012).

Pointing out the articles establishing the roadmaps for BIM research, Merschbrock and Munkvold (2012) emphasise the inevitable need to investigate BIM's potential in changing the organisational processes and practises within the construction industry. Plus, they claim that BIM research requires a broader perspective that incorporates "functional affordance" and "human agency" to provide an understanding of how well BIM serves the goals of its users. According to this definition, a technical object's functional affordance is "a connection between a user group and a technical object that specifies what the user may be able to accomplish with the object, given the user's skills and aims." Merschbrock and Munkvold (2012) argue that current BIM research covers the connection of technical and social elements sparingly; they believe that BIM research should be strengthened in this regard. Also, they claim that the relationship between BM and organisational culture is not properly studied, as using shared information technology affects the identity and practises of organisations reciprocally. Furthermore, tensions resulting from different organisational backgrounds and a lack of fit between the players' organisational cultures may produce disputes that have a detrimental impact on the communications of actors in the building project. Plus, their research supports the claim that BIM's "transformational power" to revolutionise and change the way AEC businesses do business is not properly understood.

Arayici et al. (2012) used a case study methodology to show how BIM adoption in an architectural company can mitigate management and communication problems in remote construction projects. The case study was a UK Knowledge Transfer Partnership project between the University of Salford, UK and John McCall Architects (JMA) that elaborated and justified BIM use between the architectural company and the main contractor for a remote construction project. According to Arayici et al. (2012), BIM adoption during the design stage can significantly reduce issues like poor quality construction, material unavailability, and ineffective planning and scheduling.

However, BIM has limitations in the information collection process, necessitating further development to enhance the effectiveness and efficiency of design (Arayici et al., 2012). Challenges also exist in integrating the business processes of individual practices. BIM provides advantages in correcting aspects of the architectural process, such as enhancing consistency through automation, preventing 3D geometric errors, reducing specification errors, assisting with interdisciplinary coordination, and enabling dimension-driven design and automated code compliance (Arayici et al., 2012).

Despite challenges in information exchange consistency, BIM offers significant benefits like 3D printing, automated animations, and virtual environments for efficient communication between stakeholders (Arayici et al., 2012). The case study found that working on a 3D model helped avoid misunderstandings, order the correct materials, manage site activities remotely, and monitor site progress in relation to planning and safety.Finally, from the implementation of BIM in their case study, Arayici et al. (2012) concluded it can bring forth the following advantages:

- Information such as house types, materials used, codes for sustainable home ratings, and clients are all centrally stored in knowledge databases, allowing for effective reuse of information.
- Storing experiences and lessons learned from past projects.

- Consistent information sharing with internal and external stakeholders for successful collaboration and communication.
- Enabling the stakeholders in the remote construction project to compare, examine, and correct the information shared between them.
- By automatically producing instant VR model generation, quantity takeoff, drawings, design error detection and conflict analysis, greater customer flexibility, information sharing and exchange, and simultaneous work by company employees, automation via BIM led to quality, time, and cost-efficient practices.
- The ability to check drawings for accuracy and consistency to ensure timely site material procurement.
- BIM makes it easier to design and technically review projects effectively so that future issues like changes to specifications, misuse of specified materials, and inefficient planning and scheduling can be avoided.
- Streamlined design process
- Effective sharing of information with external stakeholders.
- Automation of emails and faster access to useful information via the knowledge database.

Smith (2014) studied the role of cost management professionals in executing and evolving BIM and associated global issues in the construction industry. The paper by Smith (2014) explores the implementation of Building Information Modelling (BIM) and its various dimensions, including 4D (time), 5D (cost), 6D (as-built), and beyond. Detailed interviews with quantity surveying firms in Australia were conducted in order to compile the paper. The author emphasises the importance of project cost management professionals adopting 5D BIM to become critical players within the BIM environment.The integration of time and cost dimensions into BIM generates a 5D model that can reduce estimation time and increase accuracy, leading to improved productivity and cost optimization. BIM can also be expanded to include facility management, sustainability, and safety elements (Smith, 2014). He further asserts that despite the benefits of BIM, fragmented approaches and quality concerns hinder its effective implementation, requiring government leadership and multidisciplinary project teams to adopt a coordinated approach. Smith (2014) concludes that the transition to BIM competence and knowledge requires a re-evaluation and re-engineering of business operations and significant employee training and development.

Talebi's (2014) paper focuses on the benefits, challenges, and impacts of BIM (Building Information Modelling) in managing construction projects. The author argues that BIM adoption has been slower than expected due to industry reluctance and insufficient understanding of the benefits it can provide. Talebi (2014) found that BIM technology can facilitate decision-making, improve communication and collaboration, and reduce costs and time in all stages of the project lifecycle. BIM adoption, however, poses several obstacles that must be addressed, including technical, process-related, social context-related, and cost-related barriers (Talebi, 2014). Moreover, the author identified the need for universal guidelines to quantify benefits in the design, construction, and post-construction stages (Talebi, 2014). The study emphasizes the importance of BIM in creating value-enhancing decisions, minimizing rework, and managing costs and quality variables efficiently. Furthermore, the paper highlights the potential for BIM to improve facilities management, energy and sustainability analysis, and compliance with regulations. Ultimately, BIM technology is considered a facilitator of innovation that reengineers all impacted processes before developing new business processes and strategies (Talebi, 2014).

BIM can provide economic incentives and a win-win situation for all stakeholders, but legal concerns regarding ownership, payment, and responsibility for data sets and their accuracy pose challenges (Talebi, 2014). Successful implementation requires stakeholders to adjust to changes in the technological and social environment, and training is essential for effective use. Technical obstacles, such as interoperability and integration issues between stages, limit communication and information-sharing between participants. However, the creation and application of open BIM standards, such as COBIE and IFC, can address these issues (Talebi, 2014). Additionally, BIM software tools need to be adaptable to fit production and FM processes. BIM technology costs are typically less than 2% of total net revenue and include expenses related to software acquisition, essential hardware, project team training, and the development of the building information model (Talebi, 2014).

In conclusion, Talebi (2014) states that the benefits of BIM have yet to be unambiguously and empirically proven to assure that its use helps the overall outcome of a building project. Talebi (2014) adds that measuring advantages necessitates extensive research on characteristics that might indicate values contributed by BIM.

3.6.2BIM Impacts and Maturity Level o the Organisation

Won et al. (2013) state that there are a number of reasons why BIM adoption has not yet achieved its full potential around the world, including technical issues such as investment, interoperability, and training, as well as organisational issues such as professional liability, intellectual property, trust, and process problems. Using the findings from the work done by Lee (2007), Won et al. (2013) argue that the adoption of BIM can be broken down into four phases based on the level of organisation involved in the project. The first phase includes personal adoption, in which a BIM model is produced and maintained by a single modeller without any collaboration with others, while the resultant data may be used by others. In this regard, Won et al. (2013) exemplify the designing and producing of drawings by a single architect without data exchange with others or the production of a BIM model by a subcontracted modeller, which is not actively used in a project but can be used for presentation purposes at a client's request. This can be regarded as one of the elementary benefits of BIM in projects. In the second phase, according to Won et al. (2013), BIM is adopted within a firm's team, where the same type of BIM tool is used by several team members to collaborate on a project, such as developing an architectural model to be used only by architecture staff. Thus, making collaborative working possible in projects can be regarded as another benefit of BIM in this phase. Won et al. (2013) argue that the third phase constitutes the adoption of BIM across various types of teams in a firm, such as developing a BIM model by a team and sending it to a scheduler or estimator within the same organisation. The fourth phase, as Won et al. (2013) discuss, includes inter-organisational or between-firm adoption of BIM where coordination across various firms with different BIM capabilities in terms of electrical, mechanical, and plumbing results in more complex collaboration, coordination, and interoperability issues between BIM tools. An example of such adoption is where sharing models is required from detailers for clash detection and consolidation purposes, which in turn can be concluded as other benefits of BIM adoption in companies.

3.6.3Integrating BIM With Project Management Processes

Lucas et al. (2009) claim that often, the information defined and generated during different project processes is only developed and stored in a format and level of detail sufficient for the process in which it was created. This causes the information to be reworked in order to support a later project process. Lucas et al. (2009) researched the use of Building Information Modelling (BIM) tools and methods to support project management processes throughout the project lifecycle. The authors proposed a Work Task Information Framework (WTIF) for integrating work tasks, geometric assemblies, and various information categories based on RSMeans' assembly hierarchy which is presented in Figure 12 (Lucas et al., 2009). They evaluated the capability of three common BIM software packages (AutoCAD REVIT, Bentley Architecture, and VICOTM Constructor) and concluded that the AEC industry does not have a standard framework for integrating project assemblies with lifecycle processes and project information. By using the WTIF, information can be stored in a format that permits easy retrieval and recall, reducing the amount of recalculation required in multiple processes. The proposed framework is intended to be integrated with the BIM to process and manipulate information and models through the use of process applications such as model-based scheduling and visualization, procurement tools, estimation tools, design-to-manufacturer tools, and facility management support tools. The authors claim that BIM could help save time and money by making it easier to share information and reduce the number of change orders (Lucas et al., 2009). However, the software versions used for the analysis may be outdated, and the framework needs to be evaluated through the analysis of more case studies to validate the information categories and prove their applicability.

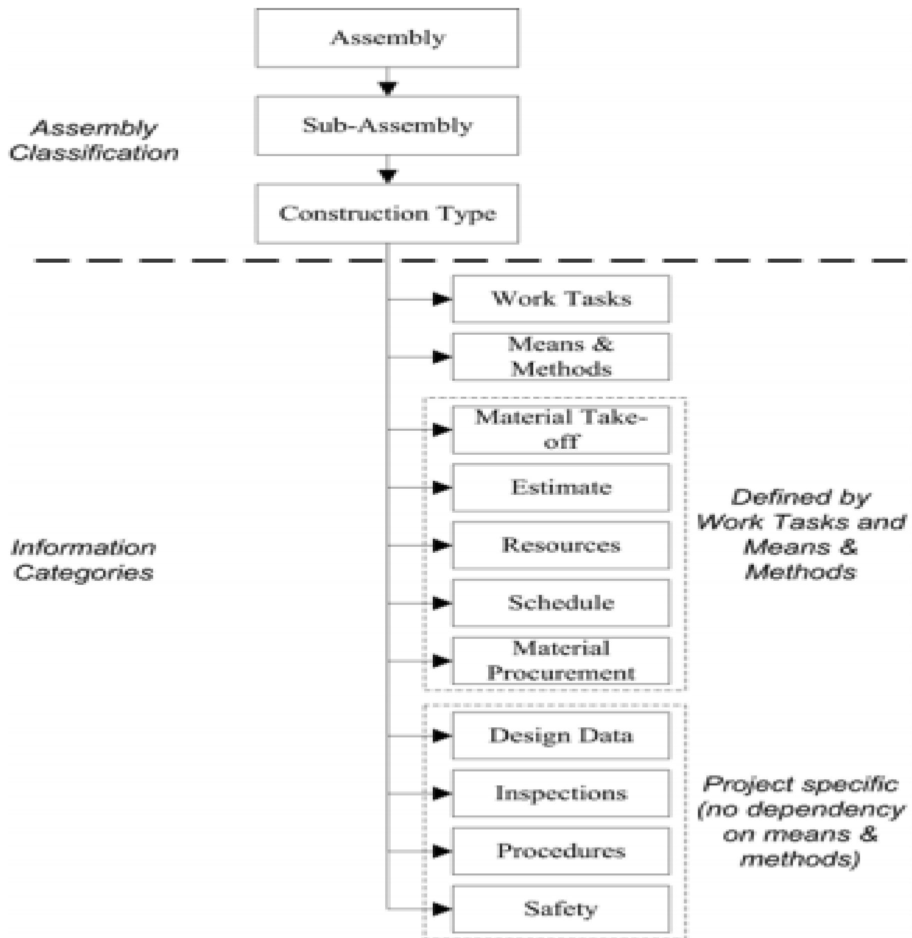

Figure 12 Analyzing Capacity of BIM Tools to Support Data Use across Project (Lucas et al., 2009, p.3).

3.6.4Mapping the Dynamics of BIM Implementation and Competencies

In another study, Succar (2009) examined publicly available global guidelines and presented the BIM Framework, which serves as a foundation for research and delivery. The paper provides a comprehensive overview of the conceptual parts of BIM, including stages, fields, lenses, and steps, and includes examples of their application and a list of the Framework's deliverables. Additionally, visual knowledge models and a specialised ontology are utilised to represent domain concepts and their relations (Succar, 2009). In this paper, the BIM Framework is introduced as a foundation for research and delivery within the AECO industry (Figure 13). It aims to map the dynamics of the BIM domain, allowing stakeholders to comprehend the underlying knowledge structures and negotiate BIM implementation requirements. The framework is multi-dimensional and can be visualised as a tri-axial knowledge model, consisting of BIM Fields of activity on the x-axis, BIM Stages of implementation maturity on the y-axis, and BIM Lenses providing the necessary depth and breadth of inquiry to identify and assess BIM Fields and BIM Stages on the z-axis (Succar, 2009).

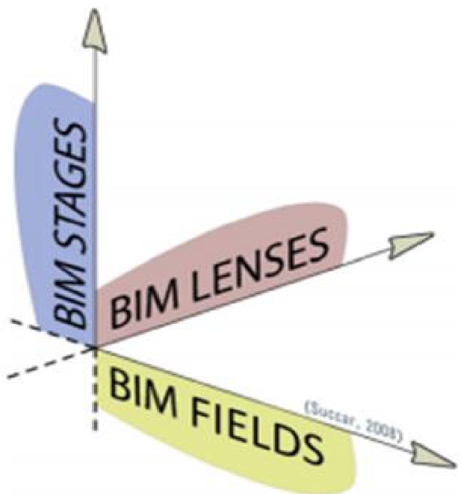

Figure 13 BIM Framework: Fields, Stages and Lenses tri-axial model (Succar, 2009, p.360)

According to Succar (2009), the BIM Framework introduces three interdependent fields of activity, namely Technology, Process, and Policy (TPP), each with two sub-fields: deliverables and players. The Framework also identifies various stages of BIM implementation maturity within organizations, projects, and industries, which are subdivided into steps. The exchange of BIM data involves the transfer of semantically rich objects and document-based information, which can be classified and measured against BIM maturity stages in various ways (Succar, 2009). The third dimension of the framework is represented by BIM lenses, which are distinct layers of analysis that generate knowledge views by selectively focusing on any aspect of the AECO industry and controlling its complexity by removing unnecessary detail. These lenses abstract the BIM domain and generate knowledge views that either highlight observables meeting research criteria or filter out those that do not.

In terms of BIM's impacts, Succar (2009) claims that BIM is widely regarded as a change agent with the potential to address various challenges faced by the Architecture, Engineering, Construction, and Operations industries, such as fragmentation, inefficiency, and high interoperability costs. Its implementation is expected to bring about significant improvements, making the industry more effective and efficient. A fully mature BIM ecosystem is expected to facilitate integrated project delivery (Succar, 2009). Although this paper is a "scene-setting" paper and excludes many non-foundational framework parts, future publications are needed to address these gaps. Besides, additional study and publications are necessary to produce a more comprehensive knowledge of the BIM domain and to expand the Framework's research potential, academic status, and industry outputs.

In another research, (Succar, Sher and Williams, 2013) argue that to meet changing market demands, businesses and academic institutions have started implementing BIM software tools. These authors claim that for the purpose of performance improvement, it is critical to identify the BIM competencies that must be learned, enacted on the job, and measured. Thus, Succar et al. (2013) conducted research in which the method for filtering, categorising, and combining individual BIM competencies into a seed competency inventory was examined. A specialised knowledge engine is then fed with competency items to produce flexible workflows, learning modules, and assessment tools. The paper also explores future conceptual and tool development efforts to enable industry-wide BIM performance assessment and improvement. It concludes by discussing the many benefits that this competency-based approach offers to industry and academia. Succar et al. (2013) define individual BIM competencies as a combination of personal characteristics, technical abilities, and professional knowledge that permit an individual to carry out a BIM activity or deliver a BIM-related output. These abilities, actions, or outcomes must be measured in comparison to performance criteria and may be gained or improved through education, training, and/or development. Also, Succar et al. (2013) organised BIM competencies into meaningful, mutually exclusive, and exhaustive clusters. They argue that by decomposing a large system into smaller subsystems, this type of clustering is goal-driven and serves to simplify the system. Their proposed hierarchy is comprised of several levels, such as competency tiers, sets, and topics. Inductively, cluster names within tiers, sets, and topics have been inferred from literature through observation and discovery (Succar et al., 2013).

Furthermore, Succar et al. (2013) argue that utilising BIM competency items for implementing an activity or delivering an outcome can be done in various ways, such as: Create task lists to facilitate the initiation of projects and processes (e.g., a step-by-step guide for importing geometry data) and the quality-checking of project deliverables (e.g., a quality check list for an audit of a model). Clarifying BIM execution activities, collaboration processes, or data exchange through the production of standard work flow diagrams, mind maps, and similar charts Prepare a list of project requirements for the purpose of procuring services, like populating a request for proposal or qualification.

3.6.5BIM and Quality Control in Projects

Using a product, organization, and process (POP) data definition structure, Chen and Luo (2014) investigated and discussed the advantages of 4D BIM in a quality application based on construction codes. In addition, an evaluation of the proposed 4D BIM application for quality control at the Wuhan International Exhibition Centre is provided as a case study. Chen and Luo (2014) explored the advantages of 4D BIM in construction projects, highlighting its potential to improve design quality, reduce rework, and eliminate conflicts. However, they note that BIM's use in construction quality control and efficient information utilisation has been understudied.

BIM technology can enhance construction and quality control processes by altering how project participants interact, providing a tool for coordinating and visualising architecture, engineering, and construction work, improving productivity, preventing errors and omissions, and supporting quality management, safety, cost, and schedule (Chen and Luo, 2014). BIM has been found to be beneficial in preparing schedules and estimates, tracking and managing changes, and managing logistics on a construction site.

BIM improves design quality in various ways, such as enhancing communication and evaluation, increasing precision and efficiency, reducing errors and conflicts, conducting simulation and optimization, producing consistent and precise information, and providing relevant and timely information to facility management (Cheng and Wang, 2010; Han et al., 2012; Kim et al., 2012; Chen and Luo, 2014).

Chen and Luo (2014) suggest that BIM's extensive data for each construction product can be used to automatically assess the significance of differences between design and as-built conditions, and monitor progress continuously. BIM technology can also improve collaboration by allowing all team members to work more accurately and effectively. Furthermore, BIM information can be combined with other advanced technologies to enable unlimited uses, such as linking digital to physical entities.

Chen and Luo (2014) define that during the construction phase, quality control is concerned with inspection and testing, as well as reporting non-conformances and taking corrective actions. Moreover, they incorporate the BIM quality model into the overall process of quality inspection, as shown in Figure 14. Chen and Luo (2014) explain that, based on the work plan, the inspection plan, and the characteristics of the project, a quality control plan is first developed. In the second step, when a contractor requests a quality checklist, the corresponding checklist is retrieved from the 4D BIM-based construction quality model, according to the process of construction activities and work classifications. As a third step, the field measurements and test results required on the checklist are recorded during the inspection. Plus, the automatic generation of comparisons between design requirements and construction results constitutes the fourth step. A non-conformance report (NCR) will be issued if the lot does not meet the specific requirements listed in the BIM-based quality model. Otherwise, the decision will be made to accept the lot and proceed to the next phase of the process. In the final step, the feedback generated from the inspection work will be reflected in the model, and both the inspection plan and the model will be updated. Although Chen and Luo (2014) presented this model by undertaking quality inspections using the BIM quality model, it can also present an opportunity to manage scope changes and prevent unexpected scope creep by evaluating the impacts of changes in the scope of the project on other aspects.

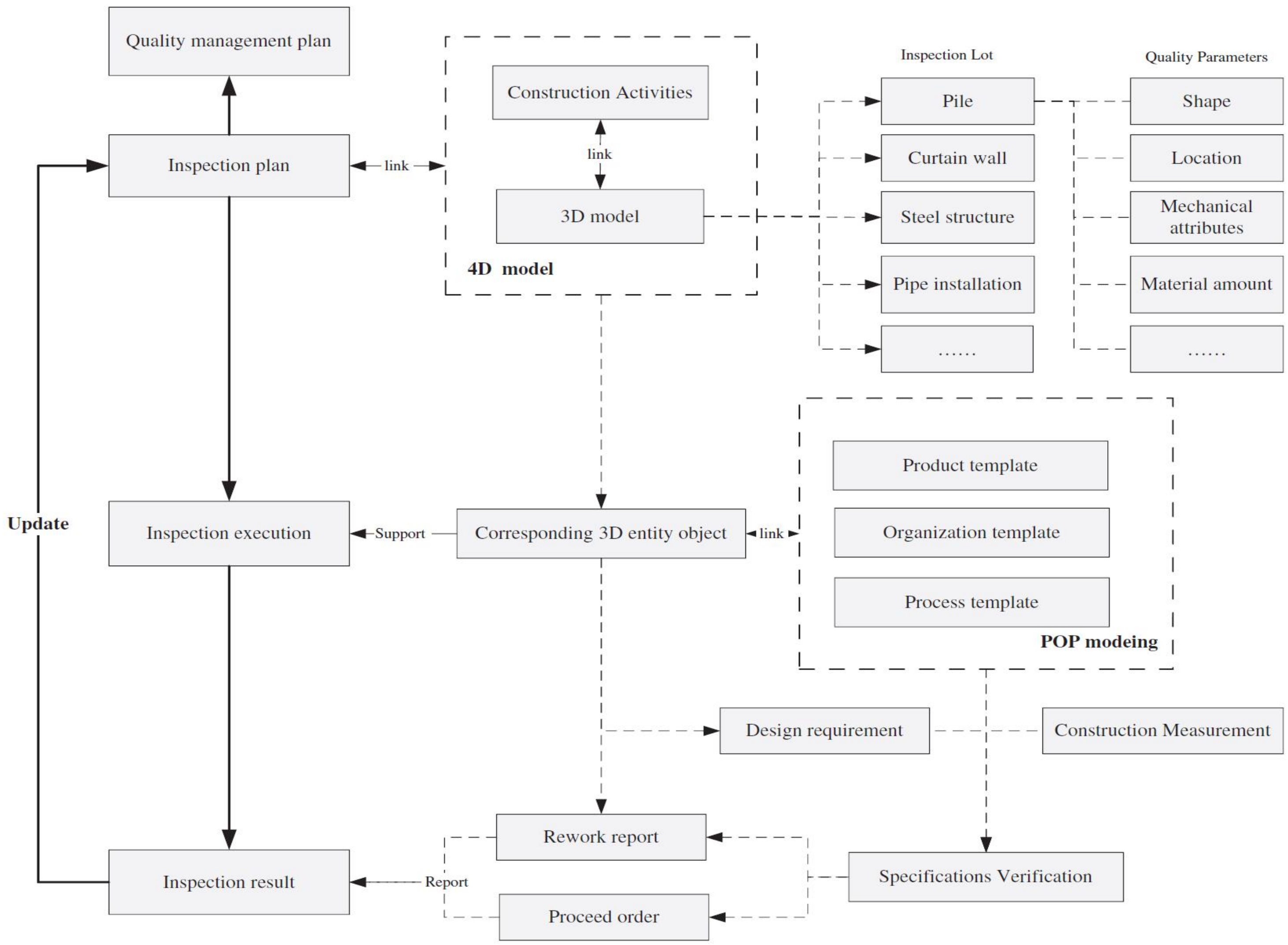

Figure 14 The execution of construction quality management inspection plan using BIM quality model (Chen and Luo, 2014, p.66)

Chen and Luo (2014) argue that for quality management purposes, it is important to organise and enrich the BIM data to construct the full set of interrelationships. Hence, using process and organisational models in conjunction with 3D product models, the Product, Organization, and Process (POP) modelling method has been proposed to support design and construction. Chen and Luo (2014) explain that a POP model method and a BIM model are combined to create a BIM-based construction quality model, where the construction product from the POP model is created to match the BIM component from the BIM, as shown in figure 15. In this framework, according to Chen and Luo (2014), first a product template should be selected for inspection based on the progress of the 4D BIM-based construction project. Then, the template will be completed with the required on-site data. Third, the compliance analysis will be done by analysing the integrity of the data and deviations. Finally, the results of the quality inspection will be provided for schedule adjustments and 3D model feedback.

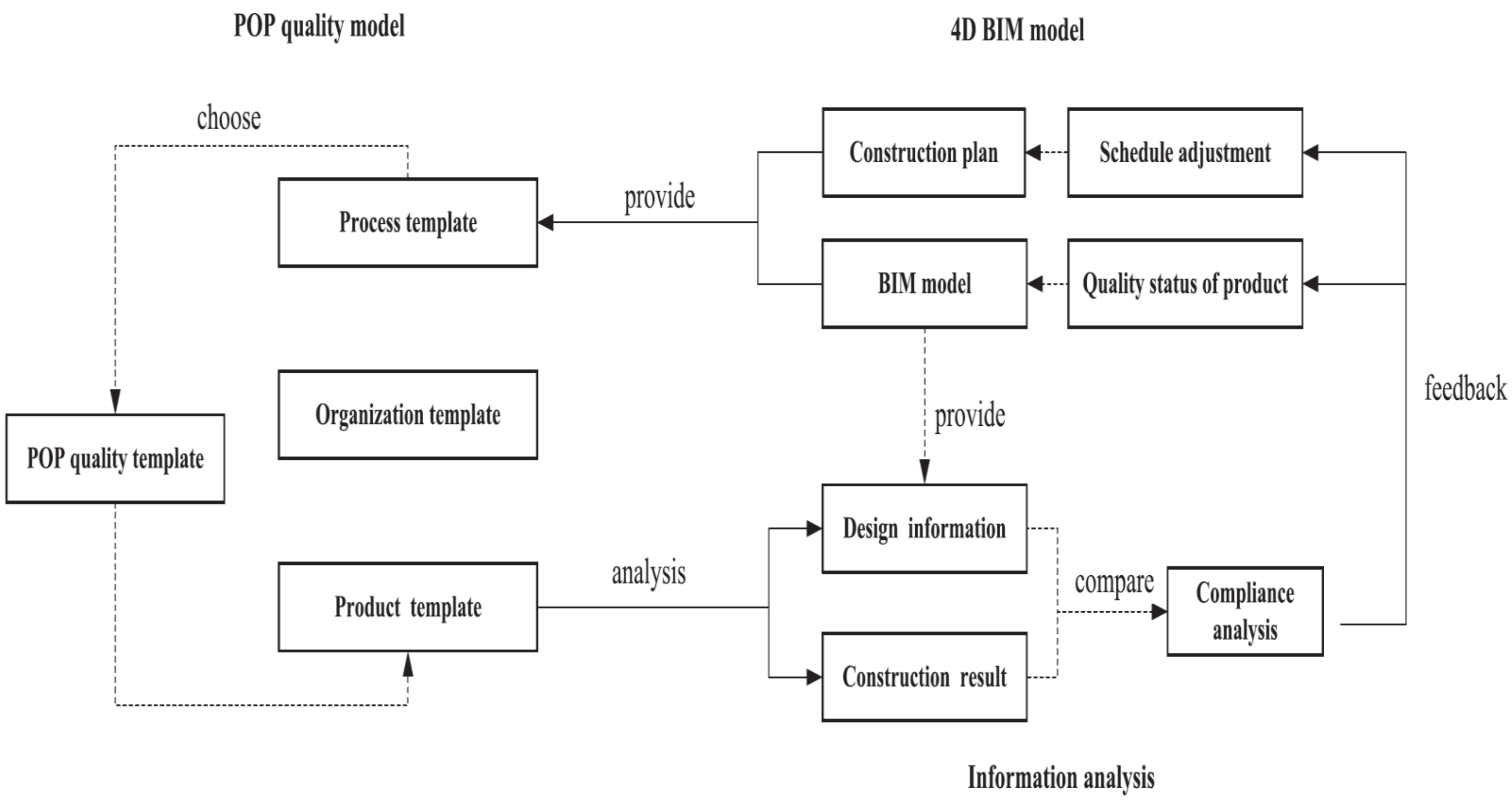

Figure 15 Framework of BIM-based construction quality model (Chen and Luo, 2014, p.69)

Additionally, Chen and Luo (2014) proposed a workflow be developed after the construction of a BIM-based quality model, as presented in Figure 16. Chen and Luo (2014) explain that after the completion of an inspection lot for the last task completed but before the start of the next task, a request for acceptance begins the quality control process. Then the continuous and real-time data compliance analysis, deviation analysis, and integrity analysis will be undertaken by inputting the collected data from the construction site into the template. Subsequently, the project will proceed to the next task if the inspection lot passes the acceptance inspection. In the event that the inspection lot is found to have failed, an NCR report will be generated with corrective actions. Upon completion of the corrective actions, the entire process will be repeated. Plus, to facilitate readability and ease of use for quality managers, the result is visually displayed in the BIM. According to Chen and Luo (2014), this approach reduces the need for repeated data entry in different forms for data analysis, data sharing, and communication since the data input is taken from the BIM-based quality model and shared throughout the construction process. The BIM-based quality model is also developed and processed based on the information collected on-site.

Overall, the process created by Chen and Luo (2014) provides useful inspiration for using the same approach to treat scope change and scope creep in projects and even manage the influence of stakeholders on the scope of the project. In this regard, quality control inspections can be employed to analyse the potential changes in the scope together with their impact on aspects of time and budget or other tasks and work packages.

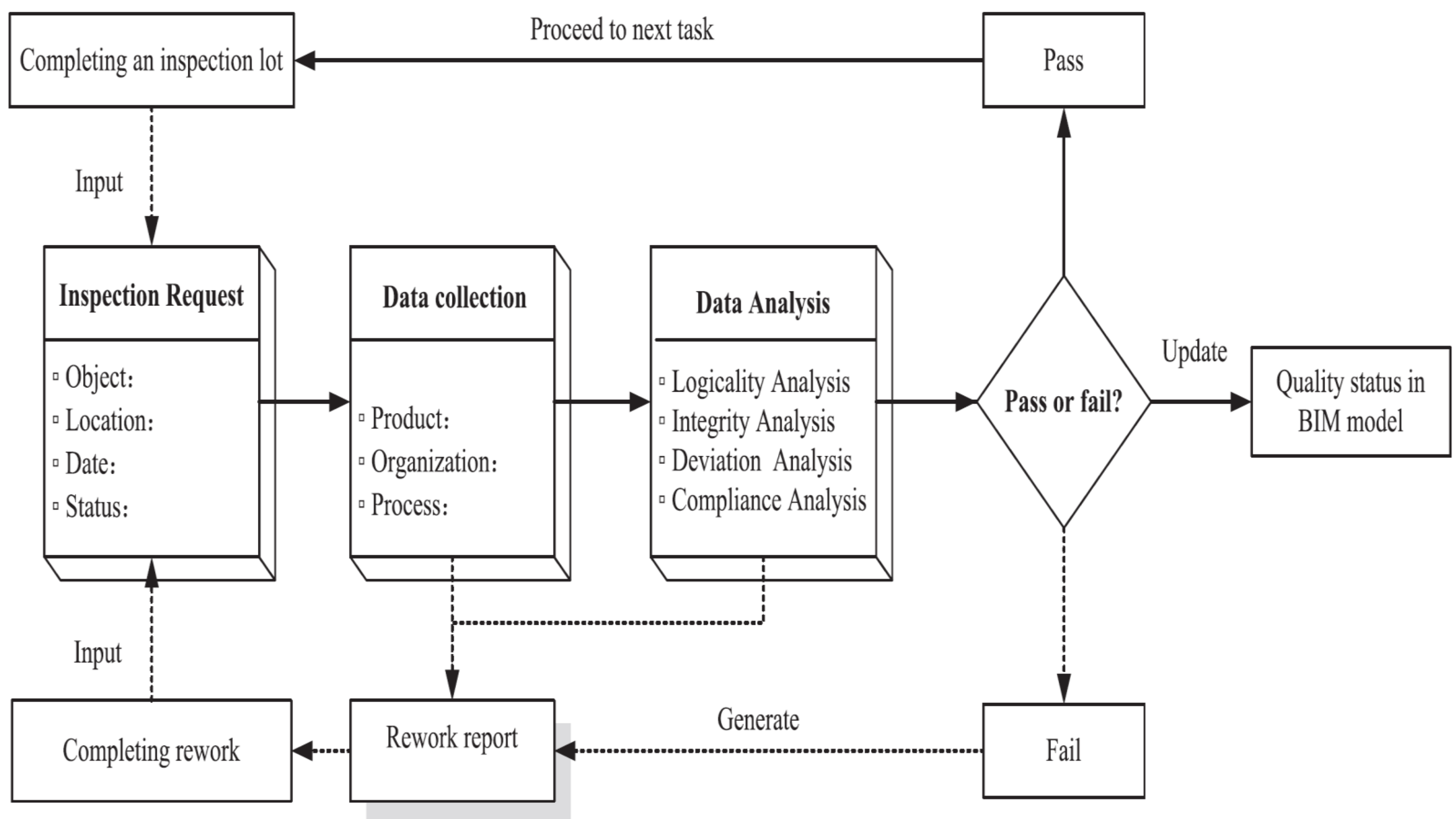

Figure 16 Workflow of BIM-based construction quality model (Chen and Luo, 2014, p.69)

Plus, Chen and Luo (2014) applied their proposed BIM-based quality model to the Wuhan International Exhibition Centre project and studied its applicability during the jet grouting process. Finally, they conclude that to comprehend issues with quality flaws or non-conforming works and monitor remedial action, participants might use the BIM-based construction quality model. Because of the visible data format, it allows project participants to collaborate more efficiently and better grasp the quality progress. However, some of the flaws in the developed BIM model include the lack of temporary structures like scaffolding or formwork and issues with the possibility of using the model on mobile devices to record field data. Plus, Chen and Luo (2014) tested their model in the jet grouting process in a single case study, and further studies during all project stages and in other countries like the UK might be needed to validate the findings.

3.6.6BIM Implementation During the Project Lifecycle

Xu et al. (2014) claim that BIM has been widely utilised in project management but has not been implemented across the entire project's life cycle. One issue is the integration of fragmented and dynamic data as each participant creates their own BIM. Xu et al. (2014) propose a framework for BIM-enabled information management during the project lifecycle, focusing on BIM-based lifecycle information management.

Traditional approaches led to scattered information due to the absence of effective information-sharing platforms, causing a lack of effective utilisation of life cycle management in projects (Xu et al., 2014). BIM can improve the information management process by facilitating an integrated method of project flow and delivery using semantically rich 3D digital building models throughout all stages of a project's life cycle (Zhang et al., 2011). However, BIM's potential in life-cycle information management is not fully realised (Xu et al., 2014).

Despite the widespread use of BIM in construction projects, participants create their own BIM, and the model is not delivered from one team member to another, leading to a bottleneck in BIM development during the construction and operation phases (Xu et al., 2014). To ensure information can be retrieved and reused, Xu et al. (2014) suggest setting up a framework for model-based information management.

Xu et al. (2014) categorised the information domain into two groups: information components and information flow, and described the information components in the phases of design, construction, and operation, namely D-BIM, C-BIM, and O-BIM. Accordingly, Xu et al. (2014) explain that D-BIM includes the information created in the design phase, such as the client's construction intentions, functional requirements, and standards of the proposed project. Based on the design content, these authors categorised the information in the design phase into six groups: public information, similar projects information, project location information, survey and design information, bidding, contract, and economic information. Subsequently, the C-BIM contains the information created in construction activities, which is diverse and complex due to the nature of activities in this phase. Moreover, Xu et al. (2014) divided the construction phase into three sub-processes: preparation, construction, and handover and defective obligation. In addition, they classified the information produced during the aforementioned sub-processes into three groups, such as general, organisation-specific, and project-specific information. As part of their study, Xu et al. (2014) examine how to manage project-specific information on site during the actual construction phase. In regards to components of information in the operation phase, Xu et al. (2014) argue that it includes general, project-related, and facility management information. Xu et al. (2014) claim that although there are three different portions of the BIM—the D-BIM, the C-BIM, and the O-BIM—information within each is not isolated. Thus, it is possible to establish information in the sub-BIM by extracting, extending, integrating, and adding new information to the previous sub-BIM.

3.6.7Impacts of BIM on Time and Cost Planning

Pučko et al. (2014) investigated the use of the BIM approach for time and cost planning in construction projects and proposed several steps. These steps include developing a 3D model of the construction object, importing the 3D model into an appropriate BIM construction management software, estimating the project costs according to criteria such as required resources, production and consumption rates, and unit costs, defining project activities, linking activities to the relevant elements in the 3D model, updating the allocated resources and costs within the model, mutually connecting the activities with established durations into a project network plan to generate the project duration automatically, upgrading the 3D model with the defined cost and schedule data. Also, an example of how BIM can be implemented in the AEC industry is presented in the paper in order to illustrate its advantages, based on the Vico Office R4 software application and findings from a medical faculty complex in Mribor, Slovenia. According to Pučko et al. (2014), a major challenge in managing construction projects using BIM is synchronising multiple data formats in a dynamic manner between the modelling software and other applications. BIM, on the other hand, aims to generate 4D models through the combination of 3D building models and scheduling information. By combining these, it is possible to produce both an animation of the construction process and a schedule associated with the 3D model. Pučko et al. (2014) state that, for successful construction businesses, accurate estimation and planning of actual project costs are also essential. In this regard, they argue that it is possible to manage construction project costs more efficiently by handling project cost data using a BIM approach. It is possible to create the 5D building information model as soon as the construction costs are identified and linked to the scheduling data and construction elements. However, the interoperability of the BIM programmes with cost estimation tools for wider use, is another challenge of BIM application mentioned by Pučko et al. (2014). Additionally, there was a lack of appropriate costing methods for the detailed calculation of construction costs in BIM applications that are transparent enough and include all required cost components such as material, labour, energy, investment, etc. According to Pučko et al. (2014), the Vico Office R4 (2012) software took a significant step forward in making the combination of BIM applications, scheduling tools, and cost estimation programmes more widely applicable. Vico Office R4 is a software programme that can be used to plan the time and cost of a construction project based on BIM. Pučko et al. (2014) claim that by implementing BIM techniques in their work, project participants can contribute to a more efficient management of construction processes using Vico Office R4. Participants in the project must, however, be willing to adapt to new approaches and alter their current work methods. Also, Pučko et al. (2014) identified and summarised the benefits of integrating BIM into the project scheduling process as follows:

- All of the information is gathered in one location and updated.
- Minimising the misconception risk.
- All construction changes and modifications have an automatic impact on other relevant sections of the model data.
- There is a dynamic link between all of the information and the building model.
- The availability of data for use at any moment, including the number of items, deometrical quantities, the needed resources, project activities implementation duration, costs, and other data.

Other benefits of using BIM for cost and time planning, according to Pučko et al. (2014) include the enhancement of project management in large scale construction projects where cost effectiveness, construction time, and quality of the building are set as crucial goals of the project.

3.6.8BIM and Disaster Management

The article by Dakhil and Alshawi (2014) investigates the potential benefits of utilizing Building Information Modelling (BIM) for managing building disasters. The authors argue that clients should play a proactive role in ensuring that structures are robust to various catastrophe hazards, and that BIM can assist in improving building disaster management through the provision of highly accurate information. The study presents a new conceptual framework depicting the link between BIM application advantages and client organization maturity levels, which can assist clients in understanding and monitoring the benefits of BIM in managing building disasters (Dakhil and Alshawi, 2014).

The article highlights that the use of BIM can enhance disaster and emergency planning by providing access to critical building information for emergency responders, improving their efficiency and minimizing potential safety risks (Dakhil and Alshawi, 2014). BIM can also provide information in advance, enabling managers to be proactive in managing disasters, and facilitate the assessment of post-disaster damage. The authors argue that stakeholders, particularly clients, can stimulate innovation for obtaining the critical advantages of BIM, such as facilitating disaster management, and that a lack of comprehension of the benefits and necessary conditions for reaping these benefits is a barrier to the widespread acceptance of BIM in the construction industry (Dakhil and Alshawi, 2014).

Furthermore, Dakhil and Alshawi (2014) argue that different BIM applications can be used at different stages of a project lifecycle based on the capabilities of users and expected benefits. They identify three main BIM applications that may facilitate disaster management: existing condition modeling, site planning, and disaster planning. The authors highlight the benefits and requirements of each BIM application, including accuracy and efficiency of representation and documentation, contribution to future modeling and 3D design coordination, visual depiction of completed work, quantity verification for cost estimation, improved decision-making for site selection, enhanced safety and energy efficiency, and real-time information for emergency responders (Dakhil and Alshawi, 2014).

Finally, the study suggests that BIM can establish a new collaborative environment where all stakeholders in the project can exchange information early in the project lifecycle. The client can receive immediate and valuable benefits from this new information sharing process, particularly a complete understanding of the project. Overall, the article highlights the potential advantages of BIM for managing building disasters, while also identifying challenges and requirements for reaping these benefits (Dakhil and Alshawi, 2014).

The findings of this study need to be validated through the collection of data from real-world projects. Another limitation of this study is that the authors focused on the client organisations only. Plus, Dakhil and Alshawi (2014) state that in future studies, the benefits and requirements of all BIM applications can be examined during the project life cycle.

3.6.9BIM and Risk Management in Projects

Tomek and Matějka (2014) conducted a study to explore the relationship between Building Information Modeling (BIM) implementation and risk management in the construction market, where BIM is not yet widely used. They found that one of the most significant benefits of BIM was its impact on risk management. However, construction companies often find it difficult to justify BIM implementation when clients do not require its use (Tomek and Matějka, 2014). The study identified and analysed the risks associated with the implementation processes and the risks related to the actual use of BIM in a construction company. The authors suggest that understanding BIM-related risks is crucial for evaluating the advantages and disadvantages of BIM implementation. BIM can be utilised throughout the entire life cycle of a project and in various fields, including budgeting, time planning, site analysis, certification, and standardisation (Tomek and Matějka, 2014). The authors argue that the methodology group, which determines how tools interact and how they can be used, is more complex and critical to the success of BIM implementation in a construction company. Ultimately, the authors found that understanding BIM-related risks is essential to build stronger arguments for BIM implementation in construction companies (Tomek and Matějka, 2014).

Tomek and Matějka (2014) argue that Building Information Modeling (BIM) can significantly impact risk management in construction projects. While there are risks associated with BIM implementation, such as legal and financial risks, BIM also offers benefits, including improved communication, reduced costs, increased efficiency, and better risk management (Tomek and Matějka, 2014). The authors classify risks as implementation and post-implementation risks and suggest that proper risk management can help optimise the overall BIM implementation process. To ensure successful BIM implementation, stakeholders must adjust to the changes in the technological environment, as well as be mindful of the surrounding social context. Furthermore, the creation and application of open BIM standards should be promoted to solve interoperability issues. Finally, the calculation of future costs and benefits and their integration present a significant challenge, as they result in a high degree of uncertainty that must be managed (Tomek and Matějka, 2014).

3.6.10 Advantages of 4D BIM

Brito and Ferreira (2015) conducted a survey of Brazilian construction professionals to explore the use of 4D modelling in construction project management. The study found that 4D modelling can collect and organise critical information at different project stages and assist in visualising planning and work progress. The study evaluated different strategies for representation and analysis of 4D modelling and found that the use of colour for differentiating internal activities, alternatives for physical advance monitoring, and planned vs. realised schedule simulation were highly regarded by participants (Brito and Ferreira, 2015). The recognition of space and time conflicts, integration and communication among stakeholders, and the identification of space and time conflicts were deemed the most significant applications of 4D modeling, while support for sequencing and optimal scheduling of work rates was considered less applicable. The survey concluded that 4D modelling is important and practical for adoption in construction management by professionals in the industry, and future work should develop functionalities for internal activity visualisation and physical advance monitoring. The study findings recommend future work to develop functionalities for internal activity visualisation and physical advance monitoring, and the evaluation of these strategies should be replicated in other countries (Brito and Ferreira, 2015).

3.6.11 BIM Application in UK Construction Industry

The purpose of Georgiadou's (2019) paper is to provide an up-to-date review of Building Information Modelling (BIM) in the UK construction industry by assessing practitioners' perspectives in the Greater London Area (GLA) on its application, value, and practical implications for residential projects. The study analyses the potential of using BIM in residential projects, as well as the benefits, obstacles, and risks connected with its adoption, through an online survey and semi-structured interviews with building professionals. Collaboration, communication, visual representation, and clash detection are all areas where the study found BIM to be particularly helpful. The study shows, however, that the advantages of waste reduction and lifecycle thinking are frequently disregarded. There is a dearth of strategic leadership in the industry, and, according to Georgiadou (2019), the cost of investing in digital capabilities is prohibitive for small and medium-sized businesses.

According to Georgiadou's (2019) research report, organisations that adopt BIM should expect to see a shift in their roles and responsibilities as a result of improvements in areas such as change management, process standardization, common metrics, and investment in training (Georgiadou, 2019). Based on the results of the research, it has been determined that existing BIM processes are conducted from a technical standpoint with the intention of producing precise and integrated 3D documentation that will allow for the detection of clashes and the coordination of the design team (Georgiadou, 2019). By cutting down on reworks, errors, and waste, BIM speeds up the construction process, boosts productivity, and lowers costs without sacrificing quality or profitability. Complete asset lifecycle management and persistent data management are also supported (Georgiadou, 2019). However, a clear policy framework emphasising "smart" regulation is required for BIM to uncover and depict inefficiencies throughout the project lifetime. This requires determining whether regulatory and voluntary mechanisms should be used in conjunction with which building types and project sizes (Georgiadou, 2019).There are still obstacles to be overcome before BIM can be used effectively in residential developments, such as increased capital expenditures in software and training and a lack of knowledge. There isn't enough demand from customers and/or the projects are too modest to warrant using BIM (Georgiadou, 2019).

3.6.12 BIM and Stakeholder Management

In another study, Zhang et al. (2022) investigated the intermediary role of stakeholder management in the relationship between BIM implementation and project performance. They state that although BIM has brought significant advantages to project delivery and performance, it has also increased project complexity. Therefore, to achieve positive impacts from BIM, it should be synchronised with stakeholder management. An extensive literature review was conducted to identify 13 critical success factors for BIM implementation, 29 for stakeholder management, and 6 for BIM project performance. These factors were tested using the questionnaire survey method and analysed using structural equation modeling. The research focused on Chinese megaprojects and complex projects with a high level of BIM development, reflecting complex stakeholder relationships and BIM implementation for project performance. The results show that effective use of BIM can directly improve project performance, and stakeholder management plays an important and positive intermediary role in the path of BIM implementation and project performance, particularly through stakeholder dynamics and stakeholder engagement or empowerment (Zhang et al., 2022).

According to Zhang et al. (2022), as with any technology, BIM can only have a beneficial impact on the industry if its various stakeholders are enthusiastic about its deployment and implementation. Cost, schedule, communication, collaboration, and product quality can all benefit from the use of BIM (Zhang et al., 2022). Earlier research has shown that the use of BIM in construction projects can have positive effects on project performance, such as improved quality control, time savings, and optimised design (McGraw Hill Construction, 2012; Dakhil and Alshawi, 2014). However, Zhang et al.'s (2022) study contributes to the literature by demonstrating that the level of BIM implementation is positively correlated with project performance. In other words, the more advanced the implementation of BIM technology, the higher the level of project performance that can be achieved (Zhang et al., 2022). The level of BIM implementation can be increased to better manage the dynamic management of stakeholders and adapt to shifts in the relationship and interests between them (Zhang et al., 2022). Project performance can be enhanced by making fewer changes, which will reduce the likelihood of disagreements or disputes (Zhang et al., 2022).

However, it is important to keep in mind that this study has its share of limitations. The research hasn't looked at the diversity and complexity of each stakeholder. The effects and connections between them in various contractual settings and BIM-enabled projects should be investigated in future research.

Besides, to reach a deeper understanding of the impacts of BIM application on four main themes of this research a Table of impacts is conducted through literature review; so, the positive effects can be improved and negative ones will be mitigated. Also, by doing this, it will be more understandable how the application of BIM influences different areas of project management in regard to the topic and aims of current research.Hence, the overall impacts of BIM on the different project management themes such as stakeholder, scope, communication, and risk management are presented in Table 19 based on the analysis of the findings from the articles discussed above.

Table 19 The impacts of BIM application on scope, stakeholder, communication and risk management themes.

Article	Stakeholders	Scope	Communication	Uncertainty
Tomek and Matějka, (2014)		-Efficient design	-Increased level of communication	BIM risks: -Positive: risk reduction / Clash detection/ Safety Planning/ -Negative: Concerns on legal and financial risks (Ownership, liability, insurance)
Succar (2009)	-Safeguarding benefits and minimizing Contestation between stakeholders -engaging with other construction players - Collaboration with other disciplinary players and key stakeholders - Enables all stakeholders to experience the building in a visual and information-rich interactive system - Collaboration processes and database-sharing skills	-Utilization of smart objects and encapsulation of 'intelligence - Higher detailed construction models - Network-based integration causes 'concurrent construction'	- Push–pull knowledge transactions occurring Within or between fields and sub-fields - Increased integration of data and information management -Effective data flows between bim stakeholders	- Reconsideration of contractual relationships, risk-allocation models - Alliance-based and risk-sharing contractual agreements
Won et al. (2013)	-Effective collaboration among project participants	-To address conflicts between obligations To scope, project, and company	-To openly share information -To share information among project participants	-Negative BIM risks: -Security risk

	-Collaboration (project) management tools -Shared liability among project participants	-Better adoption in building with complex shapes and systems	-Information-sharing protocols	-Difficulties in measuring impacts of BIM -Liability .-BIM technology training -Poor interoperability among BIM software
Chen and Luo (2014)	- Improves the construction process by changing the way participants interact with each other -More informed decisions by a project's stakeholders -collaboration between participants	-Improving design quality -reducing rework -Easy verification of design requirements -Increases efficiency and precision -Automatically assess the significance of design deviations -View activity duration in the construction schedule	-Improved communication -Open communication and exchange of data -Produces precise and consistent information -Ensure information consistency -Unlimited extension of the use of bim information when combined with other advanced technologies	-Reduces errors -Eliminating conflicts
Lucas, Thabet and Bowman (2009)				-Reducing change orders -collision detection
Merschbrock and Munkvold (2012)	-Improved cross-discipline participation	-Increasing design transparency - Rapid design visualization	-Accurate information about changes -Detail to be communicated in	- Error-free design Negative bim risk:

	-Enhancing inter-organizational collaboration -All stakeholders editing or retrieving information from commonly shared Models	-reducing rework	Construction design -Effective information sharing	-Complexity of bim -Costs involved to be a major barrier, -Product vendors add to the complexity by releasing a multitude of applications -Legal uncertainties -Interoperability, -Risk allocation
Kapogiannis, Fernando, and Kagioglou (2013)	-Effective partner and staff involvement -Collaboration among stakeholders	-Understanding of client requirements -Deliver an effective and efficient product or service design	-Improved information accessibility	-Efficient performance of risk management -Conflict reduction and efficient problem resolution -Reduction of the degree of complexity
Ellis (2006)	-Evaluation of design, construction, and management of buildings by stakeholders before project implementation	-Designers could use computable 3d to model the client's brief		
Arayici, Egbu and Coates (2012)	-Greater flexibility to satisfy customers -Avoids misunderstanding among stakeholders	-Reduce specification errors - Better material management -Managing site activities remotely	-To create and reuse consistent digital information by the stakeholders throughout the lifecycle	-Automatic low-level corrections when changes are made to the design -Discovering design errors before construction

	- Impacts on external stakeholders such as contractors, client and construction site team -Collaboration between stakeholders -Efficient connection between stakeholders through visualization(3D modeling)	-Monitoring site progress in relation to planning -Linking drawings to specification - Focusing on the construction objects - Encapsulates built facilities with specific viewpoints of stakeholders. -Stakeholders can query, simulate and estimate activities and their effects on the building process as a lifecycle entity	- Using ICT to exchange valuable information throughout the lifecycle. -To provide the required effective information exchange between stakeholders. -Information sharing -The 3D printing, automated creation of animations and virtual environments - To transfer richer data than the CAD systems. -Information exchange and sharing via IFC -Improved communication -Enabling comparison, and correction of information shared	-Visualizations to allow checking against design intent -Certain historical problems are less likely to occur -Consistency between the plans, elevations and schedules -3D geometric errors are less likely to occur -Clash detection -Discovering design errors and conflict analysis NEGATIVE: -Limitation in collecting knowledge process due to lack of integrated tools in BIM
Xu, Ma and Ding (2014)	-To visualize the project's progress for participants -Contribution of stakeholders into BIM model during the life cycle -Improved collaboration	- Collision detection model. -Optimizes construction planning and scheduling -Utilization of WBS structure decomposition in BIM to visualize the construction progress simulation	- Increases the efficiency of information management -Production of individual models by each participant -Digital representation of the data repository Of all information	- Collision detection -Elimination of conflicts - To accurately identify problems and make changes promptly. -Increases the probability and impact of positive events and decrease the

				probability and impact of adverse events
Talebi (2014)	-Minimizes the client surprise by performing value Engineering -Requires early involvement of design and construction stakeholders -Enhanced coordination among organizations -Minimizes the risk of legal disputes	-Visualisation and creation of as-built models -Evaluates the building's performance according to regulations -BIM brings together and compares designs from all organisations -Facilitating the design process -Great reduction of rework -Ability to follow up the actual construction status -Reduce design deviations	-Increased information availability -Amplified information management -Makes the design information explicit and available to all stakeholders -Project data are easily accessible through diverse BIM software -Minimizing the cost of retrieving project information -Better communication amongst parties and understanding through 3D visualisation	-Clash detection -To jointly decide and address onsite related problems more effectively -Avoidance of delays, change orders, claims and requests for information -Minimising the likelihood of legal disputes -Early detection of planning errors -The decreased likelihood of any severe problematic issue on site -To address errors and conflicts quickly Negative BIM risks: -Need for adapting new processes -Need for clear implementation plan -Support from top-level management is needed -New roles and responsibilities -Contractual changes – economic incentives and ownership of information

				-Problems of interoperability -Lack of integration between the project phases due to absence of BIM software -Associated costs with the use of BIM
Pučko, Šuman and Klanšek (2014)		-Linkage between activities and construction elements in 3D model -Calculation of quantities per location divided by the productivity rate of the work crew -Automatic linkage between changes and relevant model data -Geometrical quantities data -Required resources data -Execution times of activities data	-All of the information is collected in one place and kept up to date -Dynamic linkage between information and building model - Availability of relevant information for execution -Provides information for each construction object is stored in one place and kept up to date	-The conception risk is minimized
Dakhil and Alshawi (2014)	-Improved collaboration among Stakeholders - Full project understanding by clients		-Better exchange of information between stakeholders in the early stage of the project	
Smith (2013)	-Collaborative approach and early stakeholder involvement -Incentivization to ensure the diverse teams have good reason to work together	-The scope of work can be defined easily -Systems, assemblies and sequences can be shown on a relative scale to each other and relative to the entire project	-Reduce the information loss - Share and exchange bim in a neutral format among various software applications by using ifc	-Advocates the sharing of risk and reward among the project team(ipd) -Allows seeing on-site clash detection - To analyse congestion and accessibility more effectively

	-To share savings made for clients with stakeholders -Aligning team or project stakeholders to achieve common objectives	- View the expected outcome and understand what the designer expected to be built. - Running several alternative designs and testing their constructability utilising the scheduling of the different components of the designs.	-Savings through coordinated information -Constant intermingling of information throughout the various project phases - Easier data sharing -Knowledge sharing by professionals	-Identification of differing types of clashes: hard or soft
Brito and Ferreira (2015)		-Integrated design and construction process -Schedules optimization in accordance with the objectives and constraints(4d) -Discrepancies visualisation between executed and the planned -Support in the sequencing and ideal suitability of the schedule work rate	-Improved communication between all project stakeholders(4D)	- Errors detection before execution(4D) -Capacity of identifying potential Conflicts of space and time during construction(4D) -Visualisation of possible impacts caused by changes in planning
Smith (2014)	-Project participants can effectively visualize and analyse problems regarding sequential, spatial and temporal aspects	- To link the construction activities represented in time schedules with 3D models (4D) -To evaluate the buildability and workflow planning of a project(4D)	-Project participants can effectively communicate problems regarding sequential, spatial and temporal aspects (4D) -Involves the sharing of information amongst project participants	

Georgiadou (2019)	- Improved collaboration - Coordination among design team members	-To respond to design changes faster, optimize designs with analyses, simulations and visualization - Accelerated delivery - Reducing errors, rework, and overall waste	-Improved communication - Management of digital information - Visual representation	- Clash detection -Identification and visualisasion of inefficiencies
Zhang et al. (2022)	-Improved stakeholder engagement or empowerment - Improved collaboration	- Improved project performance - Improved product quality - Reduced changes	-Improved communication	- Reduce likelihood of disagreements or disputes

By considering and investigating Table 19, the BIM impacts on stakeholder, scope, communication and risk management themes of this research are translated into project management terminology and summarized in Table 20.

Table 20 Summary of BIM impacts on project management themes.

Stakeholder Management	Scope Management	Communication Management	Risk Management
-Minimizing contestation between stakeholders -Collaboration among stakeholders -Engaging and involving stakeholders -Change in participants interactions -Addressing stakeholders information needs -Better understanding of project -Achieving common objectives	-Improving design process & quality -Addressing conflicts between scope and other project areas -Reducing rework -Better understanding of client's requirements -Reduce specification errors -Efficient Utilization of WBS structure -visualisation and creation of as-built models -Reduce design deviations -Easier definition of the scope of work -Monitoring and simulation of activities	-Increased level of communication -Effective data flows between BIM stakeholders -open communication and exchange of data -production of precise and consistent information -Improved information sharing -Makes the design information explicit and available to all stakeholders -Project participants can effectively communicate problems	-Risk reduction and efficient problem resolution -Clash detection -Eliminating conflicts -Reducing change orders -Discovering design errors before construction -Increases the probability and impact of positive events and decrease the probability and impact of adverse events -Advocates the sharing of risk and reward among the project team

3.7 Collaborative Working

In the construction industry, the production of coordinated design and construction information is considered a crucial task that requires a time-based process carried out through collaborative working (British Standards Institution, 2013). Collaborative working entails teams producing information using standardized processes and agreed-upon standards and methods to ensure the same form and quality, enabling information to be used and reused without change or interpretation (BSI, 2013). In addition, several scholars have emphasized that building information modelling (BIM) improves collaboration among stakeholders. Won et al. (2013)

state that effective collaboration among project participants is a key success factor in BIM adoption, and the lack of it may hinder the realization of the maximum advantage of BIM.

Consequently, a collaborative working approach is often adopted as the first step in the preliminary stages to establish a consolidated basis for BIM adoption. To develop a practical framework and establish and enhance collaborative relationships, the Collaborative business relationships 1&2 standards published by BSI (BRITISH STANDARD, 2010, 2011) are utilized. The collaborative approach provides a wide range of benefits, such as better risk management and the ability for collaborative partners to share knowledge, skills, and resources to meet mutually defined objectives.

Thus, adopting a collaborative working approach in construction projects facilitates the production of coordinated design and construction information, and BIM can improve collaboration among stakeholders. Moreover, utilizing the Collaborative business relationships 1&2 standards published by BSI can enhance collaborative relationships, resulting in numerous benefits, including better risk management and improved resource sharing among stakeholders.

In addition to the collaborative working approach, there are other solutions and strategies that can help address scope creep and respond to stakeholder influence. One such strategy is effective communication.

Effective communication among all stakeholders is vital for a successful project outcome. Miscommunication or lack of communication can lead to misunderstandings, delays, and ultimately project failure. To avoid such situations, project managers need to ensure that there are clear communication channels and protocols in place. This includes defining the communication needs of stakeholders, the frequency and mode of communication, and ensuring that all stakeholders are aware of the project's progress and any changes to scope or objectives.

Another important strategy is to have a robust change management process in place. This process should outline how changes to the project scope or objectives will be handled, including how requests for changes will be reviewed, evaluated, and approved. It should also outline the roles and responsibilities of stakeholders in the change management process, and how changes will be communicated to all stakeholders.

Finally, it is important to actively manage stakeholder expectations. This involves ensuring that stakeholders have a clear understanding of the project objectives, scope, and timelines, and managing any expectations that are unrealistic or outside the scope of the project. This can be achieved through regular stakeholder engagement and communication and ensuring that stakeholders are aware of any potential risks or challenges that may arise during the project.

3.8 Integrated Project Delivery (IPD)

Integrated Project Delivery (IPD) is a collaborative project delivery approach that integrates people, systems, business structures, and practices into a process that harnesses the talents and insights of all participants to optimize project results, increase value to the owner, reduce waste, and maximize efficiency through all phases of design, fabrication, and construction. The American Institute of Architects (AIA) has published a guide that provides information and guidance on principles and techniques of IPD and explains how to utilize IPD methodologies in designing and constructing projects (National AIA, 2007). The benefits of IPD to construction projects include early and open sharing of project knowledge, streamlined project communications, increased understanding of desired outcomes, early involvement of key participants, intensified planning, open communication, appropriate technology, and organization and leadership (National AIA, 2007).

The principles of IPD, according to the AIA guide, include mutual respect and trust, mutual benefit and reward, collaborative innovation and decision-making, early involvement of key participants, early goal definition, intensified planning, open communication, appropriate technology, and organization and leadership. The guide emphasizes that IPD is built on collaboration, which is built on trust. Moreover, BIM and IPD complement each other by improving the management of the project through increased data exchange and cooperation between stakeholders (Succar, 2009). Thus, IPD is an effective approach to address scope creep and stakeholder influence.

In implementing IPD, the AIA guide recommends the formation of a core team of key participants, including the owner, architect, engineer, contractor, and major subcontractors, who are committed to the project's success and can work collaboratively in a non-adversarial manner (National AIA, 2007). The team's objectives, including project goals, target costs, and schedule, should be established early in the project to ensure that all participants are aware of the project's goals and requirements. Moreover, the guide recommends the use of appropriate technology, such as BIM, to facilitate communication, data exchange, and collaboration among stakeholders (National AIA, 2007).

In addition, the guide recommends the establishment of an incentive program to encourage collaboration, innovation, and performance improvement among team members. The program should include a shared savings pool, which allows the team to share in the project's cost savings, and a team bonus pool, which rewards the team for achieving project goals, such as quality, safety, and schedule (National AIA, 2007).

IPD has been successfully used in various construction projects, including healthcare, education, and commercial buildings (Mishmish and El-Sayegh, 2018). For instance, the use of IPD in the construction of the San Francisco General Hospital led to a reduction in construction time, improved quality, and cost savings (Kopczak et al., 2011). Similarly, the use of IPD in the construction of the University of California, Merced, led to a reduction in change orders, improved communication among stakeholders, and increased productivity (Bratton et al., 2013).

In addition to the principles of IPD, the AIA guide also provides points to consider when setting up an integrated project. These include selecting a team leader, developing a collaborative charter that outlines goals and expectations, identifying key stakeholders and their roles, and defining communication and decision-making protocols. It is important to note that IPD requires a significant shift in mindset and culture, as it moves away from the traditional fragmented and siloed approach to project delivery towards a more collaborative and integrated approach.

When it comes to implementing IPD, the AIA guide recommends a phased approach that involves establishing a core team, developing a project charter and implementation plan, conducting pre-design and design activities, preparing construction documents and specifications, and carrying out construction and post-construction activities. Throughout these phases, the core team should work collaboratively and use tools and techniques that enable effective communication and data exchange, such as BIM, lean construction, and target value design.

The use of BIM in IPD is particularly important, as it allows for the creation of a digital model that can be used by all project stakeholders throughout the project lifecycle. BIM provides a platform for collaboration and enables the sharing of information and data between different disciplines and phases of the project. This improves communication, reduces errors, and allows for more efficient decision-making (Eastman et al., 2011).

IPD is a collaborative approach to project delivery that emphasizes trust, mutual benefit, and shared decision-making. It is a shift away from the traditional fragmented approach and towards a more integrated and efficient process. By incorporating BIM and other collaborative tools and techniques, IPD can lead to improved project outcomes, increased value to the owner, and reduced waste and inefficiencies. The AIA guide provides a comprehensive framework for implementing IPD in the design and construction industry. By adopting the principles of IPD, setting up an integrated project team, and using collaborative tools and techniques such as BIM, stakeholders can work together to optimize project results, increase value, and improve project outcomes. It is important to note that IPD requires a significant shift in mindset and culture and may not be suitable for all projects or organizations. However, for those willing to embrace this approach, the benefits can be significant. Further research is needed to explore the effectiveness of IPD in different contexts and to identify best practices for its implementation.

3.9 Chapter Summary

This chapter investigated the literature on BIM and its associated concepts of collaborative working and integrated project delivery approach.

Moving into the BIM territory, various definitions of BIM were considered and the collaborative working approach was analysed through investigating Collaborative business relationships 1&2 standards published by BSI (BRITISH STANDARD, 2010, 2011). The meaning of collaborative working was defined and its crucial role for BIM adoption was emphasised. Another aspect of BIM adoption in projects is Integrated Project Delivery (IPD). In this regard, the chapter explained the guidelines published by The American Institute of Architects (National AIA, 2007). Both of collaborative working approach and integrated project delivery will be analysed and broken down into further details in the next chapters for developing a comprehensive process framework. In the next Chapter, the discussion will be made about the research methodologies and the various methods and processes adopted for collecting and analysing data in support of the literature.

Chapter 4 Research Design

4.1 Introduction

Chapter 2 reviewed the literature on scope management, stakeholder management, uncertainty and risk while chapter 3 included previous works on Building Information Modelling (BIM) together with its associated concepts of collaborative working and Integrated Project Delivery (IPD).

This chapter describes the design of the research methodology, a system for data collection and analysis. First, the chapter describes the research process and research design (sections 4.2 and 4.3). Then the research philosophy (section 4.4) is explained followed by research approach (section 4.5) and methodological choice in section 4.6. In sections 4.7 and 4.8, the research strategy and time horizon are explained. Also, the description of the technqiues and procedures, sampling, literature review, data collection and anlysis approach are presented in sections 4.9, 4.10, 4.11, 4.12, and 4.13. Finally the sections 4.14 discusses the reliability and validity issues.

4.2 Overview of the research process

A rigorous methodology was established to achieve the aim and objectives of this research. An overview of the methodology is presented in Figure 17. It is evident from the Figure that the research process is categorised into three main phases: literature review, research strategy, and output.

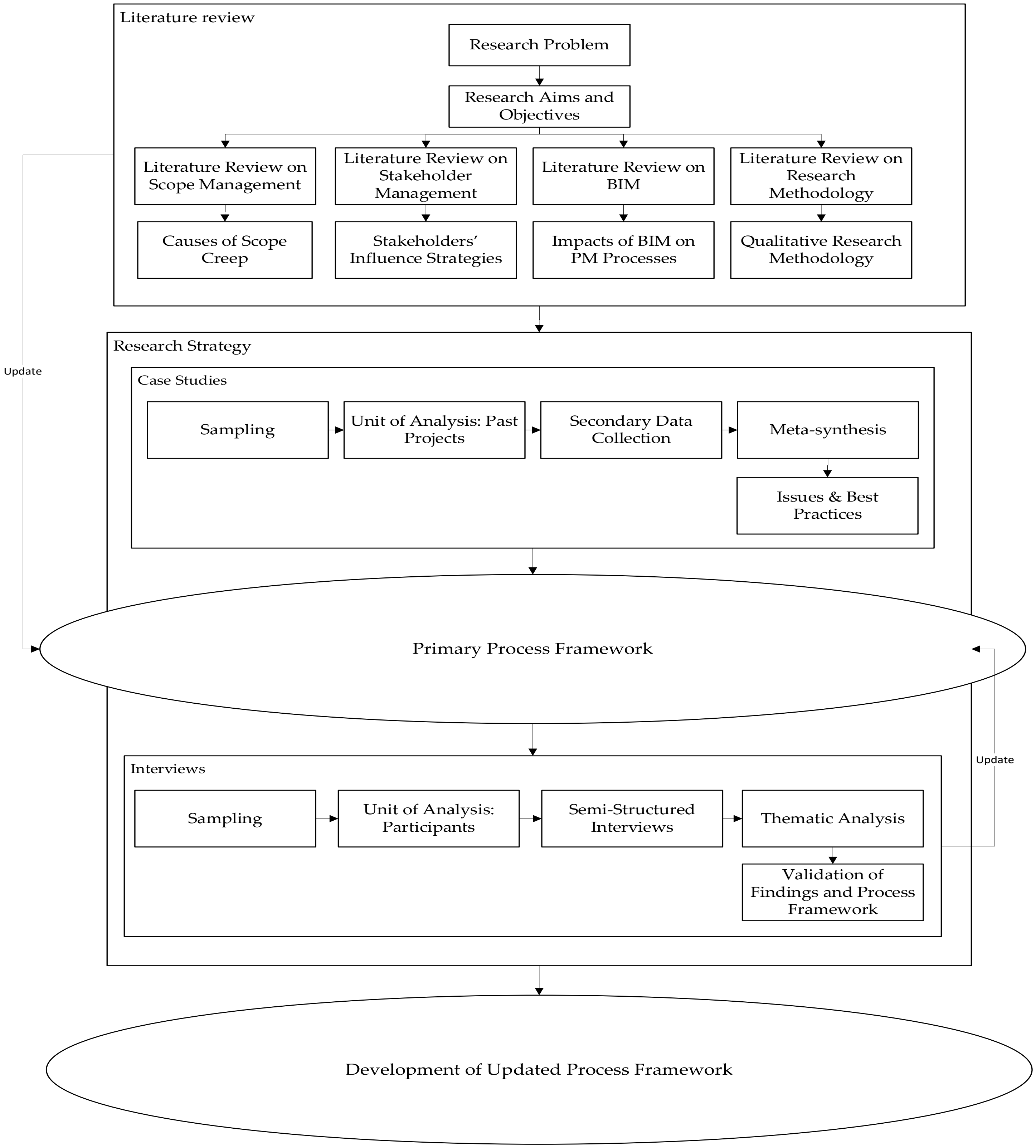

Figure 17 Overview of the research process

4.3 Research Design

The term "Research Design" is used to refer to the overarching strategy behind a study, including all of the study's constituent parts and how they fit together in a step-by-step process that is transparent, logical, and consistent with the study's stated goals and objectives (De Vaus, 2001; Creswell and Creswell, 2018). The research design is developed based on the research problem and questions to be addressed and serves as a blueprint or roadmap for the overall research process (Crewell and Creswell, 2018). (Collis and Hussey, 2009) identified methodological research designs including the philosophical basis, theoretical approach, data gathering and analysis, construction frameworks, and validation. According to Creswell (2014), the research design has three major components: research philosophy, research strategy, and research method. Research philosophies, also known as paradigms, include the positivist, constructionist, and pragmatic ontologies and epistemologies that will be used in the research. The research strategy is the selection of appropriate methods in accordance with the philosophical perspective that will most effectively achieve the research goal, which may be either quantitative, qualitative, or a hybrid of the two (Creswell and Creswell, 2018). Also, research methods are the techniques or tools used to carry out the research process, including the formulation of research questions, the execution of data collection, the analysis of results, and verification (Creswell, 2014). Crotty (1998) proposes a distinct perspective, stating that the research design includes the following elements: epistemology, theoretical perspective, methodology, and methods that will be utilized. The 'Nested Mode' suggested by Kagioglou et al. (1998) presents similar aspects to both Crotty (1998) and Creswell (2014), such as research philosophy, which involves concepts like interpretivism and positivism; research approach, which covers various methods such as experiments, case studies, and reviews, and research techniques, which involve data collection methods like interviews, surveys, and questionnaires. The model known as the "Research Onion" was developed by Saunders et al. (2019), and it outlines six distinct layers that underpin the research process (Figure 18). Saunders et al. (2019) present a more comprehensive approach to the research design process, delineating six distinct layers of the process (as shown in Figure 18). On the other hand, Crotty (1998) and Kagioglou (1998) propose four and three stages, respectively, while Creswell (2014) identifies three dimensions that characterise the research design process. The layers in Saunders et al.'s (2016) research onion include: 1. Research Philosophy, 2. Research Approaches, 3. Methodological Choices, 4. Strategies, and 5. Strategies Time Horizons, and 6. Techniques and Procedures. According to Saunders et al. (2019), the layers presented within the 'Onion' do not imply that the elements are independent of each other, but instead offer a more precise roadmap of interrelated concepts and procedures within each layer. Research conducted at a variety of levels and across disciplines supports the idea that Saunders' "Onion" model is the most thorough, explicit, and flexible approach to research design. This section will delve more into the Saunders et al. (2016) Onion model, the research design model used for this investigation.

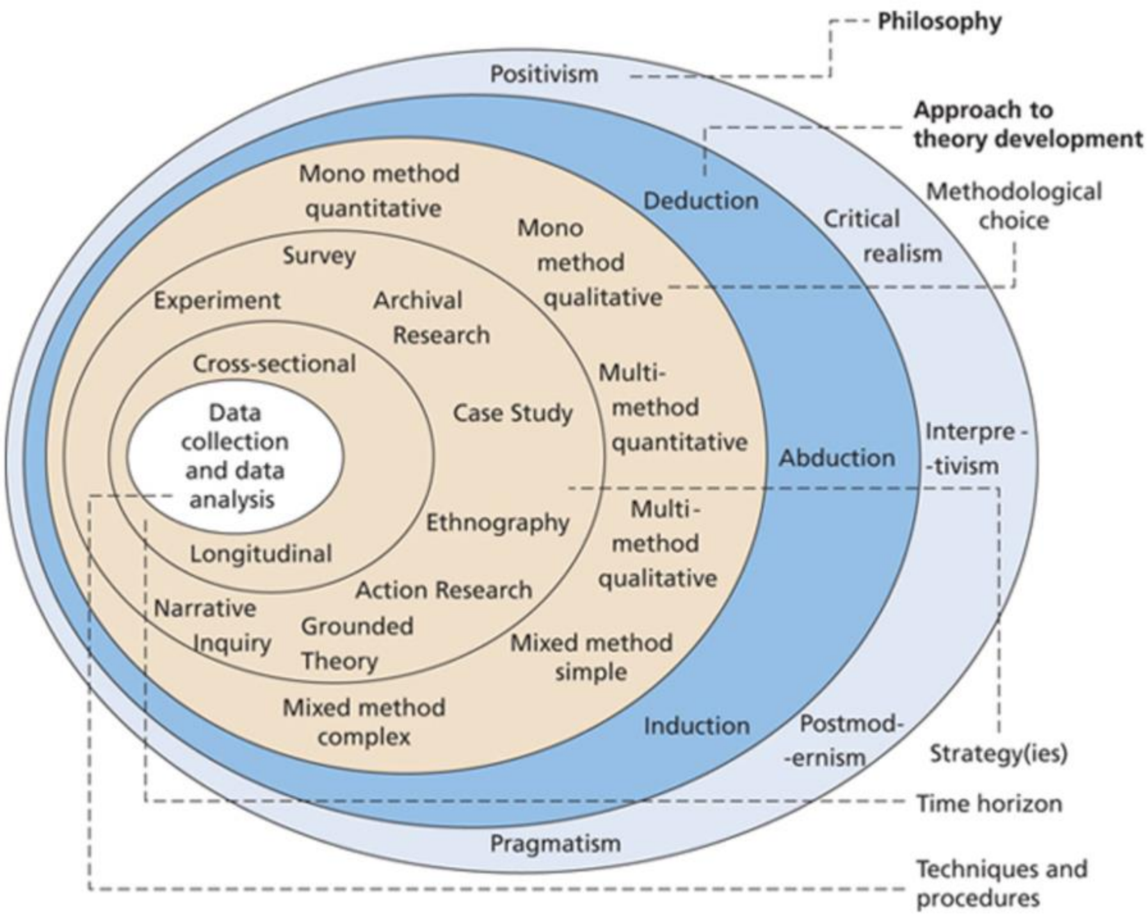

Figure 18 The 'Research Onion' (Saunders et al., 2016, p.129).

4.4 Research Philosophy

Research philosophy is the basic set of beliefs that have a significant impact on the direction and ultimate outcome of the research. It is also known as a paradigm or philosophical worldview (Guba, 1990). Saunders et al. (2019) argue that the attainment of research objectives and aims depends on the philosophical positions adopted, as these positions shape the evolution and processing of knowledge. According to Easterby-Smith et al. (2012), research philosophy can be thought of as the sections of a tree that are typically concealed from view, such as the trunk or the roots. Also, Easterby-Smith et al. (2012) assert that the selection and implementation of a viable methodology are crucial in achieving impactful and far-reaching research aims and goals, and this is influenced by philosophical reasoning that provides meaning and direction to the research process. According to Easterby-Smith et al. (2012), there are four major pillars of research that underpin research philosophy: ontology, epistemology, methodology, and methods and techniques. In contrast, Creswell (2014) outlines five major philosophical foundations that generally underlie academic research, including ontology, epistemology, theoretical standpoint, research strategy, and the methods or techniques to be employed. Ontology and epistemology are the philosophical foundations for scientific study.

4.4.1 Ontology

Ontology, which refers to the nature of reality and how things exist, is a key principle of scientific research and is underpinned by two opposing concepts, realism and relativism, which represent different viewpoints. The choice of standpoint provides support for the selection of theoretical perspectives and, subsequently, the methodology to be used (Raddon, 2010; Easterby-Smith, 2012). Saunders et al. (2016) classified ontological assumptions into two main groups, namely objectivism and subjectivism. The objectivist perspective comprises two sub-perspectives, namely positivism and realism. On the other hand, the subjectivist perspective comprises interpretivism. The concept of subjectivism is commonly associated with terms such as constructionism, social constructionism, interpretivism, and phenomenology (Saunders et al., 2009; Creswell, 2014). This ontological assumption asserts that reality is constructed socially, rather than existing objectively (Saunders et al., 2009). Subjectivism is typically employed in qualitative research, where researchers recognise that a single situation may be perceived and experienced differently by different individuals, leading to the existence of multiple realities (Creswell, 2014). To demonstrate this, researchers employ multiple forms of evidence and analyse themes, often using the exact words of research participants, in order to present different perspectives (Creswell, 2013). According to Klein and Myers (1999), interpretive research can provide researchers with a means of comprehending human cognition and behaviour in social and organisational settings. This approach allows researchers to investigate phenomena in-depth, such as system development and management, by focusing on the complexity of human sense-making rather than predefining independent and dependent variables. Instead, the interpretive approach seeks to understand phenomena through the meanings that individuals assign to them, as they emerge within the situation. Goldkuhl (2012) posited that the constructivist ontological perspective holds that social structures such as social relationships, organizations, and divisions of labour are not fixed or predetermined entities but rather dynamic elements of the world that are produced and reinforced through human actions and interactions. The paradigm considers "relations" as a crucial part of the social world, which is not composed of static objects. In this perspective, cognitive aspects such as beliefs, meanings, and intentions play a central role.

4.4.2 Epistemology

Epistemology refers to the ways in which reality can be constructed, which are influenced by the underlying ontological approach. Also, Strang (2015) defines epistemology as a theory of knowledge. The two primary epistemological views are positivism and constructionism, as per Easterby-Smith (2012). Saunders et al. (2009) noted that positivism and realism have a similar philosophical position, where they work with observable social reality, similar to the position of a natural scientist. In contrast, interpretivism asserts that researchers must understand the differences between humans as social actors. This perspective challenges researchers to enter the world of research subjects and gain an understanding of the world from their viewpoint. Therefore, interpretivism places greater emphasis on the subjective experiences of individuals and the meanings they attach to them, rather than objective reality (Saunders et al., 2016).

4.4.3 Axiology

Also, when it comes to the knowledge generation process, the axiological philosophical assumption is all about the values of the researcher (Saunders et al., 2009; Biedenbach and Jacobsson, 2016). The value limits of qualitative research (Lincoln and Guba, 1985) is influenced by values (Lincoln and Guba, 1985), and in the field of business and management, the importance of values is stressed rather than the existence of axiology itself. Axiology is a theory of beliefs and values, including religious, moral, aesthetic, and cultural values. The socio-cultural values influence the research design and literature review (Strange, 2015). Consequently, ethical issues were taken into account (Strang, 2015).

Saunders et al. (2016) further identify various philosophical positions in research, including but not limited to Positivism, Critical Realism, Interpretivism, Postmodernism, and Pragmatism.

4.4.4 Positivism

The positivist perspective regards knowledge and reality as quantifiable and fact-based entities grounded in stable cause-and-effect conditions. It emphasizes the need for predetermined principles, guidelines, and methods as the most suitable way to comprehend and deal with fundamental phenomena. Positivists embrace a more systematic and empirical approach to examining reality across social and other domains (Scot and Usher, 2011). According to the positivist and post-positivist perspectives, reality is objective and exists independently of an observer's interpretation. This philosophical position is aligned with the ontology of realism and the epistemological stance of objectivism (Scotland, 2012; Creswell, 2014). Quantitative methodologies of data processing are used by positivists in order to build broad, overarching definitions of a population to predetermined degrees of precision (as indicated by confidence intervals) (Denzin and Lincoln, 2011; Creswell, 2014). Common methods of data collection in positivist research include structured questionnaires, surveys, observations, and experiments.

4.4.5 Critical Realism

The critical realism philosophy, according to Saunders et al. (2016), aims to explain the underlying occurrences that shape observable events, providing an understanding of existential and experiential phenomena. This philosophy combines elements of positivism and postmodernism, asserting that reality extends beyond surface appearances. Critical realists advocate for a reflective approach to comprehending reality, recognizing that what we perceive empirically is a manifestation of underlying structures. They employ "retroduction" as a process of reasoning backward to uncover the causes and manifestations of reality. Critical realists adopt a relativistic epistemological position, utilizing methods such as reviewing pre-existing structures, historical analysis, replication of events, and causal assessment to interpret reality (Saunders et al., 2016; Reed, 2005).

4.4.6 Interpretivism

The interpretivist philosophy asserts that reality is shaped by the observer's perspective and that individual interpretations can provide meaning and conclusions. This philosophy aligns with the ontology of relativism, which assumes that there is no single truth or reality and that all forms of knowledge and meaning are contingent on the perspectives and understandings of those involved (Creswell, 2014). Interpretivists believe that reality is not fixed, but rather constantly changing and redefined (Sutrisna, 2009). Their epistemological position is that of constructionism or social constructionism, which is different from the positivist philosophy. Interpretivists argue that reality should not be considered solely on the basis of what is immediately observable or accessible, and that meaning and knowledge are constructed through social interaction and interpretation (Scotland, 2012). According to interpretivists, reality is influenced by the observer and is therefore subjective, and researchers should consider multiple perspectives from various sociological dispositions. In this way, researchers engage in reflection and acknowledge the diverse perspectives and dynamic conditions of the subject matter (Scotland, 2012; Saunders et al., 2016). Interpretivists typically utilise qualitative methods as their main research strategies for understanding phenomena (Guba and Lincoln, 1994; Scotland, 2012). Research methods typically employed in this paradigm include focus groups, observations, and unstructured interviews. In contrast to positivist approaches, interpretivist and constructivist philosophies do not usually seek to generate generalisations based on large samples, and the outcomes of research in this domain tend to generate new perspectives and theories (Easterby-Smith, 2012).

4.4.7 Post-Modernism

Postmodernism, akin to interpretivism, seeks to balance perspectives by employing linguistic processes that represent marginalized views. It criticizes objective/positivist philosophy and advocates developing linguistic values to comprehend diverse realities (Saunders et al., 2016). Postmodernists challenge the stability of order and categorization and highlight the inadequacy of linguistic foundations in incorporating marginalized perspectives (Chia, 2003). This philosophy aims to reveal biases favoring larger organizations at the expense of minority interests (Townley, 1994; Saunders et al., 2016). Postmodernists stress critically examining power dynamics between researchers and participants, as knowledge is influenced by these dynamics (Calás et al., 1999; Cunliffe, 2002; Saunders et al., 2016). They adopt nominalism as their ontological perspective and a deeper version of constructionism as their epistemological position, employing methods like in-depth evaluations and deconstructive queries to access nuanced voices (Cunliffe, 2003; Saunders et al., 2016).

4.4.8Pragmatism

Pragmatist philosophy seeks to reconcile objectivism and subjectivism in order to achieve a more comprehensive and rigorous methodology and address the potential limitations of singular philosophies and methods. This approach was developed by scholars like Charles Pierce, John Dewey, and William James, among others (Saunders et al., 2016). According to the pragmatist philosophy, concepts and philosophical choices are valuable only if they lead to action that produces desired results (Kelemen and Rumens, 2008). This school of thought posits that reality and phenomena cannot be fully understood and discussed from a single philosophical perspective. Hence, research and investigations are conducted in direct relation to the applicability of current situations rather than within an abstract setting. Although pragmatism has been accused of avoiding philosophical disputes, its ultimate goal is to combine the best features of different philosophical schools' methods while minimising the drawbacks of relying on any one method or strategy (Morgan, 2007). According to pragmatists, the choice of research philosophy should be determined by the research question and objectives, and it should employ complementary methodologies to achieve the intended impact (Tashakkori and Teddlie, 1998). Consequently, pragmatists view research philosophy as a continuum, where different constructs complement each other rather than being mutually exclusive.

4.4.9 Adopted Research Philosophy

Thus, this study takes a philosophical approach that is interpretative (constructivist), in that it seeks meaning and understanding from a personal perspective and views knowledge as something that is constructed in a social context. In this study, the researcher seeks to understand the role of stakeholders in the occurrence and management of scope creep and how Building Information Modeling (BIM) can facilitate dealing with associated challenges in building construction projects. If a researcher considers that all information about the world must be gleaned through social constructs like commonly held beliefs, languages, modes of thought, and technological artefacts, then their study might be categorised as interpretative (Klein and Myres, 1999). Investigators would keep an eye on the social context and attempt to identify trends that might help them understand more fundamental rules (Babbie, 2005). In this instance, there is no objective truth, only the truth as perceived and experienced by each individual (Robson, 2002). Aiming to investigate the issue of scope creep and stakeholder influence, the analysis focuses on exploring the different ways in which individual actors interpret their experiences. This approach is in line with the views of Easterby-Smith et al. (2002), who advocate for an interpretivist stance in research, emphasising the importance of understanding the subjective experiences and interpretations of individuals. Also, phenomenological research, in which participants reflect on and explain meaningful life events, is an example of the constructivist worldview in practise (Moustakas, 1994).

4.5 Research Approach

Theoretical constructs are fundamental to all research endeavours, including those in the intellectual domain, and until they are substantiated or refuted, they are regarded as abstract concepts (Ketokivi and Mantere, 2010). According to Saunders et al. (2016), researchers use three primary approaches to reasoning when generating theoretical or conceptual output.

According to Saunders et al. (2016), "deduction" is an approach in which researchers aim to test existing concepts and theories to provide proof or explanation. This approach typically involves starting with a known theory as a foundational premise and developing it through literature synthesis and sample testing.

Induction is a research approach that starts with the collection and analysis of data to develop new theories or conceptual frameworks. It involves exploring phenomena to generate novel constructs or theories that have not been previously established (Saunders et al., 2016).

Abduction is an approach to reasoning that involves collecting data and synthesizing it with literature to explore phenomena, establish themes, and explain patterns. This approach aims to generate novel theories or modify existing concepts through the use of additional data to test their validity (Saunders et al., 2016).

4.5.1 Adapted Research Approach

The process of creating knowledge and assigning meanings is an act of interpretation that reflects the individual's perceptions and experiences within a social context. This means that taking an interpretivist approach may lead a researcher to employ inductive theory construction, which involves using data to develop or construct theory rather than following a deductive process (Saunders et al., 2016, 2019). Saunders et al. (2016) suggest that when there is an extensive amount of literature available to develop a theoretical framework and hypothesis, a deductive approach is appropriate, whereas an inductive approach is more suitable when the topic is new with limited literature. An inductive approach involves data collection and subsequent analysis to generate themes. Accordingly, considering the nature of the research, which has limited literature about the phenomenon under study, scope creep, an inductive approach has been adopted.

4.6 Methodological Choice

According to Crotty (2003), "methodology" refers to the plan of action that underlies the research approach to achieve research objectives by employing suitable techniques and tools. Saunders et al. (2016) have identified three primary methodological approaches, which include mixed methods, quantitative methods, and qualitative methods. According to Saunders et al. (2019), the stage of choosing a research methodology is crucial. The authors identify three main research approaches: quantitative, qualitative, and mixed methods. These approaches are further divided into subcategories, which are illustrated in Figure 19.

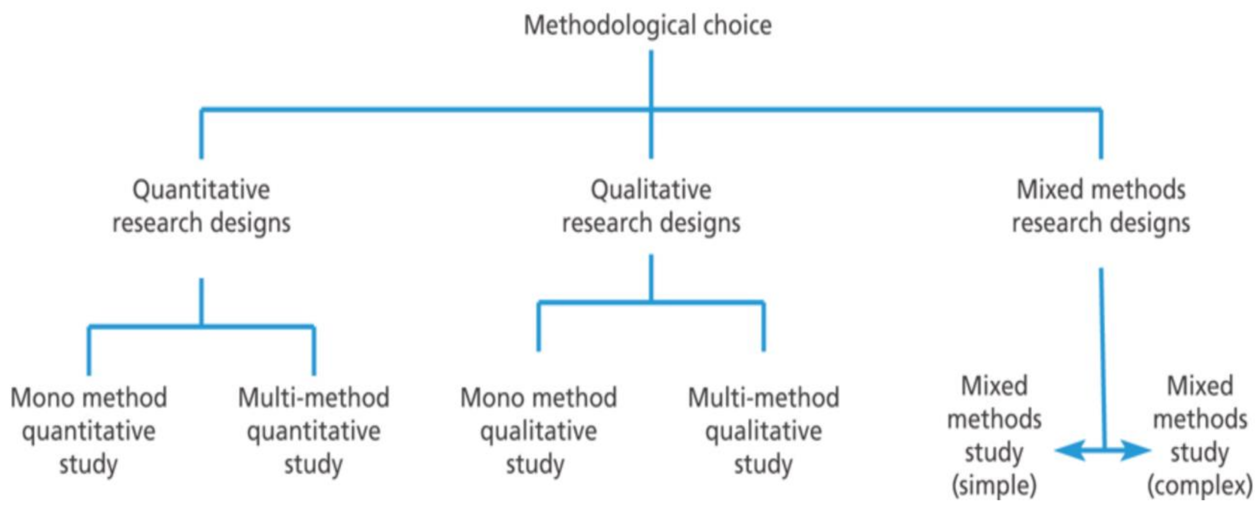

Figure 19 Methodological choice (Saunders et al., 2019, p.176)

Researchers using a mono-method approach collect and analyse data using only one methodology, whether it be qualitative or quantitative. In contrast to a mono-methodological approach, a researcher utilising a multi-method approach would select more than one data collection technique. The resulting data would then be analysed using corresponding data analysis methods (Teddlie and Tashakkori, 2009). Both qualitative and quantitative methods of data collection can be utilised in mixed-method studies, either in parallel or sequentially. The process of data gathering informs the methodology used in the subsequent analysis.

4.6.1Adopted Methodological Approach

In this research, qualitative methodology is employed due to its interpretive philosophical nature, which tries to comprehend significance from the viewpoints and encounters of individuals in the social context. The interpretive philosophical position relies on qualitative methods as they provide the subjective data necessary for interpreting meanings, as noted by scholars such as Creswell (2013) and Saunders et al. (2016). Meanings, viewpoints, and relationships between individuals and variable factors are all explored and uncovered using qualitative research methodologies. Questions that can be answered by looking deeper into a concept or phenomenon are at the heart of qualitative research (Creswell, 2014). Novel constructs and theoretical contributions are developed through the use of non-standard data collection methods (Saunders et al., 2016). The data collection process is not standardised, and it typically employs non-probability sampling methods. In qualitative research, the researcher's role is viewed as more important than in quantitative research, where the process of conducting research is seen as objective (Bansal and Corley, 2011). Thus, the focus of this method is on gaining insight into and describing the phenomenon from the viewpoints of the individuals involved (Suresh, 2006). It also involves investigating and comprehending how people view human and social problems (Creswell, 2014). Researchers can learn more about the beliefs, rituals, values, and emotions of the people and institutions involved in qualitative studies of complex phenomena, as well as their behaviours and cognitions. This can be accomplished in four ways: through verbal communication, written records, in-person observations, and visual media (including pictures, videos, and drawings) (Ograjensek, 2016). Hence, if a researcher wants to gain an understanding of the human condition, this method is a good place to start (Erlingsson and Brysiewicz, 2017).

Creswell (2014) states that in qualitative research, the research questions and procedures are not predetermined but instead emerge during the research process, and the data is often collected in the natural settings of the participants. The researcher interprets the meaning of the data as they progress from specific to general themes in their data analysis. The final report is flexible in nature, allowing for adjustments based on new insights and findings. Etikan et al. (2016) highlight that while quantitative research methods provide a broad understanding of a phenomenon, qualitative research methods provide a deep understanding of the subject matter.

There are two types of qualitative research designs: mono-method and multi-method. Monomethod qualitative research refers to studies that use a single method of qualitative data gathering and analysis. Multiple qualitative data-gathering methods and different types of analysis are used in multi-method qualitative research designs. For instance, when using case studies and unstructured interviews together.

Also, in order to gain insights from professionals in the construction and infrastructure industries, this study has utilised both primary and secondary data, employing a multi-qualitative method. A researcher can choose to use multiple data collection techniques in a multi-method approach, with each technique being analysed using a corresponding data analysis method. It is important to note that a combination of qualitative and quantitative data collection methods cannot be used together. For example, if a qualitative data collection method is chosen, then subsequent data collection methods must also be qualitative methods (Saunders et al., 2019).

4.7Research Strategy

According to Denzin and Lincoln (2011) and Saunders et al. (2019), "research strategy" refers to a structured approach that researchers use to achieve answers to research questions. It involves identifying the most effective path or process for accomplishing this objective. The research strategy serves as a crucial methodological connection between the chosen research philosophy and the selection of research methods, as well as a framework for gathering and analysing information. Yin (2003) defines "research strategy" as the logical approach that optimises the collection of evidence to answer a research question. The selection of a research strategy is closely linked to the underlying research philosophy and is primarily guided by the nature of the research questions being asked (Saunders et al., 2019). According to Robson (2002) and Saunders et al. (2019), several other factors can influence the selection of a research strategy. These may include the availability of resources, the researcher's familiarity with and experience with various approaches, and the requirements of supervisory or funding bodies. These factors can play a crucial role in determining the most appropriate research strategy for a given research project. Several research strategies are available, including experiment, survey, archival research, ethnography, action research, grounded theory, narrative research, phenomenological research, and case study (Creswell, 2014; Saunders et al., 2019). In the following sections, two of these strategies, namely case study and phenomenological research, will be explained due to their applicability in this research.

4.7.1 Case Study

Yin (2014) defines case studies as investigations into phenomena that utilize practical or real-life scenarios. The unit of analysis for a case study can include individuals, groups, organizations, past or present events, and other relevant entities. Whether or not a case is deemed researchable depends on the nature of the investigation, the researcher's goals, and the degree to which the results are likely to be accepted (Flyyberg, 2011). While case studies have been widely used in business, psychology, and other institutional-related research, this method has also received some criticism. Flyvbjerg (2011) and Buchanan (2012) argue that the units of sampling in case studies are often considered unrepresentative, making it difficult to establish encompassing generalizations. Despite criticisms, the in-depth approach employed by case studies, often using mixed-methods, can generate richly descriptive, explanatory, and exploratory interventions. This approach can facilitate greater understanding and knowledge generation within the boundaries of the case unit or similar units (Bansal and Corley, 2011; Denzin and Lincoln, 2011).

4.7.2 Phenomenological Research

An additional strategy considered in this research is phenomenological research, which is not included in Saunders et al.'s (2019) research onion. However, due to the nature and requirements of this study, phenomenological research is adopted for achieving the aims of this research. As explained by Creswell (2013), phenomenological research investigates the shared meaning of a concept or a phenomenon for a group of individuals based on their lived experiences. Phenomenologists concentrate on explaining the commonalities that all participants share as they experience the phenomenon, such as the universal experience of grief (Creswell, 2013). In phenomenology, the main objective is to capture the essence of a phenomenon through a description of individual experiences, leading to a universal understanding of the concept (Van Manen, 1990). To achieve this goal, researchers identify a phenomenon that is the object of human experience (van Manen, 1990). The researcher using the phenomenological approach collects data from individuals who have encountered a phenomenon and then composes a comprehensive portrayal of the universal essence of the experience. This portrayal includes both the details of what they experienced and how they experienced it (Moustakas, 1994). Phenomenology involves a significant philosophical element, which relies on the works of Edmund Husserl (1859–1938) and his followers, including Heidegger, Sartre, and Merleau-Ponty, as noted by Spiegelberg (1982). According to Creswell (2013), phenomenological studies often involve a number of characteristics:

• The focus of the research is on a specific phenomenon expressed through a single concept or idea, such as the notion of "professional growth" in the context of education.

• A heterogeneous group of individuals who have experienced the phenomenon under investigation is identified and included in the study. The size of the group can vary, from as small as 3 to 4 individuals to as large as 10 to 15.

• The fundamental principles of conducting phenomenological research revolve around the subjective and objective experiences of individuals concerning a particular phenomenon. The approach rejects the subjective-objective perspective and lies on a continuum between qualitative and quantitative research. This philosophical discussion emphasizes the importance of understanding the lived experiences of individuals and the commonalities that exist among them (Creswell, 2013).

• The researcher in certain phenomenological studies may exclude their own experiences with the phenomenon by discussing them separately. This approach does not fully remove the researcher from the study, but it helps to acknowledge their personal experiences and set them aside to allow for a focused examination of the experiences of the study participants (Creswell, 2013).

• The usual method of collecting data in phenomenological studies is through interviews with individuals who have experienced the phenomenon, though this is not always the case, as other sources of data may be used, including documents, poems, and observations (Creswell, 2013).

• A systematic approach to data analysis is typically employed in phenomenological studies. The analysis proceeds from the examination of small units of data, such as significant statements, and gradually moves towards larger units of analysis, such as meaning units and detailed descriptions (Creswell, 2013).

• The concluding section of phenomenology describes the essence of the experience for each individual.

The article discusses two approaches to phenomenology: hermeneutic phenomenology and empirical or psychological phenomenology. Hermeneutic phenomenology emphasises interpreting the “texts” of life, while empirical or psychological phenomenology focuses on describing the experiences of participants. Van Manen’s (1990) approach to phenomenology involves six research activities, beginning with a phenomenon that interests the researcher, reflecting on essential themes, and interpreting the meaning of lived experiences. Moustakas’s (1994) approach focuses on Husserl’s concept of epoche or bracketing, which involves setting aside personal experiences to gain a fresh perspective on the phenomenon under examination.

Phenomenology is a research approach that aims to understand a phenomenon through the experiences of individuals who have gone through it. Data collection can be done through interviews with participants, and researchers may follow the structured approach developed by Moustakas (1994). A phenomenological study requires understanding the underlying philosophical assumptions, which may be difficult to identify in a written study. It is important to select participants who have experienced the phenomenon being studied to facilitate a common understanding, but finding such participants may be challenging for some research topics. Researchers must decide how to incorporate their personal understandings into the study.

4.7.3Adopted Research Strategy

In this research, two strategies are employed, including one from Saunders et al.'s (2019) research onion, namely case studies, and another one from Creswell's (2013) book, which is called phenomenological research.

Due to the interpretive stance taken in this research, a case study strategy is deemed appropriate, as it allows for an examination of the underlying factors that contribute to scope creep in construction projects, as well as the influence of stakeholders in its occurrence and management. This approach is suitable for contexts where it is challenging to disentangle the variables of a phenomenon from its context, as argued by Yin (2003b). To examine and understand the context, processes, and sequences of events associated with a phenomenon under study, case study research is an appropriate method. According to Stake (2005), a case study focuses on describing individual or group behaviour within its complete environment. Johnston et al. (1999, p. 203) explain that case study research is a comprehensive inquiry that aims to analyse the context and processes associated with the phenomenon being studied.

In this research, a case study is used to develop a conceptual framework that can address inadequacies in existing theoretical and conceptual frameworks, particularly in areas where the phenomenon under investigation is complex and difficult to separate from its context (Chetty, 1996; Yin, 2009). The case study approach is particularly useful in advancing the body of knowledge in this study because it allows for an investigation of the influence of stakeholders on the occurrence and management of scope creep in its natural setting, which is a contemporary issue that cannot be avoided in projects. Theoretical knowledge of the phenomenon under investigation, in this case, scope creep, has not been well developed, making the case study approach important for building a more robust theoretical understanding of this phenomenon (Benbasat et al., 1987).

The case study research design has been criticised for its lack of representativeness and statistical generalizability. The data collected in a case study is rich and complex, leading to various interpretations and potential researcher bias (Cornford and Smithson 1996). However, Denzin and Lincoln (2000) countered these criticisms, stating that case studies can be generalised by looking at multiple actors in multiple settings, thereby enhancing generalizability. Additionally, Yin (2003a) suggested that analytical generalisability is possible, where the researcher aims to generalise a specific set of results to broader theoretical propositions. Besides, Creswell (2013) argues that the case study strategy can be employed in both qualitative and quantitative studies.

Phenomenological research seeks to capture the essence of a concept or phenomenon through individual experiences, leading to a universal understanding (Van Manen, 1990). In this regard, the phenomenon under study in this research is "scope creep," which is investigated based on the experiences and interactions of various stakeholders with this issue in construction projects. Plus, this research adopts a hermeneutic phenomenology approach as it considers the interpretation of stakeholder experiences in relation to the aforementioned challenge. In conclusion, the phenomenology strategy in this study mainly embraces the data collected through interviews with professionals in the field of construction and infrastructure to capture and interpret their experiences in dealing with scope creep and managing stakeholders' influence within UK construction projects. However, it can be adopted with regard to the comprehension of data collected from case studies, as these two strategies can overlap.

4.7.3.1 Multiple Case

The study uses multiple cases instead of a single case due to the requirements of the research questions. According to Yin (2003a), using multiple cases results in more convincing and strong findings, as it enables the theory to be more firmly established based on diverse evidence. In addition, another significant advantage of multiple cases is that it allows for cross-case comparison. A standard multiple-case design, as presented in figure 19, has been used for this study. The design was formulated by identifying a research gap and utilising existing theories related to the phenomenon to guide case selection and develop research questions. The aforementioned process facilitated the gathering and analysis of data across the selected cases, enabling comparisons to be made and leading to the reporting of findings and conclusions. The selection of cases in a research study is dependent on the type of research questions being addressed and is guided by an existing theory. Multiple cases are chosen to determine if the results of the first case are replicated in other cases. This approach allows for a larger exploratory study to be carried out after sufficient insight into the phenomenon has been obtained.

4.8 Research Time Horizon

Time Horizon pertains to the time frame that research is conducted within. Researchers need to make a decision whether to adopt a cross-sectional approach, which investigates a phenomenon over a shorter period by capturing a snapshot of events within a particular timeframe (Saunders et al., 2019), or to undertake longitudinal research, which extends over a much longer time period to observe the evolution of a phenomenon (Babbie, 2020). The choice between cross-sectional and longitudinal research is determined mainly by the research questions and objectives, the available resources to ensure satisfactory outcomes, and the demands of the institutional settings where the research is conducted (Robson, 2002; Saunders et al., 2019). According to Robson (2002), cross-sectional methods such as surveys and interviews are commonly used, while longitudinal studies are typically associated with experimental and grounded theory approaches.

4.8.1 Time Horizon Applicable

To adhere to time constraints in academic research, the scope of a study may be determined by the chosen research approach (Saunders et al., 2019). In this particular study, a cross-sectional approach was employed, as it enabled the collection of data through methods such as case studies and interviews, which required a shorter time frame to obtain the necessary information. Also, appreciating the fact that this research studies past construction projects to capture the challenges and success factors experienced during their implementation and investigate the evolution of a phenomenon—scope creep—that has already occurred provides further support for choosing the cross-sectional approach.

4.9 Techniques and Procedures

The term "techniques and procedures" describes the methodical way in which information is gathered and analysed. In this context, they are the kind of data-gathering and analytic operations that are supported by the overall strategy and time horizon in play (Saunders et al., 2019). Many factors, including data availability and accessibility, researcher experience and expertise with the chosen methods, the availability of resources, and anticipated study duration, play a role in determining which techniques and strategies procedures will be employed (Liu, 2008). According to Kumar (2011), three primary data collection techniques are questionnaires, observations, and interviews. Naoum (2007) categorises surveys as a data collection technique; however, Saunders et al. (2016) include them in the research strategy category.

According to Creswell (2013), while new forms of qualitative data are continuously being introduced in the literature, they can be broadly classified into four basic types of information: observations (participant or non-participant), interviews (open-ended or closed-ended), documents (public or private), and audio-visual materials (e.g., compact discs, photographs, and videotapes). To conduct a phenomenological study, the primary method of collecting information is in-depth interviews with individuals, aiming to describe the meaning of the phenomenon for a small number of participants who have experienced it (McCracken, 1988). It is common to conduct multiple interviews with each participant. In addition to interviews and self-reflection, Polkinghorne (1989) recommends gathering information about the experience from depictions outside the research context, such as descriptions by novelists, poets, painters, and choreographers.

4.9.1 Interviews

Interviews are a valuable data collection method that can yield detailed information and provide a broader range of individual opinions and perceptions compared to other methods (Saunders et al., 2019). Interviews facilitate a deeper level of insight and reflection from the interviewee beyond mere question-and-answer interactions that may limit the scope of data collected by researchers. According to Robson (2002), the interview process permits the interviewee to clarify any unclear areas and to provide answers based on a feedback process (Denscombe, 2010). Unstructured, semi-structured, and structured interviews are the three main types of interviews used in research (Robson, 2002).

-Unstructured interviews are characterized by the use of open-ended questions, which promote a conversational approach and allow for further clarifications and more in-depth responses (Thomas, 2002). This type of interview supports an exploratory method of data collection that provides flexibility and openness to the process. As a result, new dimensions of knowledge may emerge that could lead to modifications in the research scope and objectives (Denscombe, 2010).

-In a semi-structured interview, the researcher has a predetermined set of questions or themes to be covered during the interview, but allows for flexibility in the questioning process. This approach provides the interviewer with some control over the interview process while allowing the interviewee to provide detailed responses and expand on their answers (Thomas, 2002; Saunders et al., 2019). The researcher can also use open-ended questions to seek further clarification or feedback, which can provide valuable information and insights into the research topic.

-Structured interviews involve the use of predetermined sets of questions, often in the form of closed-ended questions, to collect data and are well-suited for research with clearly defined objectives that require specific and concise responses (Robson, 2002; Thomas, 2002).

4.9.2 Case Study: Secondary Data

Creswell (2013) states that case study research involves a variety of data collection procedures, which allows the researcher to develop a comprehensive understanding of the case being studied. Yin (2009), in his book on case study research, identified six different types of data sources that can be used for this purpose: documents, archival records, direct observation, interviews, physical artifacts, and participant observation. The use of secondary data, which is data collected for a purpose other than the current research project, is increasingly being encouraged among researchers as it can provide additional or different interpretations or conclusions (Saunders et al., 2019). This data can include raw data and published summaries and can be further analysed to meet the objectives of the current research project. There are now many sources of secondary data available that are easy to access and may provide answers to the research question(s) being addressed (Bishop and Kuula-Luumi, 2017; Bulmer et al., 2009). The literature indicates that governments provide open access to survey data, including censuses of population, which can be downloaded in aggregated form via the Internet (Saunders et al., 2019). Additionally, many of these survey data are available from data archives. Furthermore, companies and professional organisations often have websites that contain useful data for research projects (Saunders et al., 2019). Saunders et al. (2019) state that secondary data can be both quantitative and qualitative and is used mainly in descriptive and explanatory research. Secondary data can be either raw data that has not been processed or compiled data that has undergone some form of summarising or selection. It can be structured data that is organised in a format that is easy to process, such as in a database or spreadsheet. On the other hand, it can be unstructured data that does not have a predefined structure and is not easy to search or process. According to Saunders et al. (2019), it is beneficial to categorise secondary data into three main types: surveys, which include regular and ad-hoc surveys as well as censuses; documents, which can be in the form of text, audio, or visual media; and data that is compiled from multiple sources to create a snapshot, time series, or an updated dataset. Saunders et al. (2019) summarised these sources along with relevant examples in Figure 20.

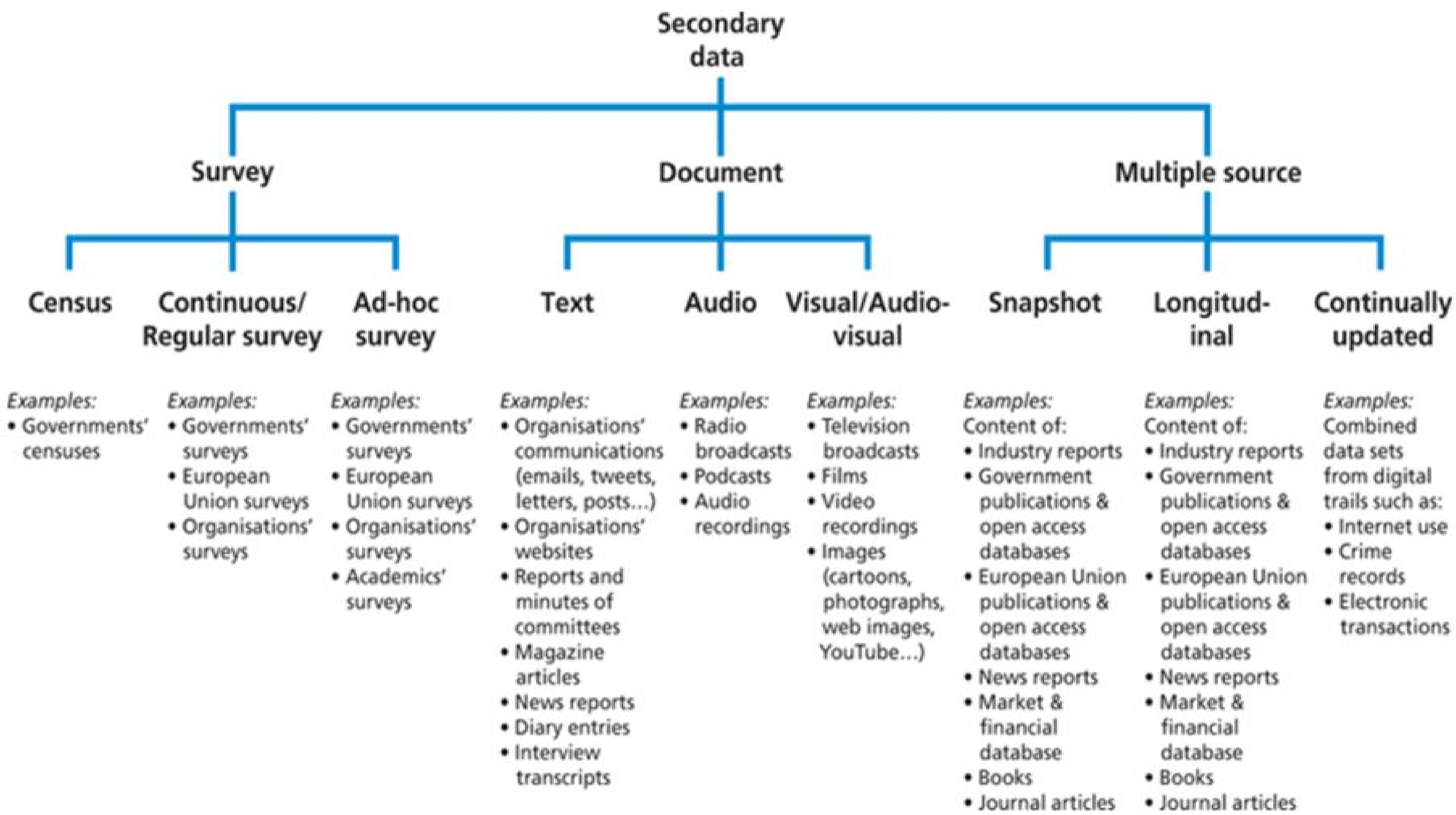

Figure 20 Types and examples of secondary data (Saunders et al., 2019, p.342)

Also, other available data collection techniques and procedures are focus group exercises, observations, questionnaire.

4.9.3 Adopted Technique And Procedure

In this study, both primary and secondary data were collected and analysed through the use of a case study strategy and semi-structured interviews with professionals in the UK's construction and infrastructure industries. Leonard-Barton (1992) employs a combination of interviews and archive documents to collect data. Case study research uses various methods to gather data, such as interviews, direct observation, documentary sources, archival records, and focus groups (Mouton 2001; Myers 2009; Vohra 2014). Therefore, Leonard-Barton's data collection approach is deemed suitable for this study. After a systematic review of the literature and under a case study strategy, secondary data were collected. The secondary data were the information collected from documentary sources (the National Audit Office (NAO), the House of Commons, and the Learning Legacy website) to investigate and evaluate six selected construction projects in the United Kingdom. Additionally, archive documents, also known as documentary sources, are valuable in enabling researchers to unearth meaning, build understanding, and acquire relevant insights (Merriam 1998). A crucial aspect of qualitative research is triangulation, which involves the use of multiple sources and methods to achieve convergence and corroboration (Bowen 2009). Documentary sources, as one of the sources, provide valuable insight and support for the research findings, helping to uncover meaning and develop an understanding (Merriam 1998). Therefore, data collection and analysis will be conducted using secondary sources such as archival documents and government reports published by the National Audit Office (NAO), the House of Commons, and the Learning Legacy website. The focus is to investigate and evaluate incidents, challenges, and best practises related to scope creep occurrence and the role of stakeholders' influence.

The primary data included information collected by the researcher via semi-structured interviews with the aim of validating the developed process framework and findings from the literature review through understanding directly the participants’ experiences and perceptions in relation to the problem of scope creep and the role of stakeholders in its occurrence and management. Therefore, a comparison could be made between the perceptions and experiences of interviewees and the developed process framework by focusing on its fundamental elements such as scope management, stakeholder management, and BIM management in construction projects. Interviews are useful in studying how interactions are carried out and provide an opportunity to comprehend and evaluate constructs within their natural environment (Berg 2007; Cohen et al. 2007; Punch 2005; O’Leary 2007, p.126).

The selection of semi-structured interviews in this study was informed by the research objectives and the type of information needed, as they offer characteristics that are a combination of structured and unstructured interviews (Cachia and Millward, 2011). Semi-structured interviews were chosen for the following reasons:

- They allow for the researcher to maintain openness and flexibility to explore the research participants' experiences in greater detail, including any specific areas that may arise during the interview (Knox and Burkard, 2009).

- The collected data can be considered comparable as the questions are posed in a consistent sequence.

In conclusion, an initial exploratory approach was adopted by reviewing the literature, which is recommended by Thomas (2002). This was followed by a case study aimed at evaluating the circumstances under which scope creep occurs as a result of stakeholders' influence and capturing issues and best practices, the development of a process framework based on the findings from the literature review and the case studies, and a semi-structured interview with professionals towards validation of findings from the literature review and the developed process framework.

4.10 Sampling

As discussed before, this research employs both primary and secondary data. First, the secondary data is collected through a case study strategy by collecting archive documents and reports on past construction projects in the United Kingdom. Then, the primary data were collected by conducting semi-structured interviews with professionals and practitioners in the U.K.'s construction industry.

The term "sample" refers to a portion of the entire population that is selected to represent what the population looks like, as stated by Naoum (2013). There are two main types of sampling methods: probability (random) sampling and non-probability (non-random) sampling. Probability sampling allows for the probability of each element being chosen for the sample to be specified. A common feature of probability sampling is that each element has an equal chance of being selected (Diserens, 1985) due to the use of a random selection procedure (Etikan et al., 2016). In contrast, non-probability sampling does not allow for the estimation of the probability of selecting each element in the sample (Diserens, 1985). This type of sampling also does not ensure that every element has an equal chance of being selected (Diserens, 1985). Non-probability sampling does not rely on the randomization of elements and does not involve the calculation of each element's probability of being selected. In non-probability sampling, the selection of elements is based on subjective methods rather than randomization. Non-probability sampling is typically employed when the population is not well defined, when there is less emphasis on generalising the results from the sample to the population, and when it is more cost-effective compared to probability sampling methods (Etikan et al., 2016).

In this research, Creswell’s (2013) sampling approach was followed. According to this approach, the purposeful sampling approach in qualitative research involves three main factors, which may differ depending on the approach taken. These factors are the selection of participants or sites, the type of sampling strategy used, and the size of the sample being studied (Creswell, 2013).

4.10.1 Participants In the Sample

Creswell's (2013) research revealed a limited set of sampling techniques that are appropriate for phenomenological studies. It is crucial that all participants have first-hand experience of the phenomenon under investigation. Criterion sampling is a suitable approach when all individuals selected are representative of those who have experienced the phenomenon. Participants in a grounded theory study are selected for their potential to make meaningful contributions to the construction of the theory. Theoretical sampling, as described by Strauss and Corbin (1998), involves selecting people who can help develop the theory's initialization and axial coding. The process of theoretical sampling in grounded theory research involves selecting individuals who can contribute to the development of the theory, beginning with a homogeneous sample of individuals who share a common experience and later moving to a heterogeneous sample (Strauss & Corbin, 1998).

Hence, in this study, the inclusion criteria were those of professionals working in construction organisations within the United Kingdom only. The study targeted individuals employed in various organisations located in cities such as London, Birmingham, etc., as well as in the towns surrounding them, across the United Kingdom (UK). Although some of the organisations were multinational companies, they all had a presence in the UK.

Based on Creswell's (2013) approach, another criterion was being familiar with the scope creep phenomenon in projects and the concepts of stakeholder management and BIM. In this regard, with the consultation of the supervisory team as mediators for selecting and approaching participants, the individuals who were deemed to have relevant experience and expertise were selected. Also, during the interviews, it was ensured that the interviewees possessed a sufficient level of familiarity with the aforementioned concepts. Although the grounded theory approach was not employed in this research, this criterion has similarities with theoretical sampling (Strauss and Corbin, 1998) in the sense that the individuals selected could contribute to the development of the process framework. Their expertise in the subject matter was recognized, and they held high-level positions within their respective organizations. According to Dullaimi and Langford (1999), employees' knowledge of the workplace and its essential activities can be significantly influenced by the workplace itself. Therefore, in addition to the necessary academic and professional qualifications, it was considered essential to include experts with practical experience in the institutional and industrial settings of the study.

An additional inclusion criterion was that participants must be working at managerial levels or higher in their companies, such as project managers, project directors, or BIM managers. The reason for choosing this criterion was to make sure that selected individuals were responsible for or directly involved in managing BIM and different project management processes and activities. The minimum experience considered was 5 years, and all the interview participants had over 10 years of experience.

4.10.2 Sampling Strategies

According to Creswell (2013), researchers must consider who or what should be sampled, the type of sampling to be used, and the appropriate sample size. These decisions are crucial as they will have an impact on the validity and reliability of the study results. The selection of the appropriate sampling method is contingent upon the research questions being asked (Setia, 2016) and the characteristics and scope of the study (Etikan et al., 2016). As each methodology has distinct criteria and guidelines for determining the requisite number of elements (participants) to meet its objectives, it is crucial that the sampling strategy aligns with the research objectives (Palinkas et al., 2013). According to Patton (2002), probability sampling aims to achieve generalization, while purposive sampling aims to gain an in-depth understanding. Hence, if a researcher prioritises a comprehensive understanding of a subject matter over generalization, purposive sampling is a suitable approach to adopt (Setia, 2016). According to Patton (2002), random probability sampling cannot achieve the same level of in-depth detail as purposeful sampling. Moreover, random sampling is employed when specific characteristics of subjects, such as their organisation size, background, and type of work, are not significant. This study uses purposive sampling methods because of the qualitative nature of the data being collected.

According to Creswell (2013), there are various qualitative sampling strategies that a researcher can use, depending on the research question and the study's objectives. Some of the commonly used qualitative sampling strategies include snowball sampling, theoretical sampling, maximum variation sampling, and convenience sampling, among others. Each strategy has its strengths and limitations and should be selected based on the research question and the desired outcomes of the study. Furthermore, researchers may employ multiple sampling methods simultaneously (Creswell, 2013).

In this research, three sampling forms are employed including critical cases, snowball sampling, and convenience sampling. Critical sampling focuses on collecting specific information related to a problem, while convenience sampling involves selecting sites or individuals that are easy to access and collect data from. Snowball sampling is a strategy for identifying information-rich cases through referrals from individuals who are familiar with the cases.

4.10.3 Sample Size

According to Patton (2002), there are no fixed guidelines for determining the appropriate sample size in qualitative research. Typically, qualitative researchers use a purposive sampling approach (Etikan et al., 2016), where the sample size is not a critical consideration (Mason, 2002). Etikan et al. (2016) and Palinkas et al. (2013) explained that purposive sampling prioritises data saturation, which means that the collection of data continues until a comprehensive understanding of the research topic is achieved and no new significant information is required. In addition, convenience sampling indicates that as the sample size increases, statistical reliability also increases (Etikan et al., 2016). However, for purposive sampling, the sample size is determined by data saturation rather than statistical reliability (Zhi, 2014). The determination of the sample size is reliant on the research question, research objectives, credibility, usefulness, available time, and resources (Patton, 2002).

Creswell (2013) asserts that determining the sample size is an equally important decision as selecting the sampling strategy during the data collection process. In qualitative research, one common guideline is to not only study a few sites or individuals but also collect in-depth details about each of them (Creswell, 2013). The primary aim of qualitative research is not to generalize information, except in some forms of case study research, but to provide a comprehensive understanding of a particular and specific topic (Pinnegar & Daynes, 2007).

Creswell (2013) reports that the number of participants in phenomenology studies varies widely, from one participant (Dukes, 1984) to as many as 325 participants (Polkinghorne, 1989). According to Dukes (1984), a range of 3 to 10 participants is recommended, while Riemen (1986) studied 10 individuals for their phenomenological study. Crouch and McKenzie (2006) suggest that the orientation and objectives of researchers are likely to be relevant. They argue that small sample sizes, which are less than 20, can be beneficial for qualitative researchers, particularly in interview-based studies, as they can allow the researcher to have closer interaction with participants and generate more detailed data (Bryman, 2016).

The purpose of conducting semi-structured interviews in this research is to validate many elements of the developed process framework, which are the results of interpreting findings from literature reviews and case studies. Using a high number of participants for the interviews seems impractical because interviewing more participants will increase the complexity and reduce the clarity of the collected data. This, in turn, makes qualitative analysis of the data time-consuming and hinders the ability to compare and evaluate the findings. In total, 10 construction and infrastructure companies in the UK were identified purposely and invitations for participation were sent to the identified potential participants amongst whom 5 of them from 5 different companies responded positively and agreed to participate. This is equivalen to 50% of the target population of samples.

Table 21 presents a summary of the interviewees' profiles who participated in the study, including their experience in the field, which ranged from 14 to over 30 years. Participant D was the least experienced, having 14 years of experience, while participants C and A were the most experienced, with a minimum of 21 years of experience. On average, the participants had 20.6 years of experience. Additionally, the participants held various job titles in different organizations, ranging from BIM and Revit developers to project directors. This diversity in job titles and experience levels ensured that insights were gained from individuals working at different levels and that common themes were identified.

Table 21 The profiles of research participants

Participant	Position	Experience
A	Director	21 Years
B	Principal Advisor – Structures Delivery / Structures Team Leader	19 Years
C	Projects Director	30 Years
D	Associate Director	14 Years

E	BIM and Revit Developer	19 Years

4.10.4 Case Study Selection

The majority of the sampling principles discussed above are applicable to the selection of case study samples. For the purpose of sampling in this research, a non-probability sampling approach is adopted using the purposive technique to select samples. Non-probability sampling techniques include elements of subjective judgment. Hence, the sample size is dependent on research questions and objectives, what is needed to find out, what will be useful, what will have credibility, and what can be done within available resources (Patton, 2014). Purposive sampling, sometimes known as "judgmental sampling," is often used when working with a very small number of samples, such as in case study research and when you wish to select particularly informative cases (Neuman, 2014). Also, Saunders et al. (2019) determine the scale of proper sample size within this technique between 4 to 12 cases while considering a homogenous population. However, Creswell (2013) suggests that including more than 4 or 5 case studies in a single case study research project is not recommended. This number is considered sufficient to identify common themes across the cases and perform cross-case theme analysis. Hence, after reviewing the available cases in this area, 15 projects were collected as the target population of this study, and 6 case studies were selected through the process of sampling.

So, the main goal of using a case study strategy in this study is to look into and explain the problems and issues that came up during the implementation of selected construction projects (case studies) that relate to the topic of this research about how stakeholders affect how project scopes are managed and what role Building Information Modeling (BIM) plays in solving these problems. The goal of this objective is to think about and deal with these identified issues within a new process framework to come up with a complete and effective way to handle the phenomenon that this research is looking at. Also, the London 2012 Olympic Construction Program will be looked at as an example of a successful construction project. This will help strengthen the process framework, especially by capturing the best practises and lessons learned. This is in line with the maximum variation sampling strategy. Maximum variation sampling is a common qualitative sampling approach that involves identifying specific criteria that differentiate the sites or participants and then selecting sites or participants that differ greatly on those criteria. This method is often preferred because it maximises differences between cases from the outset of the study, which is advantageous for uncovering diverse perspectives and themes (Creswell, 2013).

The main criteria for selecting these case studies were the availability of information and data, being executed in the construction context, the size of the projects (major construction projects), the location of the construction project (United Kingdom), having confronted difficulties in managing the scope of the project (scope creep) due to the influence of stakeholders, or having carried out a robust scope and stakeholder management system.

Hence, the 6 case studies selected through the process of sampling include:

1. Metronet London Underground Modernization
2. Scottish parliament house project
3. Wembley stadium project
4. The Paddington Health Campus scheme
5. The BBC's management of three major estate projects
6. the Olympics Stadium construction project

Secondary data from archival documents and government reports published by the National Audit Office (NAO), House of Commons, and Learning Legacy website are used for data collection and analysis to investigate and evaluate the incidents, challenges, and best practises in relation to the occurrence or avoidance of scope creep and the role of stakeholders' influence. Subsequently, the identified issues with their associated causes and the captured best scope and stakeholder management practises and strategies will be interpreted to develop a process framework incorporating BIM principles to address those challenges.

4.11 Literature Review and Paper Retrievals

The use of systematic reviews to collect data from the scientific literature is gaining popularity (Tranfield et al., 2003; Mallet et al., 2012). In addition to its use as a tool for gathering secondary data, systematic reviews are also crucial for compiling primary data, thanks to their thematic and meta-analysis of relevant papers. This process is considered essential for identifying gaps, inconsistencies, and patterns in research, and for providing a sound evidence base for policy and decision-making (Tranfield et al., 2003). Recent research by Mahamadu (2016) and Osei-wusu Kumi (2020), among others, has used a complementary technique of verifying the acceptability of findings from the systematically reviewed literature by asking for the opinions of subject matter experts. Expert evaluation or opinion can be used to verify or adjust findings from other sources, as stated by Iriste and Katane (2018). To guide the data-gathering process, a semi-structured interview was developed based on previously established theoretical notions (Thomas, 2002).

A comprehensive literature review is performed to study previous works and identify the most reliable methods, processes, and approaches developed by other authors for managing stakeholders' influence and impacts, uncertainty, communication, scope management, and Building Information Modelling, together with the synthesis of their findings to be used within the framework stages. This has been done by collecting journal articles through the Google Scholar search engine and using EBSCO, Emerald, and Science Direct databases. After paper retrievals, findings from collected publications were broken down, synthesized, and interpreted to identify the causes of scope creep, available stakeholder influence strategies, essential features, processes, and steps for managing the influence of stakeholders, effective scope management in construction projects, and the way in which BIM can contribute to the improvement of these processes. Several search criteria are established and used for paper retrieval. Firstly, only academic journals and reliable government bodies' reports are included in the review. Secondly, editorials and book reviews were eliminated. This was done in order to make sure that a similar analytical construct in terms of research methodology, aims, and area of study (construction and infrastructure) can be used for the investigation of retrieved papers. Also, the keywords used for searching the literature include stakeholders' influence, stakeholders' uncertainty, stakeholder management, scope management, scope creep, Building Information Modeling (BIM), major construction projects, and complex construction projects. The search rule used are ("stakeholders' influence" OR "stakeholders' impacts" OR "stakeholder management") AND ("stakeholders' uncertainty" OR "stakeholders risks") AND ("scope management" OR "scope creep" OR "requirements management" OR "collecting requirements") AND ("BIM impacts" OR "BIM application") AND ("major construction projects" OR "major infrastructure projects" OR "complex construction projects"). The irrelevant retrieved publications were screened out by using a filtering process that comprises two stages. In the first stage, the publications that did not contain the aforementioned keywords in their title or abstract were removed. Although, due to the shortage of literature in areas like scope creep and scope management, further considerations were undertaken to identify publications that study these areas implicitly. Secondly, the irrelevant or less relevant papers were excluded by reviewing their contents and area of study (construction and infrastructure).

4.12 Data Collection

As discussed, both primary and secondary data are collected to achieve the aims of this research. First, the secondary data type and collection steps are explained, and then the primary data collection process is described in accordance with their sequence of occurrence.

4.12.1 Secondary Data Collection

Saunders et al. (2019) state that secondary data are used primarily in descriptive and explanatory research, and include both quantitative and qualitative data. These data may be raw or compiled, and structured or unstructured. Structured data are organised in a way that is easy to process, while unstructured data lack a predefined structure, and may include text, audio, visual, or audio-visual data, as well as dates and other numerical data. In business and management research, secondary data are most commonly used in case study and survey research strategies (Saunders et al., 2019). As described in previous sections, Saunders et al. (2019) have categorised the various types of secondary data into three main groups for ease of understanding. These include surveys, which can be in the form of a census, continuous, regular, or ad hoc survey. The second group is documents, which can be in the form of text, audio, or visual media. The third group comprises data that are compiled from multiple sources to create a snapshot, time series, or continually updated dataset.

4.12.1.1 Document Secondary Data

Document secondary data can be utilised not only in research projects that also gather primary data but also in isolation or with other secondary data sources, such as for business history research using archival research strategies. These types of data are durable, including in digital formats, allowing them to be relocated across time and space and analysed for a different purpose than their initial collection. They include text, audio, and visual media and can be downloaded as structured data for secondary analysis (Saunders et al., 2019; Lee, 2012). Saunders et al. (2019) describe text media as encompassing a wide range of sources, such as notices, correspondence (including emails), minutes of meetings, reports to shareholders, transcripts of speeches and conversations, diaries, administrative and public records, the text of web pages, books, journal and magazine articles, and newspapers. Although compiled secondary data are often stored in books, articles, journals, and reports, text media can also be important raw secondary data in their own right. For instance, an analysis of the text of companies' annual reports could reveal the attitude of companies in different sectors towards environmental issues (Saunders et al., 2019). In accordance with Saunders et al. (2019), audio media, which comprises archived recordings of radio programmes, speeches, audio blogs, and podcasts, can be analysed both quantitatively and qualitatively by transcribing the spoken words and treating them as text. Nevertheless, it may disregard other crucial features of these data, including the tone of voice.

When conducting a research project, the availability of document sources can be influenced by various factors, such as access to an organization's records and the ability to locate data archives, commercial sources, internet resources, and library resources. The availability of an organization's data may be subject to the approval of gatekeepers within that organization. Document secondary data is commonly used in within-company action research projects or as a case study of a particular company (Saunders et al., 2019).

4.12.2 The Pros and Cons of Using Secondary Data

According to Saunders et al. (2019), the advantages of using secondary data include fewer resource requirements, unobtrusiveness, feasibility of longitudinal studies, providing comparative and contextual data, new insights, and the permanence of the data. The primary advantage of using secondary data for many research questions and objectives is that it saves considerable resources, particularly time and money (Vartanian 2011). Generally, it is less expensive and less time-consuming to use secondary data than to collect data oneself, particularly if the data can be downloaded in a file format that is compatible with one's analytical software. This approach also allows for more time to be spent on considering theoretical aims and substantive issues, as well as analysing and interpreting the data (Saunders et al., 2019). The use of secondary data in organisational research offers the advantage of providing an unobtrusive measure since the data has already been collected. This advantage is referred to as "eavesdropping" by Cowton (1998), highlighting its usefulness in sensitive situations. Secondary data can be particularly useful for research projects where time constraints make longitudinal studies difficult or impossible. This approach can be particularly useful for research questions and objectives that require regional or international comparisons (Saunders et al., 2019).

According to Saunders et al. (2019), it can be advantageous to compare primary data that has been collected with secondary data. This will enable the researcher to position their own findings within a broader context or to triangulate their findings. For example, if a questionnaire was used to gather data from a sample of prospective customers, secondary data like a national census can be utilised to evaluate the generalizability of the findings, indicating how well these data can represent the entire population. New discoveries and insights may also emerge from reanalysing secondary data that were not originally anticipated. (Saunders et al., 2019). In addition, secondary data sources provide a more permanent and easily verifiable source of data compared to data that are collected through primary research methods. As noted by Denscombe (2007), secondary data sources are often available in a form that can be easily checked by others, thus increasing the transparency and accountability of the research findings.

On the other hand, the disadvantages of using secondary data sources are mentioned by Saunders et al. (2019) as matching the collected data to the purpose of study, difficulty of accessibility, unsuitability of aggregations and definitions, controlling data quality, and the impact of the initial purpose on data presentation.

The first step in using secondary data for research is to determine if the necessary data is available. This can be guided by the research questions, objectives, and literature review. Clues can help identify the types of data that are likely to be available (Saunders et al., 2019). The process of finding relevant secondary data involves two stages: first, determining whether the type of data needed is likely to be available as secondary data, and second, locating the specific data required. This can be challenging due to the diverse locations where potential secondary data are stored, despite the growing importance of the internet as a source (Saunders et al., 2019). The literature review of a research topic can provide clues about the availability of secondary data. Journal articles and books that use secondary data can provide an idea of the type of data available, as well as references to the sources of the data. If these references refer to published secondary data, such as online databases or survey reports, it is often easy to find the original source (Saunders et al., 2019). The process of finding the precise location of the secondary data involves different levels of ease depending on the source of the data. For data held in online databases or published by governments, finding their location can be relatively easy, especially if a full reference exists. Specialist libraries may also hold published secondary data that are relatively easy to locate. However, locating data held by companies, professional organisations or trade associations can be more difficult and may require the assistance of an information or data manager within the appropriate department who can act as a gatekeeper to the information (Saunders et al., 2019).

4.12.3 Adopted Secondary Data

Since obtaining access to the organisational data, reports, and documents on each of the selected case study projects was not possible due to the sensitivity and confidentiality of the information, the next reliable source of secondary data was to use governmental documents, reports, and articles published on public platforms. As mentioned, the secondary data on the case study projects is collected from the National Audit Office (NAO), House of Commons, and Learning Legacy websites and analysed using a meta-analysis approach to identify and capture the impactful events and issues, best practices, and the lessons learned during project execution.

4.12.3.1 The National Audit Office (NAO)

The National Audit Office (NAO) has been in existence since 1983, but the history of the public audit function for central government in the UK goes back much further. The NAO is an independent public spending watchdog in the UK that supports Parliament in holding the government accountable and improving public services through high-quality audits. The NAO operates independently of the government and the civil service. Its leader, the Comptroller and Auditor General (C&AG), Gareth Davies, is an officer of the House of Commons with statutory authority to audit and report on the financial accounts of all government departments and other public bodies, as well as to examine and report on the value for money of how public money has been spent.

The Public Accounts Commission (TPAC) is responsible for overseeing the National Audit Office's (NAO) work and is comprised of Members of Parliament (MPs). The NAO has recently adopted a five-year strategy from 2020 to 2025 with the aim of enhancing their assistance to Parliament in scrutinising public sector performance, generating more actionable recommendations that result in improved outcomes, and sharing more of their independent expertise. The NAO's work facilitates government scrutiny by Parliament, creates positive financial impacts, and has a tangible impact on people's lives.

The Public Accounts Committee (PAC) is supported by an organisation that conducts audits of public sector accounts, which include all government departments, executive agencies, arm’s-length bodies, companies audited under statute or voluntarily, and some charities. The audits are conducted by a team of experts with various specialties and aim to scrutinise government policy implementation and public spending. Their reports are used to hold evidence sessions by PAC, and the audited bodies are required to respond to the recommendations made. The organisation provides an independent audit opinion on approximately 400 accounts per year, and the results are reported to Parliament by the Comptroller and Auditor General (C&AG).

Their work aims to enhance transparency and ensure that public funds are being utilized according to the Parliament's intentions. This helps government entities in managing taxpayers' money more effectively. Their reports submitted to Parliament assess whether the government is delivering value for money. They define value for money as the optimal use of resources, i.e., economy, efficiency, and effectiveness, to achieve the intended outcomes. Around 60 value-for-money reports are published annually that are relevant, timely, and impactful and address complex challenges faced by the government. These reports provide recommendations on how the government can improve services and achieve value for money. They also produce responsive reports to establish facts and investigate emerging concerns about public spending. Their role is not to question government policy objectives but to assess how government funds have been utilised to deliver those policies and whether they have been used in the best way to achieve the intended outcomes.

The National Audit Office (NAO) provides practical and valuable insights to improve public services based on their extensive work on issues that are of priority for the government. Their expert insight teams observe both recurring issues and innovations. Their work includes the publication of "lessons learned" and "good practice" guides. The "lessons learned" publications consolidate their knowledge on cross-cutting issues of importance to the government. The "good practice" guides are accessible resources that provide practical overviews and tips to assist stakeholders involved in delivering or overseeing public services.

4.12.3.2 House of Commons

In the UK, Parliament is responsible for examining the actions of the government, creating new laws, setting taxes, and discussing current topics of interest. Both the House of Commons and the House of Lords have distinct roles in carrying out Parliament's duties. The primary functions of Parliament include scrutinising and questioning the government's work, passing and amending laws, engaging in debates on significant matters, and authorising the government's expenditures and taxation.

Parliament comprises three central components: the House of Commons, the House of Lords, and the Monarchy. The principal activities of Parliament are carried out in the two Houses. Ordinarily, the decisions taken in one House need to be endorsed by the other.

One of the primary responsibilities of Parliament is to scrutinise and challenge the actions of the government. Both the House of Commons and the House of Lords use comparable means of scrutiny, albeit with differences in procedures. The primary techniques used are questioning government ministers, holding debates, and conducting investigations through committees. The government is expected to provide public responses in order to explain and defend its policies and decisions.

Parliament has several committees composed of smaller groups of MPs or Lords that scrutinize specific policy issues or legislation in detail. The House of Commons has departmental select committees, which shadow government departments and scrutinize their spending, administration, and policies. The House of Lords and both Houses also have permanent and temporary committees, and MPs and Lords work together in Joint Select Committees. The committees' roles vary, ranging from offering advice to altering legislation, and they examine issues in detail, including government policies, proposed laws, and broader topics such as the economy. The government provides responses to most committee reports. Much of the House of Commons' and House of Lords' work occurs in these committees, which typically consist of 10 to 50 MPs or Lords.

Select Committees operate in both Houses of Parliament and are responsible for examining and reporting on a variety of areas, such as government department operations and economic affairs. The results of these investigations are publicly available and often require a response from the government. In the House of Commons, there is a departmental Select Committee for each government department, which scrutinises spending, policies, and administration. These committees have at least 11 members who decide on the scope of the inquiry and gather evidence in written and oral form. The findings are published on the Parliament website, and the government typically responds to the committee's recommendations within 60 days. Some Select Committees, such as the Public Accounts or Environmental Audit Committees, have a remit that cuts across several government departments. Other Commons Committees have various ongoing investigations, such as the administration of the House or allegations of misconduct by individual MPs. Committees can also appoint specialist advisers, who are external specialists paid on a daily basis, to provide additional support to the committee. These advisers are often academics and assist the clerk, who is the head of the committee's staff.

The Public Accounts Committee is responsible for scrutinising the efficiency, economy, and effectiveness of public spending on government projects, programmes, and service delivery. They draw upon the National Audit Office's work and hold government officials accounTable for their spending decisions.

4.12.3.3 Learning Legacy

The guarantee of the future of an industry resource aimed at retaining lessons from the London 2012 construction programme has been ensured. The Learning Legacy website, developed by the Olympic Delivery Authority (ODA), contained more than 300 papers on ten themes, promoting successes in areas such as health and safety, procurement, project management, transport, and sustainability, as well as case studies and reports. The ODA and its supply chain of companies across the UK, along with contributions from independent industry bodies and academics, produced the papers. The website was the first of its kind in the UK construction sector to capture knowledge on such a large scale. The Major Projects Authority (MPA), a partnership between the Cabinet Office, HM Treasury, and other departments to improve the success rate of major projects across central government, will now oversee the website's continuation.

In the past, the Learning Legacy website was planned to grow by adding new case studies, reports, and research papers from the London Organising Committee of the Olympic and Paralympic Games (LOCOG) and their associates and suppliers. These additions were intended to address various topics, such as carbon footprint and temporary materials, the implementation of the London 2012 Food Vision, waste management, and sustainable sourcing.

The ODA collaborated closely with various industry and professional associations to share the knowledge acquired from its work on the London 2012 construction project. These associations included

- the Association for Project Management,
- Chartered Institute of Building,
- Health and Safety Executive,
- Institution of Civil Engineers,
- Institution of Occupational Safety and Health,
- Royal Institution of Chartered Surveyors,
- The Institution of Engineering and Technology,

- The Landscape Institute,
- and UK Green Building Council.

The Learning Legacy website features ten overarching themes that the ODA has identified as essential to the successful completion of the London 2012 construction programme. These themes are:

- Design and engineering innovation;
- Equality, Inclusion, Employment and skills;
- Health and safety;
- Masterplanning and town planning;
- Procurement and supply chain management;
- Programme organisation and project management;
- Sustainability;
- Systems and technology;
- Transport;
- Archaeology.

Most of these themes are further divided into four distinct sub-sections, which include Micro reports, Case studies, Research summaries, and Champion products. Micro reports provide short examples of lessons learned, best practises, and innovative practises from the construction programme by the ODA, its Delivery Partner, contractors, and industry partners. Case studies comprise peer-reviewed papers discussing lessons learned, best practises, and innovative techniques from across the Programme by the ODA and its Delivery Partner, the supply chain, and industry. Research summaries consist of summary reports detailing research projects conducted by academia and industry on the London 2012 construction project. These organisations will also publish full research papers as they become available throughout 2012. Champion products showcase successful tools and templates used on the project.

4.12.4 Primary Data Collection

Interviews, according to Hughes (2016), should be viewed as a series of steps rather than a single event. So, several steps were outlined by the author, including pre-interview preparations, introductions, beginning the interview, during the interview, ending the interview, and post-interview.

As mentioned before, potential participants are identified through gathering information on construction and infrastructure companies through web searches, networking, and the assistance of the supervisory team. So, the potential participants in this research were construction and project managers, people in charge of managing stakeholders and scope, and BIM managers (if available). Hence, the identified potential participants were contacted by sending online participation invitations to their email addresses. The emailed invitations included the researcher's information, the topic of research, and a brief explanation of the aim of research and participation requirements, along with an information sheet and consent form for participation. Once they agreed to participate by responding to the emails, they were approached again to set up the time and location of interviews according to their preferences. In a formal manner, the researcher sent emails to the participants requesting their availability for an interview and providing options for a face-to-face, phone, or Skype interview. Some participants expressed their willingness to use any of the methods. However, the researcher preferred face-to-face interviews whenever possible. As stated by Hughes (2016), the interactions that occur during the interview planning stage, such as securing agreement for the interview and finalizing the logistics, contribute to the interviewee's perception of the interviewer's professionalism. In total, 10 emails of invitation were sent to the identified potential participants, among whom 5 responded positively and agreed to participate. The interviews were conducted face-to-face and took between 60 to 90 minutes. Also provided is a list of the interview's themes and relevant key questions. The interview questions are structured in 5 categories as follows:

- Stakeholder management and influence
- Scope management and scope creep
- Uncertainty and risk management
- Communication management

- BIM

The list of key questions for each of the aforementioned categories is depicted in Appendix 1. In total, 11 questions are designed under the aforementioned 5 themes. Where needed, complementary questions were asked during the interviews to clarify and comprehend participants' meanings and perceptions. The key questions are the main pillars of the interviews, which are based on the research questions and aims of this study. These are shown in Table 22. The reason behind conducting 48 interview questions was to achieve enough data saturation, clarify any ambiguities, facilitate capturing the essence of participants' knowledge, perception, and experience, and consequently, create the possibility of comparison with and validation of the elements included in the developed process framework. However, not all of these questions were asked in every interview, as the perceptions and experiences of each individual and the amount of data they provided in response to the key questions were different.

Table 22 The key questions in the interview process

Themes	Key Questions
Scope Management	• Key 1: From your experience, what are the main causes of scope creep in projects? • Key 2: Can you describe your company's approach to effectively managing and preventing scope creep in order to ensure project success?
Stakeholder Management	• Key 3: According to your experience, what is the role of stakeholders' influence in the occurrence and management of scope creep? • Key 4: What kinds of influencing strategies did stakeholders use to impose changes on scope? • Key 5: In your company, what kinds of responding strategies do you choose to counter the influencing strategies of stakeholders?
Stakeholder Uncertainty & Risk	• Key 6: What types of effects did the uncertainty in scope bring forth, in terms of positive or negative?
Stakeholder Communication	• Key 7: From your experience, what is the role of communications in managing the project scope and influence of stakeholders? • Key 8: In your company, what kinds of methods and approaches do you adopt for stakeholder engagement and communication?
Building Information	• Key 9: From your perspective, what are the positive and negative effects of using BIM in the project

Modelling	management of construction projects? • Key 10: How can Building Information Modelling (BIM) be leveraged to mitigate the adverse impacts of scope creep in your organisation's projects? • Key 11: What is the potential role of BIM in managing the influence of stakeholders on the scope of the project?

Before starting the interview, the researcher informed each participant of the purpose of the interview and guided them through the interview process. This approach was recommended by Hughes (2016) as a best practice, as it ensures that both the interviewer and the interviewee start on neutral ground.

The interviews began by thanking the participant for considering the request for access and agreeing to the meeting. The purpose of the research and its progress to date were outlined briefly, and the consent form and information sheet were given to participants, which are provided in appendices 2 and 3 and include the following sections (Saunders, Lewis, and Thornhill, 2019):

- The nature of research
- Requirements for taking part
- Implications of taking part and participants' rights
- About the use of the data collected and how it will be reported
- Who to contact to raise any concerns or questions about research

Also, the agreed-upon rights to anonymity and privacy were reaffirmed by saying that nothing said by participants will be linked to them without their permission first. Emphasis was placed on the participant's right not to answer any questions and to stop the interview at his or her request. Plus, information is provided on the nature of the research output and what will happen to the data collected. If participants wish, a summary of the research findings will be provided to them. In addition, the request to record the interview electronically is restated and agreed upon. Hughes (2016) suggested that interviewers should avoid passing judgement on the views expressed by the interviewees and allow a rapport to develop between the interviewee and the content they are discussing. The author also recommended that interviewers should listen actively to the interviewee. The researcher in this study followed these recommendations. Also, data are captured by audio recording the conversation using an MP3 Voice Recorder device and taking notes. The participants or interviewees remain anonymous due to the confidentiality of project information for some organisations or companies. The collected primary data are stored on an external hard drive for five years, and after that time, they will be removed and deleted. Finally, the participants were requested to read and sign the "informed consent form."

To conclude the interviews, the researcher did not abruptly end them, but instead, politely asked the interviewees if they had any further questions. The researcher reiterated the assurance of data confidentiality, as was done at the beginning of the interviews.

After the interviews were conducted, the participants were sent an email expressing gratitude for their participation in the study. The email also emphasized the confidentiality of the data and assured the participants that the findings of the study would be shared with them once the research was completed.

4.13 Data Analysis Approach

In this research, the secondary data collected on case studies are analysed by employing the thematic-synthesis method, and thematic analysis is employed for the analysis of the primary data collected through semi-structured interviews. Each of these approaches is explained in the following sections.

4.13.1 Secondary Data Analysis

Creswell (2013) suggests that in case study research, similar to ethnography, the analysis involves producing a thorough portrayal of the case and its context. If the case features a sequence of events, the researcher should analyze various sources of data to identify the supporting evidence for each stage or aspect in the progression of the case.

Recent years have seen the emergence of various systematic approaches for the review, evaluation, analysis, and synthesis of studies investigating the same phenomenon, using methodologies that overlap or are similar in many aspects. These approaches are known by different labels such as qualitative meta-analysis, qualitative meta-synthesis, meta-ethnography, grounded formal theory, meta-study or meta-summary, among others (Thorne et al., 2004). According to Timulak (2014), qualitative meta-analysis involves a secondary analysis of primary studies that investigate the same research question. This type of analysis has two primary objectives: to provide a comprehensive and concise overview of the findings of these studies and to evaluate the impact of methodological factors on these findings. The ultimate aim of qualitative meta-analysis is to produce a new conceptualization that encompasses the essential elements of the reviewed studies and provides a more substantive understanding of the phenomenon in question (Schreiber et al., 1997; Finfgeld, 2003). According to Timulak (2014), there are various approaches to qualitative meta-analysis. Ponterotto's (2005) classification distinguishes between approaches that have more post-positivistic characteristics and are primarily focused on summarising the findings of the original studies, and approaches that have a more constructivist-interpretive orientation, which aim to interpret the studies and present an overarching or particular perspective through conceptualisation. The author Timulak (2014) explains that there are several other methods of qualitative meta-analysis available, which have been given various names such as critical interpretive synthesis, thematic synthesis, meta-ethnography, meta-study, meta-summary, and grounded formal theory.

The thematic synthesis approach of Thomas and Harden (2008) is another brand name approach to qualitative meta-analysis. Unlike other approaches, it focuses on analysing the results of the original studies instead of just describing them. Their approach uses a particular interpretive framework, which leads to inferential analysis and the creation of analytical themes. Additionally, they stress the importance of examining the contribution of individual studies to the final synthesis, including testing how the results are influenced by the inclusion or exclusion of studies with varying methodological quality (Timulak, 2014).

Various authors have suggested methods for conducting qualitative meta-analysis, with the approach determined by the meta-analysts' epistemological and theoretical stances (Timulak, 2014). All qualitative meta-analysis methods have a common feature of using a flexible analytical strategy, which involves comparing, abstracting, and observing similarities and differences among the primary studies while retaining contextual influences and details. The analytical methods differ in their focus on interpretive or descriptive processes, the level of abstraction, and the level of inclusion of diverse theoretical approaches. Rare findings are also taken into account during the analysis (Finfgeld, 2003; Thorne et al., 2004; Timulak, 2014).

Timulak (2014) proposes a comprehensive approach to the analytical process involved in qualitative meta-analysis, which is based on procedures outlined by Elliott and Timulak (2005) and Hill et al. (1997). This approach draws on aspects of post-positivistic and constructive-interpretive research paradigms and involves credibility checks and independent perspectives while also giving voice to participants and recognizing the dialogical nature of research. Variations of this approach may emphasise either interpretive or descriptive analytical processes (Timulak, 2014). The descriptive-interpretive approach to qualitative meta-analysis involves a series of steps for data analysis, starting with identifying relevant studies and assessing their methodological aspects (Timulak, 2014). Once the data has been gathered, the meta-analysts create a conceptual framework that helps organise the data into manageable portions or domains. This framework follows a logical structure, allowing the meta-analysts to break down complex phenomena into smaller areas, such as helpful and unhelpful experiences of therapy or the chronological stages of conflicts in the therapeutic relationship (Timulak, 2009). The next step in the qualitative meta-analysis process is to assign the data within the domains established by the conceptual framework and break them into manageable meaning units while retaining references to the original studies (Timulak, 2009). These meaning units are then compared and clustered according to similarities, and abstracted wording is provided for the clustered meaning units. The abstracted wording can be descriptive or interpretive, depending on the meta-analysts' epistemological approach. The abstracted categories presented within a clear conceptual framework represent the meta-analytic findings (Timulak, 2009). The findings of qualitative research are typically extensive and lengthy, and therefore require summarisation for readability. To ensure trustworthiness, several credibility checks are recommended during the meta-analysis process, including an inspection of how the original studies are represented and how their methodological aspects impacted the final synthesis (Sandelowski & Barroso, 2003; Morrow, 2005; Sandelowski & Barroso, 2007; Timulak, 2014).

4.13.1.1 Thematic Synthesis

Bryman (2016) reminds us that the discussion of qualitative data analysis thus far has mainly focused on data collected by the analyst. However, there has been an increase in the interest and discussion of the secondary analysis of qualitative data. Unlike the secondary analysis of quantitative data, which has been a part of research for many years, the use of qualitative data has only recently gained attention. However, secondary analysis of qualitative data presents some practical challenges. Nonetheless, it provides ample opportunities for researchers because qualitative researchers often generate vast and unwieldy data sets, and a significant portion of this data remains unexplored (Bryman, 2016).

Bryman (2016) notes that qualitative researchers have become increasingly interested in synthesizing qualitative studies that pertain to a specific research area. This concept of synthesis is similar to conducting a meta-analysis of quantitative studies. Synthesizing qualitative research in a particular domain can provide a comprehensive understanding of what is currently known in that area, and can serve as a foundation for future research endeavors. Such a synthesis can be carried out in a methodical manner to ensure its rigor (Bryman, 2016). There are a number of ways to go about conducting a synthesis of qualitative studies, and the field isn't exactly close to settling on a favoured alternative. Two of the available approaches to qualitative synthesis, as Bryman (2016) suggests, are meta-ethnography and thematic synthesis.

According to Bryman (2016), thematic synthesis is a method of applying thematic analysis to studies that already exist in a specific research domain. Although this approach is typically considered a way to synthesize qualitative studies, it can also include quantitative studies, as noted by Kavanagh et al. (2012). Bryman (2016) explains that conducting a synthesis of studies in a particular research domain involves several steps. First, the researcher must define a clear research question, which will guide the search for relevant studies. The researcher then needs to screen the identified studies against the defined criteria and exclude those that do not meet the criteria or fail to meet the quality assessment standards. Once the selection of studies to be synthesized is finalized, there are three main stages in implementing a synthesis: coding the text in the studies, generating descriptive themes, and generating analytic themes (Thomas and Harden, 2008; Thomas, Harden, and Newman, 2012). Finally, the quality assessment of the included studies should be considered when presenting the synthesis.

The initial stage in synthesising qualitative research involves coding the text in the studies. The reviewers need to identify the findings and determine whether they relate to the participants' reports or the researchers' conclusions. This involves a line-by-line coding process, where each line of text is analysed to determine its significance for the research question (Bryman, 2016). The second stage of thematic synthesis involves generating descriptive themes from the codes identified in the first stage. The many codes produced through line-by-line coding are combined to create higher-order themes. If the descriptive themes have provided adequate answers to the research question, the synthesis may stop at this stage (Thomas et al., 2012). The final stage of thematic synthesis, if undertaken, involves generating analytic themes that go beyond the descriptive themes established in the second stage. Thomas et al. (2012) describe this stage as creating "new conceptualisations and explanations" that are broader in scope than the primary studies. To achieve this, the authors recommend examining each descriptive theme and considering how it contributes to addressing the research question. According to Thomas and Harden (2008), generating analytic themes is a contentious stage in thematic synthesis as it heavily relies on the researcher's interpretation and creativity. However, without this step, thematic synthesis may merely compile studies without contributing to new understandings. Finfgeld (2003) argues that authors who prefer the term meta-synthesis for the systematic review and synthesis of qualitative studies suggest that this method is more interpretive than aggregative. Therefore, the term synthesis is considered to be more suitable than meta-analysis.

Critics state that combining findings from different studies with divergent epistemological perspectives is difficult and may result in a misrepresentation of the original results. However, it has been suggested by recent trends that synthesising data that is provided through multifold qualitative epistemologies can be recognised as a form of triangulation. Guba and Lincoln (1989) mention that triangulation is the analysis of findings or results generated from multiple methods and theories. Thus, the meta-synthesis of the new translation of findings resulting from different methodological and philosophical perspectives will enhance credibility.

As mentioned, the secondary data on the case study projects is collected from the National Audit Office (NAO), House of Commons, and Learning Legacy websites and analysed using a thematic-synthesis approach to identify the the best practises and impactful events and issues during project execution. The main goal for doing this is to identify the effective and efficient practises and realise what went wrong in those projects, interpret the issues that occurred into project management terms and processes, and address them within the Process Framework. Hence, the reports on case study projects were analysed and major issues were mapped by using the MindGenious software, and the reason for the occurrence of each captured issue was identified and coded. Then, the aoverarchings themes were developed by linking coded data to the relevant project management processes defined in the PMBOK GUIDE (PMI, 2017). Also, the London 2012 Olympic Construction Program was looked at as an example of a successful construction project. This helped to strengthen the process framework, especially by capturing the best practises and lessons learned. The outputs of this step, together with the findings from the literature review, establish the basis for the development of the primary process framework. The findings of this step are presented in Tables 19 and 20 of the following chapter.

In conclusion, secondary data collected from official reports (NAO, House of Commons, and Learning Legacy) on case studies is summarised in a mind map by using MindGenius software for each project. These concept maps are presented in Appendices 5 to 12. To do this, the findings from these reports are analyzed, broken down into further details, and interpreted according to the main themes of project management processes in this research. The major events and problematic issues that occurred during the lifecycle of each case in accordance with stakeholder, scope, communication, and risk management themes are consequently captured and categorised. These learned lessons and identified issues guided the path towards developing a process framework by clarifying the most problematic issues and identifying successful approaches (Olympic Project).

4.13.2 Primary data analysis

The process of analyzing text and other forms of data is a challenging task for qualitative researchers. Saunders et al. (2019) argue that there is no standardised approach to analysing qualitative data, but some of the existing procedures and approaches may be associated with specific rules while others may rely much more on the researcher's interpretation. In addition to analyzing text and image data, the process also involves organizing the data, conducting a preliminary read-through, coding and organizing themes, representing the data, and forming an interpretation of them (Creswell, 2013). These steps are interconnected and form a spiral of activities related to the analysis and representation of the data (Guest, MacQueen, & Namey, 2012).

Creswell (2013) suggests that in phenomenological data analysis, the data from the research questions are used to identify "significant statements" or quotes that provide insight into how the participants experienced the phenomenon. Moustakas (1994) refers to this process as horizonalization. After identifying these significant statements, the researcher develops themes by clustering them into groups of meaning.

As mentioned, the thematic analysis approach, which is a general approach to analysing qualitative data, is employed for the analysis of the primary data. According to Braun and Clarke (2006), thematic analysis is considered a fundamental technique for conducting qualitative analysis. According to Saunders et al. (2019), thematic analysis is an approach used to identify patterns or themes across a set of data, such as interviews, documents, or observations. The researcher uses this approach to code qualitative data and identify themes or patterns that relate to their research question. According to Braun and Clarke (2006), thematic analysis is an approach that is both systematic and adaptable for the analysis of qualitative data. The method is systematic in its application of a structured and methodical process for analysing qualitative data. Thematic analysis can be applied to large or small data sets to generate detailed descriptions, explanations, and theories (Saunders et al., 2019).

Thematic analysis is a valuable tool for researchers as it enables them to manage and make sense of large volumes of qualitative data, integrate related information from different sources, and identify key themes or patterns within the data set (Saunders et al., 2019). It can also help in producing a comprehensive and thematic description of the data, developing and testing theories based on the identified patterns, and drawing valid conclusions (Saunders et al., 2019). Thematic analysis is a flexible approach that is not constrained by a specific research philosophy and can be applied regardless of whether an objectivist or subjectivist position is adopted (Saunders et al., 2019). In practice, the process of thematic analysis is not a straightforward linear progression but rather a concurrent and recursive one. This involves the researcher analysing data as it is being collected and revisiting earlier data and analysis as they refine the coding and categorization of newly collected data and search for analytical themes.In Thematic Analysis, there are four elements involved in the procedure, which include: familiarising yourself with the data, coding the data, searching for themes and identifying relationships, and refining themes as well as testing propositions (Saunders et al., 2019). This generic approach is utilized in this research.

The primary data collected by conducting semi-structured interviews with participants is transcribed from audio or handwritten to word-processed text and saved separately for each project with detailed file naming. This is done by fully transcribing interviews and typing them by syncing recordings in MP3 format to a computer and by using Transcribing Services and Atlas.ti software. The transcribed data are saved in Rich Text Format (.rtf) using MS Word. Since CAQDAS software (Atlas.ti) is used for data coding and analysis, activities such as spell checking, find and replace for anonymizing data, and speaker identifiers are performed and applied in MS Word before importing data to the software. The ATLAS.ti software is a tool that allows researchers to manage and organise their audio, text, visual, and graphic data, as well as their findings coding and memos. It also facilitates the coding, annotation, and comparison of data segments. The programme features an interactive margin screen that allows for the drag and drop of codes. With this software, researchers can easily search, retrieve, and browse notes and data segments, and can even create unique visual networks in a concept map. Additionally, data can be exported to programmes like HTML, SPSS, XML, and CSV. This software also enables a group of researchers to collaborate on the same project, compare coding methods, and analyse the data collectively.

Taylor and Gibbs (2010) and stated that coding is the process of combing the data for themes, ideas, and categories and then marking similar passages of text with a code label so that they can easily be retrieved at a later stage for further comparison and analysis (James, 2022). Also, they mentioned that codes can be based on themes, topics, ideas, concepts, phrases, and keywords. Crabtree and Miller (1992) describe a continuum of coding strategies that ranges from prefigured to emergent categories. In the coding process, Creswell (2013) suggests starting with a short list of five or six categories with shorthand labels called "lean coding". As the researcher continues to review the database, the categories are expanded, but Creswell recommends not developing more than 25-30 categories regardless of the size of the database. Researchers who end up with 100 or 200 categories in a complex database often struggle to reduce the number to the five or six themes needed for most publications (Creswell, 2013). The use of preexisting codes in the coding process can limit the analysis to the prefigured categories rather than allowing for emergent categories to emerge. The use of prefigured codes is common in other domains of science too, but may not allow for the full reflection of participant views. However, if prefigured codes are used, researchers should remain open to the emergence of additional codes during analysis (Crabtree & Miller, 1992; Creswell, 2013).

In qualitative research, there is a question of where to derive the code names or labels used during the coding process. According to Creswell (2013), these labels can come from different sources, such as being in vivo codes derived from the exact words of participants, or they can be names taken from the social or health sciences. The researcher may also create names that best describe the information being analyzed.

The codes for this research are developed by using the "Prior Codes" approach, in which the codes are identified from sources such as previous theories, research questions, topics and questions from the interview schedule, and the researcher's feelings about the data. The codes and their categories in this research are developed based on the topic of this research, the research questions, the aims, the literature review, the project management processes, the BIM, the findings from the case studies, and the elements used for the development of the primary process framework. Thus, a comparison could be made between the findings from the literature review and the elements of the primary process framework with the findings from the interviews to validate the developed process framework. The new codes were developed if an identified theme from the collected data fit the codes already developed. Also, the qualitative procedure will be applied to compare coded passages with each other within and between chosen case studies to ensure consistency and consider the possibility of finding new codes, dimensions, and phenomena. The scheme of codes is developed and presented in Appendix 4 for this research in accordance with the aims and questions of this research to validate the findings from the literature review, case study, and the primarily developed process framework.These codes are arranged in code groups, and memos are created for recording their definition, the reasoning for using them, and any other analytical thoughts about their significance and relationships.

The data collected through the primary data collection process is used to validate elements of the primary process framework and explain the relationship between variables such as stakeholders' influence, scope management, and the potential role of BIM in resolving occurred issues; it also allows identification of the strengths and weaknesses of the developed process framework by considering it within the context of each project to reach a deeper understanding of the effectiveness of the process framework in managing those occurred problematic issues. The objectives for the Olympic Stadium case study will be mostly the same as those for other case studies, with a slight difference between their essences of analysis. Data collected from the Olympic Stadium will be used to identify and reach a deeper understanding of successful practises and processes to be included in the process framework and complement it. These objectives will be obtained by using the aforementioned generic approach for analysis (Saunders et al., 2019) and by using Atlas.ti software. The feedback from this stage goes back again to modify and refine the framework. As the final stage of development, the framework will be evaluated one more time against collected data from the case studies and literature to make sure about the reliability and connection of the process framework with the scientific background and previous works.

4.14 Reliability and Validity

Although the term 'Reliability' is commonly used for testing and evaluating quantitative research, it is also often employed in all types of research (Golafshani, 2003). In qualitative studies, the quality of the research is the most important test, as a good quality qualitative study can aid in understanding a complex situation (Eisner, 1991, p. 58). While the concept of reliability is used in quantitative research to explain phenomena, the purpose of evaluating quality in qualitative research is to generate understanding (Stenbacka, 2001, p. 551). The difference in the purposes of evaluating quality in quantitative and qualitative research is one reason why reliability is not relevant in qualitative research. According to Stenbacka (2001), using reliability as a criterion for evaluating a qualitative study can be misleading, and may even suggest that the study is inadequate (Golafshani, 2003).

Patton (2001) argues that validity and reliability are important considerations for qualitative researchers when designing and evaluating their studies. Healy and Perry (2000) suggest that the quality of a study in each paradigm should be judged by its own paradigm's terms. In the qualitative paradigm, the essential criteria for quality are Credibility, Neutrality or Confirmability, Consistency or Dependability and Applicability or Transferability. Lincoln and Guba (1985) propose using "dependability" as a term that closely corresponds to the notion of "reliability" in quantitative research. They suggest that an inquiry audit can enhance the dependability of qualitative research. Clont (1992) and Seale (1999) endorse the concept of dependability and consistency in qualitative research. Campbell (1996) suggests that data consistency can be achieved by verifying the research steps through the examination of raw data, data reduction products, and process notes (Golafshani, 2003).

Lincoln and Guba (1985) argue that reliability cannot be achieved without validity in a study, and that demonstrating validity is sufficient to establish reliability. Patton (2001) further supports this idea, stating that reliability is a result of the researcher's ability and expertise in conducting a valid qualitative study.

Winter (2000) argues that the concept of validity in qualitative studies is not a universal or fixed concept, but rather a contingent construct that is grounded in the processes and intentions of particular research methodologies and projects. While some qualitative researchers argue that validity is not applicable to qualitative research, many have developed their own concepts of validity, and have generated or adopted terms such as quality, rigor, and trustworthiness (Davies and Dodd, 2002; Lincoln and Guba, 1985; Mishler, 2000; Seale, 1999; Stenbacka, 2001). Researchers such as Creswell & Miller (2000) suggest that the researcher's choice of paradigm assumption and perception of validity in the study can affect the validity of the study. According to Lincoln and Guba (1985), maintaining the credibility of a research report requires addressing the issues of validity and reliability. Mishler (2000) suggests that instead of relying on measures of validity and reliability to discover the truth, the focus should be on achieving trustworthiness. Trustworthiness is seen as a defensible means of establishing confidence in the research findings (Johnson, 1997; Lincoln & Guba, 1985).

The concept of generalizability is an important aspect of research quality and is closely related to the validity and trustworthiness of a study. Stenbacka (2001) suggests that generalizability is essential for doing and documenting high-quality qualitative research, and increasing the validity or trustworthiness of research results. However, Maxwell (1992) argues that the ability to generalize findings to wider groups and circumstances is a factor that distinguishes quantitative and qualitative research approaches. While the validity in quantitative research is specific to the test it is applied to, triangulation is used as a strategy for improving the validity and reliability of research in qualitative research (Golafshani, 2003). Triangulation helps to control bias and establish valid propositions in naturalistic and qualitative approaches to evaluation (Mathison, 1988). Furthermore, generalizability is considered a criterion for quality case studies, depending on the case selected and studied, according to Patton (2001).

In order to strengthen a study, Patton (2001) suggests using triangulation, which is combining data or methods, including both quantitative and qualitative approaches. According to Creswell and Miller (2000), triangulation is a validity technique in which researchers search for convergence across various and distinct sources of information in order to establish themes or categories in a study. Barbour (1998) questions the idea of combining methods within a same paradigm, such as qualitative research, because of the different theoretical underpinnings that drive each approach. While triangulation is frequently employed in quantitative research for confirmation and generalisation, Barbour (1998) advises defining triangulation from a qualitative research perspective within each paradigm. For instance, in quantitative research, each exception in the triangulation of multiple sources of data may result in a disconfirmation of the hypothesis, yet in qualitative research, exceptions are utilised to revise hypotheses and are beneficial (Golafshani, 2003).

Johnson (1995) argues that the aim of any qualitative research is to gain deeper understanding rather than just examining surface features. Constructivism is a useful framework to achieve this aim. According to Hipps (1993), constructivism suggests that reality is constantly changing, leading to multiple and diverse constructions of reality. To acquire valid and reliable multiple realities, researchers need to use multiple methods to gather data, including the use of investigators, method and data triangulations (Johnson, 1997). Open-ended perspectives are vital in constructivism, as they allow participants to assist in research questions and data collection. Using multiple methods like observation, interviews and recordings will lead to more valid, reliable and diverse constructions of realities. Triangulation can also involve multiple investigators or peer researchers to interpret data in different locations and times. However, researchers should choose the methods of data collection and analysis carefully, as the choice depends on the criteria of the research, as there is no fixed method for all research studies (Golafshani, 2003).

4.14.1 Establishing Trustworthiness

Merriam (1998) warns against applying the concepts of reliability and validity to qualitative research since they stem from a positivist perspective and are typically used in quantitative research. To address this, Guba and Lincoln (1981) and Creswell (1998) propose that trustworthiness can be used as an alternative measure to establish the quality of qualitative research, based on four strategies: credibility, transferability, dependability, and conformability. These strategies are similar to the quantitative criteria of internal and external validity, reliability, and neutrality. To achieve trustworthiness, researchers use criteria such as reflexivity, triangulation, and dense descriptions (Guba & Lincoln, 1981; Creswell, 1998). Consistent with the interpretive position underlying this study, the researcher adopts the term trustworthiness, which is commonly used in qualitative research as a measure of quality (Merriam, 1998).

4.14.1.1 Credibility

According to O'Leary (2004), credibility in qualitative research is defined as the degree to which the data and data analysis can be considered reliable and trustworthy. In quantitative research, credibility is similar to internal validity, where researchers use the term to indicate how research findings correspond to reality. However, in qualitative research, reality is a relative concept as it is constructed by social actors and may have multiple interpretations and meanings. Therefore, the extent to which research is credible depends on the reader's understanding of the study.

Graneheim and Lundman (2004) propose that credibility in qualitative research can be established by showing the ways to judge similarity and difference between different categories. They suggest two ways of achieving this: by presenting quotes from research participants and by seeking agreement from experts, colleagues, or participants. In this study, credibility was established by discussing the developed categories with supervisors and colleagues and through the use of quotes from diverse participants. Several quotes from different interviewees are presented and discussed in this study.

4.14.1.2 Transferability

Transferability is the concept of being able to replicate a study's outcome in a different context, and is comparable to external validity, which measures the generalisability of findings (Bitsch 2005; Tobin and Begley 2004). In qualitative research, it is difficult to achieve generalisability due to the subjectivity of the researcher. However, transferability can be improved by providing detailed descriptions of the research methods, contexts, and assumptions underlying the study, using purposeful sampling to gain deeper understanding, and selecting information-rich cases that are central to answering the research question. Theoretical informed approaches can also enhance transferability (Teddlie and Yu 2007). This thesis has used these methods to improve the transferability of its findings.

The study adhered to various criteria for establishing transferability. The research methodology was properly documented and justified. The use of cross-case analysis was deemed appropriate for establishing transferability, and the outcomes of each case were presented and analysed. The study also provided thick descriptions of the context and background to allow readers to assess the relevance of the research to other situations. Ritchie and Lewis (2003) suggest that assessing the transferability of findings to another setting requires judgement of the context and phenomena found.

4.14.1.3 Dependability

The term "dependability" in qualitative research refers to the consistency of obtaining the same results under similar circumstances, similar to the concept of reliability. Merriam (1998) defines dependability as the extent to which research findings can be reproduced under comparable conditions and contexts, highlighting the need for researchers to account for the changing contexts that may affect research outcomes. However, in social research, reliability is challenging due to the highly contextual and dynamic nature of social actors' behaviour, which is influenced by various factors and can result in multiple interpretations of reality.

Merriam (1998) proposes that reliability in qualitative research should be evaluated based on the consistency of the results with the collected data. To ensure reliability, the researcher should describe the study's assumptions and theory, use multiple methods of data collection and analysis, and provide a detailed account of data collection for auditing purposes. To ensure internal validity in qualitative research, Merriam (1998) suggests six strategies, including the use of multiple sources of data, member checks, peer examination, participatory or collaborative modes of research, and clarifying the researcher's biases, assumptions, worldview, and theoretical orientation at the outset of the study.

The approaches adopted in this study include triangulation methods using multi-qualitative approaches and various sources of data such as articles, reports, and archival documents on case studies and interviews with professionals from the construction and infrastructure industries. Also, biases, assumptions, worldviews, and the theoretical approach of the researcher were clarified at the commencement of the investigation. The achievement of dependability can be attained through an audit, as noted by Seale (1999). This process necessitates the need for rich and detailed data and descriptions of the research. Therefore, it may require modifications to the research design as new discoveries emerge during data collection.

4.14.1.4 Confirmability

According to Baxter and Eyles (1997), confirmability refers to the extent to which the results can be confirmed by other researchers, and Tobin and Begley (2004) explain that it involves ensuring that the data and interpretations are derived from the data and not from the researcher's imagination. Confirmability is related to objectivity, which refers to the degree to which a researcher accounts for personal bias or subjectivity. Seale (1999) suggests that procedural documentation of research can be used to ensure confirmability, as it details the steps taken in conducting the research. This study uses a detailed methodological approach and organises the data in a retrievable manner to support the results when necessary, such as through the use of voice recordings for interviews (Nair and Reige 1995) that can be reviewed for consistency of transcripts.

4.14.1.5 Process Framework Validation

As mentioned before, the primary process framework in this research was developed based on findings from a literature review and case studies, and the validity of its composing elements and concepts was obtained by conducting semi-structured interviews with professionals from the construction industry to capture their perceptions and experiences in regards to the scope creep issue and the influence of stakeholders. Consequently, this resulted in the development of the final process framework.

The credibility and accuracy of the model were verified by conducting a documentary analysis of pertinent project information, which confirmed the resulting variables. The correctness of the model was further confirmed using a triangulation method that involved interviews with different participants, as well as a review of available documents on the scope creep issue. The development of the process framework was designed to address the primary research questions specific to this study, and other experimental and empirical literature from other fields were used to compare the study's findings.

4.15 The Overall Adopted Research Design

This study adopts an interpretivist research philosophy, employing an inductive research approach and a qualitative research method, to investigate the phenomenon of scope creep and stakeholder influence. The study uses both primary and secondary data and employs a case study strategy and a phenomenological research strategy. A cross-sectional research time horizon is used, and a purposeful sampling approach is followed for selecting the study's participants. Data analysis is conducted through thematic synthesis and thematic analysis methods. The study primarily focuses on collecting data through semi-structured interviews with professionals from the construction and infrastructure industries, while secondary data are collected from sources such as the National Audit Office (NAO), the House of Commons, and the Learning Legacy website. The analysis aims to capture and interpret the experiences of stakeholders and their interaction with scope creep and management issues in UK construction projects. The following table summarises the overall research design of this study.

Table 23 The overall adopted research design

Research Element	Description
Research Philosophy	An interpretivist stance is taken in this research, emphasising the importance of understanding the subjective experiences and interpretations of individuals.
Research Approach	Inductive approach, due to limited literature about the phenomenon under study.
Methodological Choice	A multi qualitative methodology is employed due to its interpretive philosophical nature.
Research Strategy	Two strategies are employed, including one from Saunders et al.'s (2019) research onion, namely case studies, and another one from Creswell's (2013) book, which is called phenomenological research.
Research Time Horizon	A cross-sectional approach is employed in this study as it enables the collection of data through methods such as case studies and interviews, which required a shorter time frame to obtain the necessary information.
Sampling Approach	Purposeful sampling approach was used, where 15 projects were collected as the target population of this study, and 6 case studies were selected through the process of sampling.
Data Collection	Both primary and secondary data collection. The primary data is collected through semi-structured interviews, while the secondary data is collected through documentary sources such as the National Audit Office (NAO), the House of Commons, and the Learning Legacy website.
Data Analysis Approach	Both thematic-synthesis and thematic analysis methods were used for the analysis of the secondary and primary data collected.

4.16 Summary

This chapter described the high-level requirements and design of a methodology that helped to collect and analyse data to develop a process framework for managing the influence of stakeholders on the scope of projects through the use of BIM. The chapter started by describing the research process followed by the research design of this study. Then, the research philosophy was discussed, including a definition of the interpretivist stance as the adopted philosophy. Accordingly, considering the nature of the research, which has limited literature about the phenomenon under study (scope creep), an inductive approach has been added. Also, in order to gain insights from professionals in the construction and infrastructure industries, this study has utilised both primary and secondary data, employing a multi-qualitative method. Section 4.7 provided a description of two strategies employed, including a multi-case study and phenomenological research. A cross-sectional research time horizon is used, and a purposeful sampling approach is followed for selecting the study's participants. The analysis of data is carried out using methods of thematic synthesis and thematic analysis. The research mainly focuses on gathering primary data by means of semi-structured interviews with experts belonging to the construction and infrastructure sectors, while secondary data are gathered from sources like the National Audit Office (NAO), the House of Commons, and the Learning Legacy website. The analysis strives to apprehend and construe the experiences of stakeholders and their interplay with scope creep and management concerns in construction projects in the United Kingdom. The data analysis and findings are covered in the following chapters, which describe the implementation of primary and secondary data analysis together with the development of the primary and final versions of the process framework.

Chapter 5 Secondary Data Analysis

5.1 Introduction

Chapter 4 presented the design of the research methodology of this study. This chapter builds on that design by detailing the key aspects of the secondary data analysis implementation.

The chapter is organised as follows. To continue, the secondary data on case study projects will be analysed in section 5.2 to identify and interpret the problematic issues and captured the successful approaches and techniques. In this regard, analysis of data on five problematic projects is presented in section 5.2.1 while the analysis of London 2012 Olympic Games Construction programme is discussed in section 5.2.2. Finally, in Section 5.3, a summary of the chapter is given.

5.2 Case Studies Secondary Data Analysis

5.2.1 The Five Problematic Projects

As mentioned before 6 projects are chosen as case studies, amongst which five of them confronted issues in managing stakeholders and the scope of projects together with the sixth case study (London 2012 Olympic Construction Programme) as the successful example. These six case studies are as follows:

1. Metronet London Underground Modernization
2. The BBC's management of three major estate projects
3. Scottish parliament house project
4. The Paddington Health Campus scheme
5. Wembley stadium project
6. London 2012 Olympic Construction Programme

The secondary data for the five problematic projects are collected from the National Audit Office (NAO) and House of Commons' reports published for each of these case studies. The major events and problematic issues that occurred during the lifecycle of each case in terms of stakeholder, scope, communication and risk management are firstly captured and depicted in Mind Maps (Appendices 5 to 12) and then translated and interpreted into project management terms by using PMBOKGUIDE (PMI, 2017b) guidelines, processes and subprocesses; the interpretation and categorisation of occurred issues into project management processes are provided in appendix 19. Also, the summary of these issues in project management terms (processes according to PMI, 2017) is presented in the appendix 20. Therefore, any developed approach or process framework should address these issues for the management of the influence of stakeholders on the project scope and preventing scope creep.

5.2.1.1 Metronet

In 2003, the government got involved in three innovative 30 years PPP contracts with contractors from the private sector to update London's underground rail system. Metronet was a project for the modernization of London Underground's infrastructure on 9 lines. Metronet BCV and Metronet SSL were responsible for two-thirds of the modernisation work according to their Public-Private Partnership (PPP) contract. Also, Tube Lines was another company to which the other PPP contract was awarded. Metronet BCV was responsible for the modernisation of the Bakerloo, Central, Victoria and Waterloo & City lines, while Metronet SSL undertook the modernisation of District, Circle, Hammersmith and City, Metropolitan and East London lines. Both companies were ultimately owned by a consortium of Balfour Beatty plc, Bombardier Inc., WS Atkins plc, EDF SA (formerly Seeboard Group plc) and Thames Water plc. Figure 21 shows the roles of key stakeholders in this project.

Metronet BCV and Metronet SSL as the responsible companies for modernising London Underground's infrastructure went into administration for almost a year when they became unable to meet their spending obligations. In this regard, 132 station refurbishments, enhanced refurbishments and modernisations were planned for delivery by Metronet until March 2010. Amongst these, eight stations were supposed to be delivered by the end of March 2005, none of which were delivered on time, and 35 stations by March 2006 while only 11 of them were delivered. The Metronet claimed in 2007 that the cost of the station programme will be £1.1 billion more than it was originally planned.

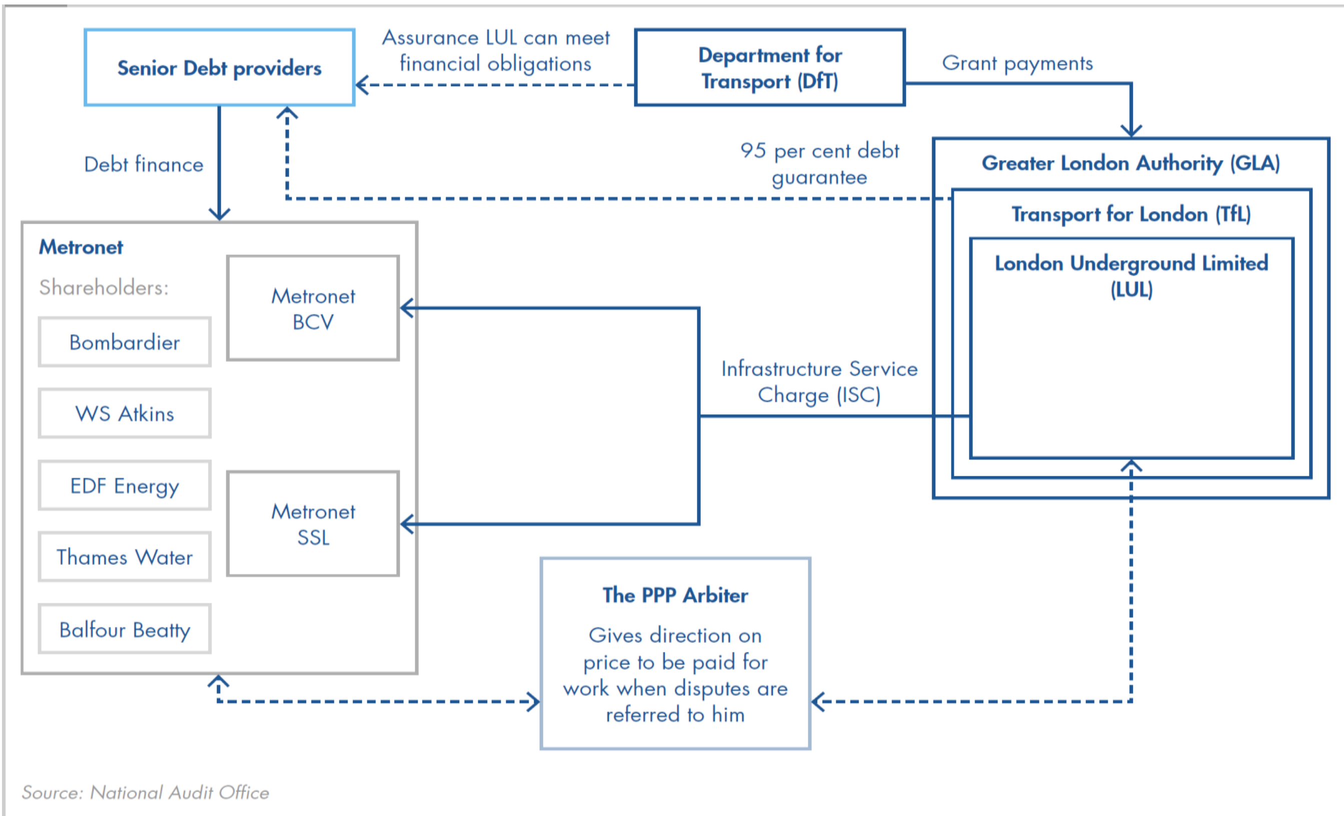

Figure 21 Roles of key players of the Metronet project (NAO, 2009).

Consequently, London Underground Limited (London Underground) had to buy 95 per cent of Metronet's outstanding debt obligations from its private-sector lenders in 2008 instead of repaying it in 30 years. The Department for Transport (DfT) made £1.7 billion of grant available to help London Underground cover the debt.

National Audit Office estimated that the failure of the Metronet cost the taxpayers up to £410 million. After ten months of being in administration, in May 2008 the Department for Transport (DFT) and TFL found an interim solution and the assets and liabilities of Metronet BCV and SSL's were transferred to two new subsidiaries of Transport For London (TFL).

Despite the clear roles and responsibilities and project deliverables in the PPP contract, ambiguity in other parts led to disagreements between stakeholders. Accordingly, the ambiguity of specifications and phrases like "replace/renew" caused different interpretations of what a refurbishment would include. Therefore, agreements had to be made on the scope of refurbishment for each station. Also, another issue that occurred was the diverging expectations of stakeholders, London underground and the companies, due to the minimal specification. London Underground applied a more extensive interpretation while the Tube Lines and Metronet preferred a less costly interpretation of the contract. So, all the stations examined by the National Audit Office were subject to scope disagreements which resulted in delaying the project progress.

Hence, the national audit office mentioned the main causes of Metronet failure as poor corporate governance and leadership caused by shareholders influence on decision making, conflicting motivations of shareholders who acted as suppliers of the project as well, frequent changes of executive management, poor quality of information and the power of suppliers over the scope of work with the option to be paid for extra work undertaken. other identified issues were DFT's poor risk management, lack of monitoring and risk management strategy due to the nature of the PPP contract and devolution of powers.

The National Audit Office (NAO) conducted this report for assessing the background and aftermath of Metronet failure to examine whether it could be avoided and how DFT managed the consequences. So, the report examined the history of PPP and key factors in Metronet's failure, DFT risk management approach and the costs and other consequences. Accordingly, the study team reviewed a number of documents in the field of PPP contracts and used different sources of data to estimate the direct loss to taxpayers and provide an indication of return on investment. Also, they used semi-structured interviews with representatives of key stakeholders and four case studies from the station modernisation project to investigate how London Underground and Metronet worked together. Besides they brought together a panel of experts for the provision of this report. Also, the report published by the House of Commons in 2010 confirms the findings on this project from the National Audit Office's (NAO) report.

5.2.1.2 The BBC's Management of Three Major Estate Projects

The Comptroller and Auditor General, head of the National Audit Office prepared a review under an agreement between the Secretary of State for Culture, Media and Sport and the BBC. The management of BBC's three estates projects was examined in this review to see whether the projects were delivered in line with expectations. The BBC project constituted three estate projects such as Broadcasting House – London, Pacific Quay – Glasgow and Salford Quays – Salford. These projects accounted for BBC expenditure of more than £2,000 million over 30 years. The BBC handled each project differently as they were managed independently of each other and developed at different times. The differentiation in BBC's approach in delivery the three projects was originated from factors such as different purpose, financing, constraints over location and lessons learned from the issues occurred un phase 1 of the Broadcasting House project.

The project was first approved by the BBC governor in 2003 but phase 1 of the Broadcasting House project was delivered with one year delay in January 2006. The project suffered from the lack of proper scope definition which resulted in 42 contract variations with a total value of £13.9 million and caused a dispute with the developer and significant delays. It is stated in NAO's report that poor change control processes and weak governance contributed to increased costs and severe delays of phase 1 of the Broadcasting House project. After negotiation with the developer, the BBC rebased the project in July 2006 and agreed on a fixed cost for the remaining work which was £58 million more than the first budget. In the new contract, the timeTable and scope of the project were extended and the specification of the building was simplified. The BBC forecasted the delivery of the project within the revised budget, although phase 2 of the Broadcasting House was delivered with a few weeks delay. consequently, this project was delivered over 4 years later than originally planned with an additional £50 million in costs due to updating some of the technology used and extension of leases for other properties. Table 24 presents the information on the Broadcasting House project.

Table 24 The Broadcasting House project information (NAO,2010).

	Original Budget	Revised Budget	Achieved
Construction Finish Date	Phase 1: December 2004 Phase 2: December 2007	Phase 1: n/a Phase 2: October 2010	Phase 1: January 2006 Phase 2: December 2010
Fully Operational Date	December 2008	December 2012	April 2013
Total Cost	£991 million	£1,049 million	£1,046 million

In the other project, the business case of the Pacific Quays was revised in 2005 and the project was delivered for £188 million in 2007 and within the specified time and budget. The original plan for the delivery of this project was approved by the BBC Governors in 2002 with an estimation of £126 million in costs and mid-2006 as the delivery due date. However, both the technical requirements and the size of the building were increased as the BBC decided to produce more programmes in Scotland, incorporating High Definition production facilities, and sought subsequent approvals from the Governors.

The scope of the Broadcasting House and Pacific Quays projects changed after the BBC Governors first approved the projects, adding costs of £28 million and £60 million respectively. Among these, the Broad Casting House project confronted the most severe problems comparing with the other two projects. The Broadcasting House project cost £55 million more than originally approved and is delivered over four years later than first planned, leading to further costs of £52 million.

Also, the Salford Quays project was delivered within the approved time and budget as the BBC applied the lessons learned from the other two projects to avoid repeating the same mistakes and prevent similar issues. In fact, the first building (building C) of this project was handed over to BBC one month earlier than planned in September 2009.

In conclusion, the NAO identified the main causes of severe delays and cost overruns in phase 1 of the Broadcasting House project as a lack of clear scope definition, weak governance, poor change control process. Although in 2004 the BBC improved the governance of the project and the management of remaining stages, in 2006 the Governors commissioned consultants to monitor these changes. Also, the Pacific Quays project confronted similar issues caused by unclear scope definition. Other issues identified by the NAO are lack of benefits management plan, identification of required skills, competency of the project team, risk assessment and inadequate contingency.

5.2.1.3 New Scottish Parliament Building (the Holyrood project)

In 1997, the evaluation of the costs for developing a new Scottish Parliament building was produced in the form of a white paper. From the outset, the project was planned to be delivered by 2001-2002 with a budget of £24.5 to £34 million. In 1998, the costs estimate increased to £55 million when Holyrood Hill in Edinburgh was selected as the site for construction. The project suffered from 3 years of delay and the cost estimates revised to £300 million in 2003 when a formal enquiry was launched to investigate the causes of failure. On 7 September 2004, the building was finally ready to open while the total cost estimations approached £450 million (White and Sidhu, 2005). The main parties involved in the Holyrood project are as shown in Figure 22.

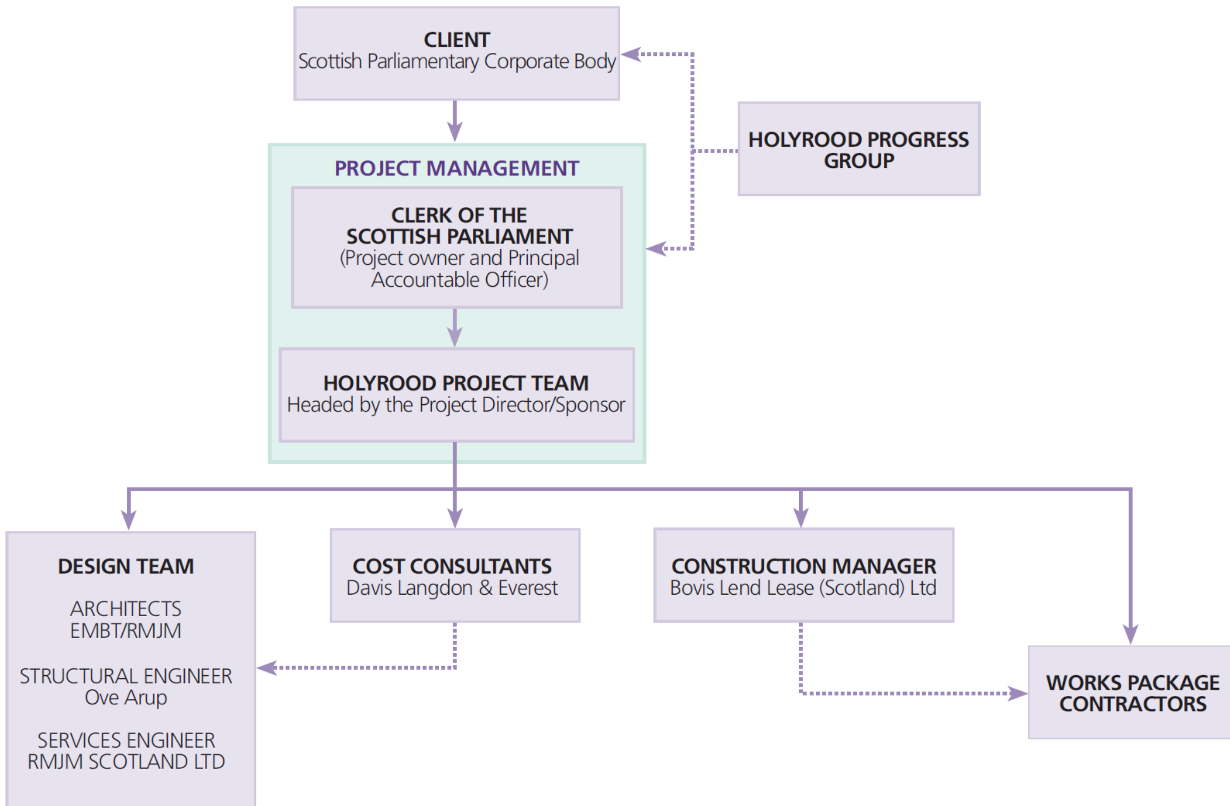

Figure 22 The parties invokved in Holyrood Project (Auditor General, 2000).

In 1998, the architects found it difficult to comply with unrealistic project brief compared with the total area specified. Accordingly, the first design met the requirements for a quality building in the location, there was worriment about the cost and overall size of the project. For several times, the client accepted the Official's advice to increase the required space and after the commencement of the project in 1999 the Corporate Body saw the need for other changes. Consequently, while the scheme design was supposed to be approved by March 1999, this was achieved completely until June 2000. Besides, the inability of the client to freeze the design and brief until June 2000 caused uncertainty about cost estimates. In this regard, the project managers were reluctant to acknowledge the increase in the budget until assured that these were necessary. So, the client was informed by the project management about the consultant's predictions on costs. Hence, completion of the complex and large programme of work on-site and within a tight timeline increased the uncertainty and risk of the project. Another issue that occurred was the expansion of project scope as the result of the increase in the total area of building, unrealistic space target allowance, increasing demands of the Parliament and increases due to functional reasons. Also, there was an unusual change in the project's client as in June 1999 the responsibility transferred from Secretary of State for Scotland to the Scottish Parliamentary Corporate Body and this made the project more complicated (Auditor General, 2000).

Also, it is stated in the formal enquiry under Lord (Fraser, 2004) that the time and quality of the project had priority over the costs for Scottish Office officials. He mentions that the budget never had any basis in reality and there was an insufficient inquiry of the chosen architectural firms (a joint venture between EMBT and RMJM Ltd) as they did not stick to the user brief or the budget. Also, (Fraser, 2004) stated that despite the extensive design development between 1998 to 2000, no amendments were made to the brief which shows the design development was not undertaken against a clearly formulated set of client or user requirements. The other failures identified in this report are lack of construction management assessment and risky procurement method (conventional instead of PFI).

The Auditor-General for Scotland is the Parliament's watchdog for safeguarding propriety and value for money in the spending of public funds. He prepared a report on the management of the project to provide the new Scottish Parliament building (the Holyrood project). It is stated in the report that this was a complex and difficult building project with an extra £220 million of costs and 20 months schedule slippage while satisfied the high standard of building quality at the same time. Also, the construction management method of procurement is mentioned as the heart of the problems that occurred which resulted in the majority of the risks staying with the client rather than the contractors. Besides, he identified the cause of the 20 months delay as the late supply of information during execution and production of detailed design variations. Plus, it is mentioned that architects nad the trade contractors did not deliver some of the crucial design works on time. Like other papers, in this report, the performance of the project management team and the construction manager was criticised as they failed to address the root cause of the problems including testing the new revisions of the programme and ensuring that the design team, contractors and construction manager had commitment and resources to deliver on time. Another finding shows that although the client did not change its requirements after 2000, the cost increased due to design development and construction process delay which accounted for 72% of the £431 million total project costs.

Also, other scholars and researchers such as (Arabiat, Edum-Fotwe and McCaffer, 2007) and (Jackson, 2002) have discussed the management of the Scottish Parliament building project in their articles. However, they only discuss the findings from the aforementioned reports and since they do not provide any further analysis of the project, they are excluded from this section to avoid to avoid repetition.

5.2.1.4 The Paddington Health Campus Scheme

The Paddington Health Campus Scheme was a complex and ambitious attempt to build a world-class healthcare facility that would replace three run-down hospitals (St Mary's, the Royal Brompton and the Harefield) and address problems with the configuration of specialist services in north-west London. However, after five years and £15 million spent trying to develop a robust business case, the Paddington Health Campus scheme collapsed. By May 2005, projected costs had risen to £894 million (primary estimation of £411 million in 2005 prices) and the expected completion date had slipped to 2013 (The Committee of Public Accounts, 2007). The organisations involved in the Paddington Health scheme are shown in Figure 23.

The NAO (Bourn, Mcdougall and Palmer, 2006) identified the main reasons for the scheme failure as the total number and scale of risks, lack of a single sponsor, the scheme organisation and governance by the partners, inadequate land for the scheme and lack of strategic support for campus vision. However, the detailed list of the reasons behind this failure goes beyond this list. In 1998, the West London Partnership Forum prepared the Strategic Outline Case and submitted it to the Department of Health followed by the submission and approval of the original outline business case in 2000.

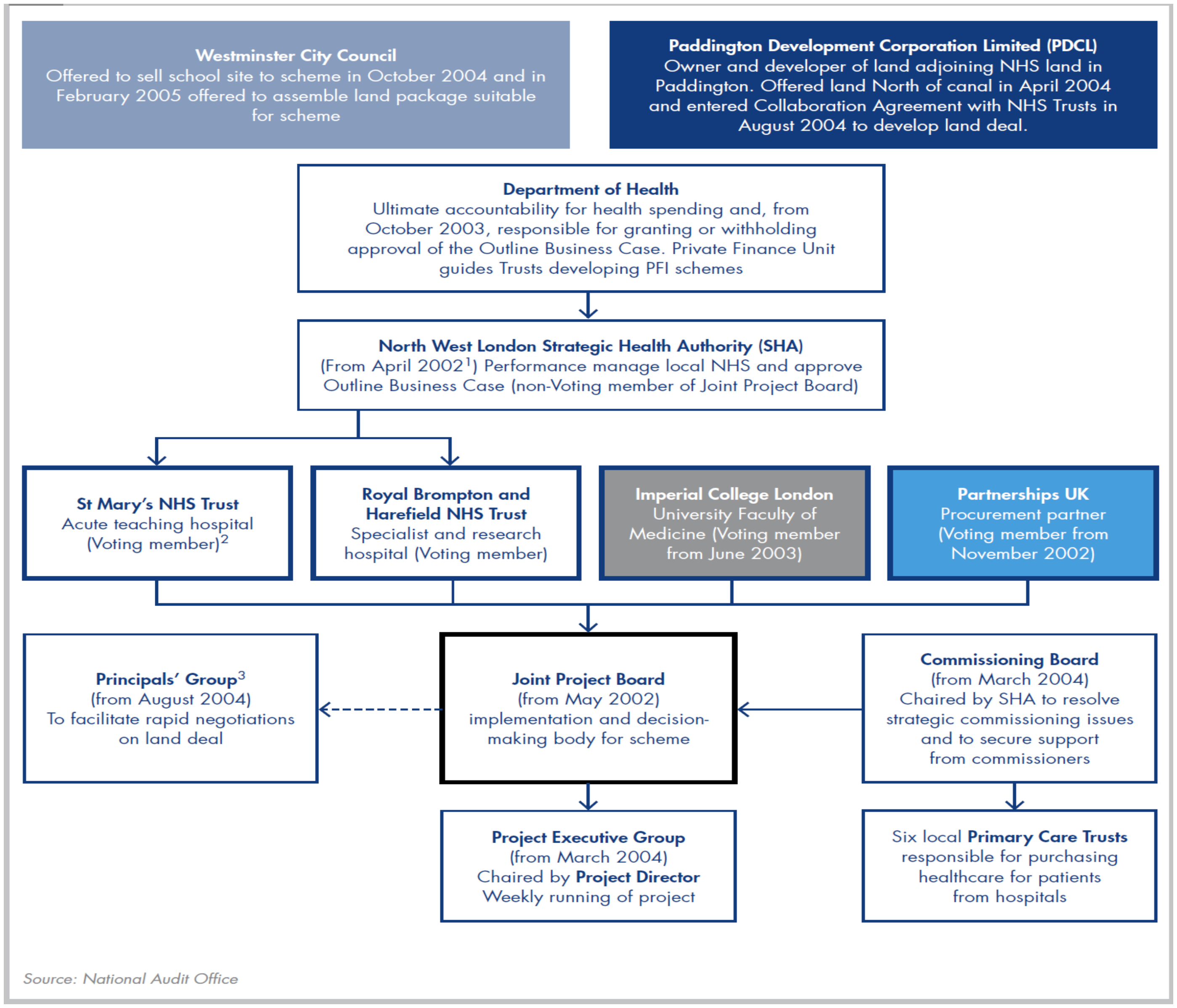

Figure 23 The principal organisations involved in the Paddington Health Campus scheme (Bourn, Mcdougall and Palmer, 2006).

In 2002, it was stated by the external consultants that the estimated costs had more than doubled since the original business case approval. Also, the Westminister City Council advised that the available land was not adequate for the scheme. Therefore, the campus should have prepared a new business case or cancelled the scheme in 2003 to address the doubling cost estimation, absence of adequate land and lack of available funds. A new business case was developed for the whole scheme in summer 2004 by the campus partners at the request of the Chief Secretary to the Treasury, but in May 2005 the campus partners could not agree on a revised business case. The NAO (Bourn, Mcdougall and Palmer, 2006) points out that the scheme partners underestimated the risks to the scheme caused by the complexity and timescale of the project, introduction of new national policies for NHS, the mismatch between the size of the scheme and available land and funding, changes in the structure of NHS and lack of effective risk management strategy. Accordingly, the partners failed to address the requirements of the Department's Capital Investment Manual in developing the business case including creatin a register as part of the 2000 business case, a formal reappraisal of the 2000 business case and the decision of the Project Director for not embedding the risk management process in the scheme.

Also, it was discussed in the report published by the House of Commons (The Committee of Public Accounts, 2007) that the partners were imprudent in submitting the outline business case in 2000 as it was inadequate because they did not consult their stakeholders (doctors and nurses) about the required clinical contents of the campus and consequently couldn't determine the land requirements and the likely costs. Hence, it was expressed that without the inputs from doctors and nurses about the clinical content and sufficient design work, the outline business case should not have been approved in 2000. Another issue that occurred was the conflict between stakeholders and their interests. In 2000, after the St Mary's NHS Trust entered the scheme the Royal Brompton and Harefield NHS Trust claimed that a merger was not an option as they were concerned a merger would undermine their capacity to provide very different patterns of services that they delivered to patients. However, St Mary's NHS Trust did not have any problem with a merger. Therefore, although the NHS Capital Investment Manual mandates a single sponsor for investment projects, the London Regional Office of the NHS rejected the joint agreements when approving the business case and the Department for Health did not press for a merger either. Consequently, the lack of a single Sponsor or AccounTable Officer led to confusion between partners about their roles and responsibilities as they had no idea about who was the AccounTable Officer for the scheme.

Hence, it can be stated that lack of proper scope definition from the outset and unclear requirements together with the influence stakeholders, the weak organisation and vague roles and responsibilities of the scheme partners are some of the major reasons behind this failure. For instance, due to the lack of coordination and clear responsibilities between stakeholders, the bed capacity required by the scheme to meet the patients' healthcare needs fluctuated between 835 to 1200 bed during the five-year development of the scheme.

5.2.1.5 The English National Stadium Project at Wembley

The creation of the National Lottery in 1994 provided increased funding for sports in England and this resulted in the cascade of applications from different English cities for Lottery funding to build new stadiums. It was decided by Sport England to set up a

National Stadium competition and in December 1996 Wembley was chosen as the site for the new stadium. The English national stadium project at Wembley began in 1996. The original completion date for the project was May 2003 but the stadium did not host its first sporting event until 24 March 2007. The cost of the new Wembley project soared from the original estimate of £326.5 million to £792 million. Disputes occurred between the project owner (Wembley National Stadium Ltd (WNSL)) and the main contractor (Multiplex) regarding delays and cost overruns due to changes in design during the progression of the project.

The stadium project was financed by a mix of partnership funding and Lottery money. However, it did not run smoothly and in December 2000 it failed to secure the commercial financing needed. Consequently, the Football Association requested the involvement of other stakeholders in April 2001. In September 2002, it was announced by the Secretary of State and the Football Association that an additional £41 million was provided for the project from public funding. Also, the costs of the project doubled comparing with the estimations in 1998 when the contract was awarded. There were many bodies involved in the project from both the public and private sector which are presented in Figure 24.

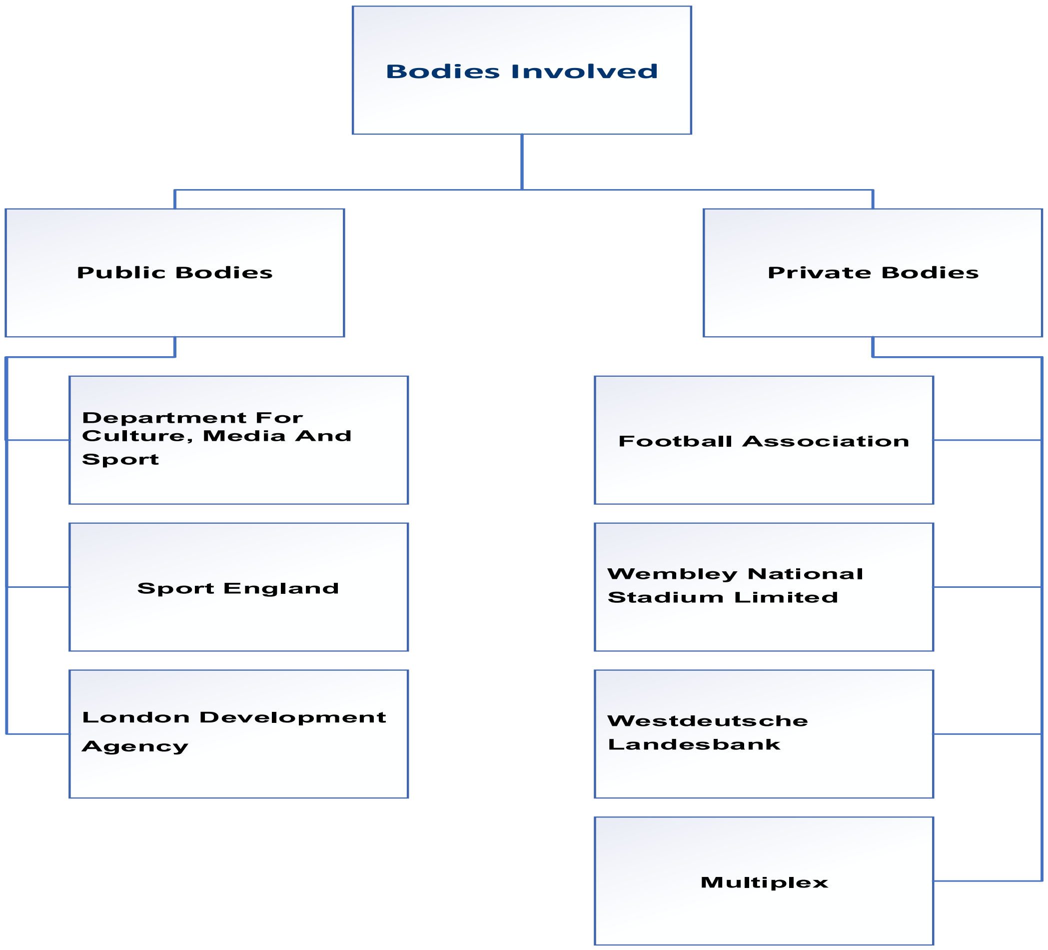

Figure 24 The key bodies involved in the Wembley Stadium project (Bourn *et al.*, 2003).

The project was deemed as a private enterprise led by the Football Association and sponsored by The Department for Culture, Media and Sport's which had the responsibility for overseeing the Sport England activities as well. The Lottery funding was provided based on the assumption that the project would also be capable of hosting major international athletic events as well. But in October 1999, the Department requested a review of the technical merits of the proposed design due to concerns about the platform solution. As a result, in December 1999 the Secretary of State announced that the athletics will be withdrawn from the plans under the condition that 20 million of the Lottery funding should be repaid to Sport England in instalments over a 5 year period beginning in December 2000. However, Wembley National Stadium Limited did not sign the agreement and the first repayment passed without any money being returned to Sport England as the Football Association was reviewing the project as a whole and was unable to secure the commercial financing needed. Consequently, the provision for athletics was added to plans again (Bourn *et al*., 2003). This shows parts of the changes to the scope of the project which increased the uncertainty and caused subsequent issues. Besides, because Wembley National Stadium Limited could not secure the commercial financing needed, it was the responsibility of Sport England to recover the full grant of £120 million it had paid to Wembley National StadiumLimited and this made the situation more complicated. Plus, the department conducted several reviews of the project as concerns were raised regarding the procurement methods and in November 2001 it was concluded that the procurement process had fallen short of the industry best practice and Wembley National Stadium Limited failed to undertake, adopt and implement a detailed formal procurement process. The main issue in this regard was awarding the contract to Multiplex, an Australian contractor, which their experience and capabilities for executing such a major complex project were questioned (Bourn *et al.*, 2003).

Also, there were three major litigations about the definitions of project quality which were part of eight major litigations in this regard. Accordingly, the contractor sued the engineering consultant for £253 million as they were not satisfied with their services. Particularly, it was the case between two of the Wembley Stadium contractors, Multiplex Construction Ltd and Honeywell Control Ltd, caused by the dispute about the statement in the contract which had obliged the engineering consultant to deliver communication systems and hospitality facilities with the highest quality (Basu, 2014).

(Arabiat, Edum-Fotwe and McCaffer, 2007) stated in their paper that clients can be the cause of risk in projects as was the case with the new Wembley Project. Another issue mentioned by them was the project failure to estimate the risk adequately. In addition, the rising costs and one year delay in finishing the steel job caused the Multiplex as the main contractor to receive warnings which were rejected by them. Besides, there were minor delays during the installation of the seats which were blamed on one of the suppliers. Although there was a dispute between Wembley National Stadium Limited and Multiplex, this contractor claimed that the majority of delays should be blamed on the complicated nature of the project design and the 560 changes made by the Wembley National Stadium Limited to the project brief. In this regard, the client acknowledged that these changes to the scope of the project have caused severe delays. Hence, the major issue in this project occurred when the client focused on transferring all the risks on the contractor and supply chain during the development of their procurement method which created an adversarial environment between stakeholders. Besides, Multiplex was unfamiliar with the British construction industry’s culture, their relationship with the suppliers was not effective and they had no exit strategy (Arabiat, Edum-Fotwe and McCaffer, 2007). Other problems with the Multiplex as the contractor were its inability to adapt to the limitations and changes required by the client and lack of flexibility in the contract for the contractor to do so.

The list of the Wembley Stadium project issues seems never-ending, including the strike of workers due to dispute about the working and break hours, death of a scaffold worker, near collapse of the contractor company and resignation of their executive chairman and bad publicity. Hence, it was a complex and troublesome task to manage internal and external stakeholders in the Wembley Stadium Project due to the mixture of public and private funds and diverse requirements of the public stakeholders associated with the project (Aritua, Bower and Turner, 2008).

5.2.1.6 Findings From 5 Problematic Projects

The identified issues which occurred during the implementation of case study projects guided the path towards developing a process framework by clarifying the most problematic issues and uncertainties that needed to be addressed and covered in the process framework. For this purpose, the identified issues through analysis of NAO's reports, House of Commons reports and other government bodies' reports, were firstly captured by creating a set of Mind Maps as are presented in Appendices 5-12, then translated into a Table of project management terms which is presented in Appendix 19. A summary of the translation of identified issues is presented in Appendix 20. Then, the translated problematic issues were interpreted and each of them was linked to a particular project management process according to the guidelines and processes defined in the PMBOK GUIDE (PMI, 2017b) which are presented in Table 25. By doing this, it can be understood that the majority of these problematic issues were caused by inadequate scope management, the influence of stakeholders on the scope, lack of communication, and lack of a proper risk management strategy. Hence, this approach helped to understand the origins of these issues, identify the solutions for them and address them in the developed process framework.

Table 25 Interpretation of problematic issues into the relevant project management processes.

Processes	Stakeholder Management	Scope Management	Communication Management	Risk Management
Issues	- Identify stakeholders' needs and expectations - Analyse stakeholder power and interest - Monitor stakeholders - Manage the influence of	- WBS creation and estimates - Control scope and reworks - Define Specifications &	- Facilitate information sharing - Control communications quality - Plan information & communication	- Develop a risk management strategy - Identify risks - Plan risk responses - Analyse risks - Roles and

	stakeholders - Internal & External Stakeholder engagement - Roles & responsibilities - Conflict & dispute management - Develop an exit strategy	Scope - Manage scope change - Identify requirements - Value creation and management - Validate scope deliverables - Develop a realistic scope - Manage scope changes - Collect requirements	management - Manage communications	responsibilities - Prepare contingency - Risk allocation

5.2.2 London 2012 Olympic Games Construction Project

As mentioned before, the London 2012 Olympic construction program as a successful case study as it was delivered on time and within the budget and the planed scope was delivered successfully and thoroughly. So by analyzing the project management of the Olympic project, the crucial and successful practices, approaches and elements can be identified for developing the primary Process Framework. Hence the data on management and delivery of the London 2012 Olympic Games project is collected from reports published by the Learning Legacy website. The Learning Legacy's intention is aimed at sharing the success story through the lessons learned from the London 2012 construction project. Moreover, knowledge derived from the construction project will be shared to highlight the rising status of the construction sector and subsequently manifest the relevance of the UK plc.

London's fruitful initiative of London's bid for the 2012 Olympic and Paralympic Games provided a take-off base for a major refurbishment of the needed infrastructure for the events. To host the event successfully, the construction programme proved integral in the provision of venues and other infrastructure for hosting the Games. The construction program was not only all-encompassing but also susceptible to both technical and political factors. The slated program was also placed against a time limit with the date of the Opening Ceremony of the Games already set in July 2012. Given that the Olympic Bid was planned to be delivered through a rigorous process of restructuring of the roads, stadia and bridge with the mandate to achieve these deliverables given to the Olympic Delivery Authority (ODA). With the planned completion of these deliverables slated one year before the event, ODA had at least five years to work on strategies that included contracting, procuring, and delivering construction of works that were estimated to cost around £6 billion. Most of these constructions as stipulated by ODA were supposed to be carried out in dilapidated and polluted areas situated in Stratford, East London (Olympic Delivery Authority, 2011).

In regard to the construction project that was planned for the London 2012 Olympic and Paralympic Games, ODA delivered the deliverables within the stipulated time and budget. Based on the drawn targets and milestones, the ODA ensured that stakeholders engaged in the process, for example, the project's supply chain met all the required industry standards. In addition to realising increased sustainability, it is imperative to note that the project set high levels of health and safety records. The project also reported astounding records that challenged historical implications of the existing inequalities in the United Kingdom, particularly in the construction sector.

The Olympic Delivery Authority (ODA) is an integral constituent of the Executive Non-Departmental Public Body (NDPB), which is answerable to the Secretary of State for Culture, Media and Sport (DCMS). The institution of ODA was implemented on 30 March 2006 fostered by the London Olympic Games and Paralympic Games Act 2006. The role of ODA pertains to the delivery of the infrastructure, stadia facilities, and enhancing the transport system for the Games. Additionally, ODA is also the identified legal Planning Authority tasked with the responsibility of taking care of the sections of the Olympic Park (ODA and Authority, 2011).

5.2.2.1 ODA Programme

The ODA Programme is composed of a range of related projects including 6 project portfolios as manifested in Figure 25 below. For each of the 6 project portfolio, numerous projects are structured with common links, namely; venues, utilities, infrastructure, which are grouped by function and the Stratford geography. This function is headed by the ODA AccounTable Director. The management of the ODA transport projects and the Village Vertical Build Projects are programmed under the sub-programmes with distinct management and reporting channel (Olympic Delivery Authority, 2011).

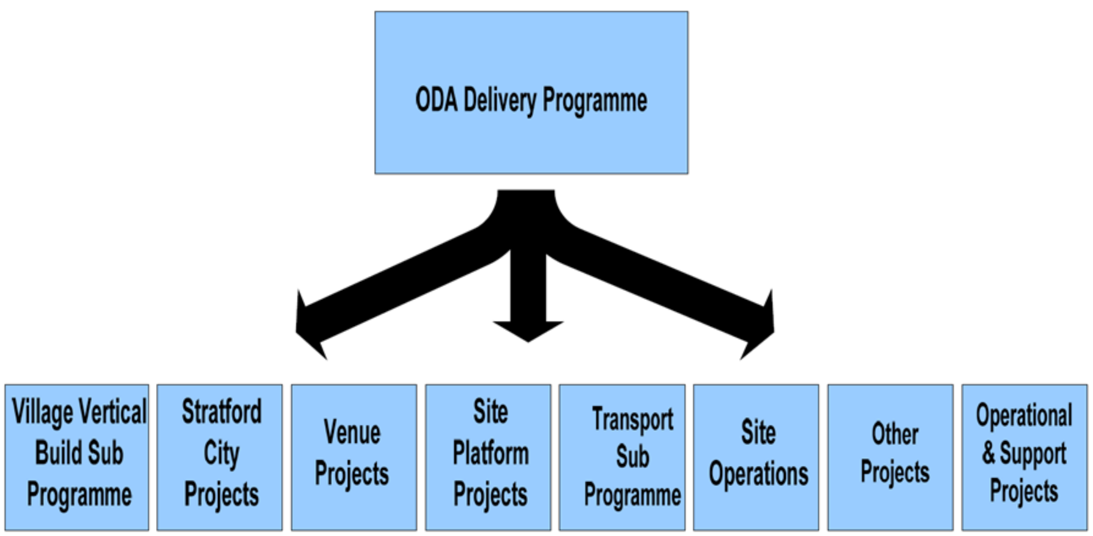

Figure 25 Programme Breakdown (ODA and Authority, 2011).

The ODA achieved the objective of bringing on board the Delivery Partner – CLM that would help in the delivery of the London 2012 ODA Programme. Whereas ODA had the inclusive role of delivering the programme, the inclusion of the CLM was based on contractual terms where they would ensure a certain percentage of management function was included in the delivery package. In addition to boasting a brilliant client role, ODA managed the construction and the building initiatives single-handedly. The ODA took overall responsibility for approving, monitoring, building financial systems, and handling the reporting processes purposely to ensure that the CLM operates efficiently. The operation of CLM is guided by the policies, procedures and standards stipulated by ODA (ODA and Authority, 2011).

The CLM's role in the delivery of the Olympic Park site further involved roles in project management and contract management. It was through these roles that CLM worked to ensure that the on-park venues were ready for the games. Other inclusive roles included creating and handling the interface that links up the following processes; the ODA Transport Sub Programme, the Stratford Projects, and subsequent the off-park venues. The ODA was also collaborating with Stratford City Development Corporation (SCDLC) who are credited with developing the Stratford City Retail Development. On the other hand, CLM worked to ensure that the programme interface was linked with the SCDLC appropriately. The delivery of the deliverables had ODA select Lend Lease as one of the partners to take charge of the Village Vertical Build. CLM was involved in this case as it took the role of a client representative, thus, representing ODA. The developer chosen for this cause was Stratford Village Development Ltd (SVDL) as a funder's decision to cater to the Village as directed by ODA. Hence, Figure 26 shows the framework of ODA's delivery partners (ODA and Authority, 2011). By considering the aforementioned relationships among stakeholders and clear allocation of roles and responsibilities, it can be concluded that an accurate plan was designed for managing the stakeholders' network of relationships and their roles and responsibilities to improve collaboration among project stakeholders.

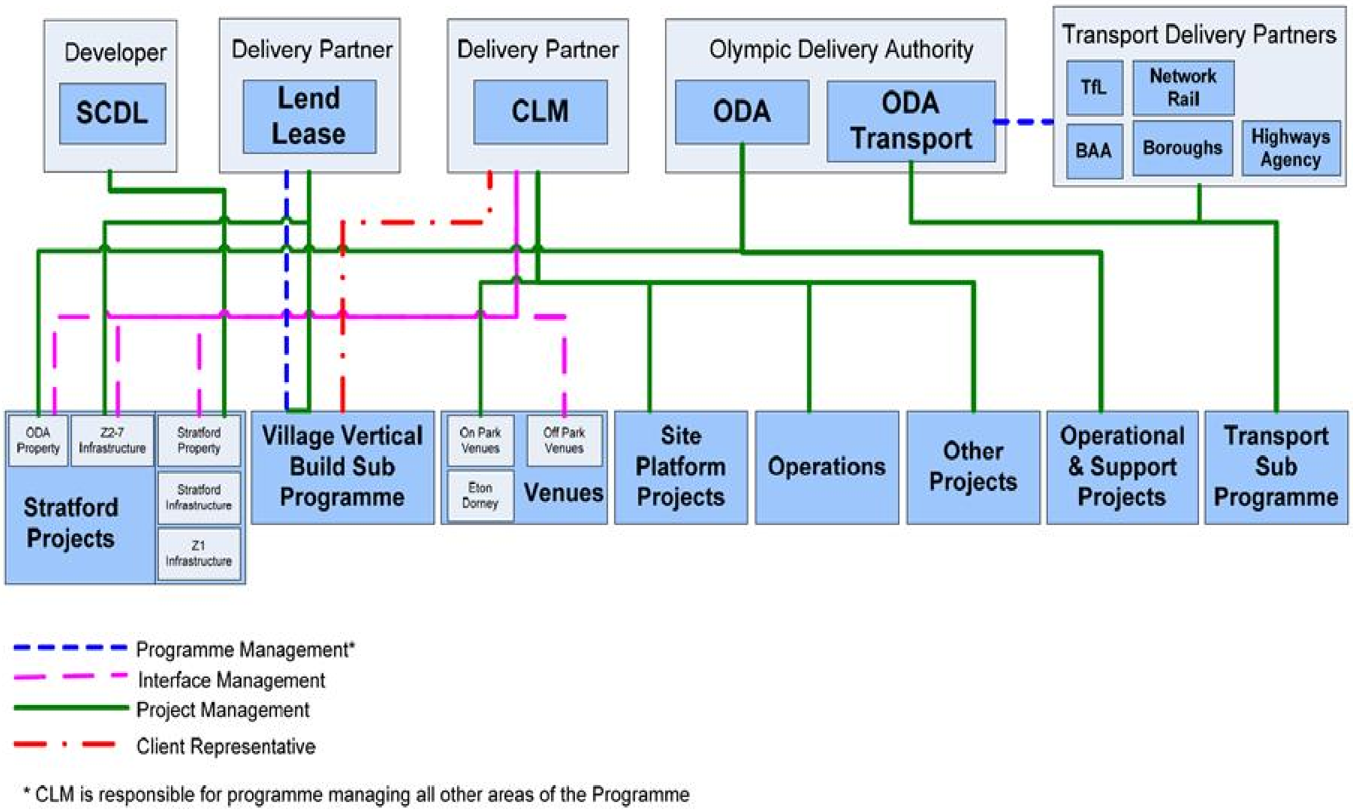

Figure 26 Delivery Partner Framework (ODA and Authority, 2011).

5.2.2.2 Programme Management Process

The delivery of the objectives specified by ODA required a mix of specialists with expertise resulting from a range of projects and work-streams necessitated by large and diverse organisations. Whereas the CLM took the initiative of developing project programme management processes, ODA harnessed the business objectives and provisioned close monitoring of the programme. The ODA redirected the focus not only on controlling the costs, standards and quality but also facilitating the delivery of the deliverables of the programme. The stipulation of these processes provided the Delivery Partner to ensure that the programme delivery ran efficiently.

The programme management procedure was divided into three phases as demonstrated in Figure 27:

1. Programme Start-Up

2. Programme Delivery

3. Programme Close

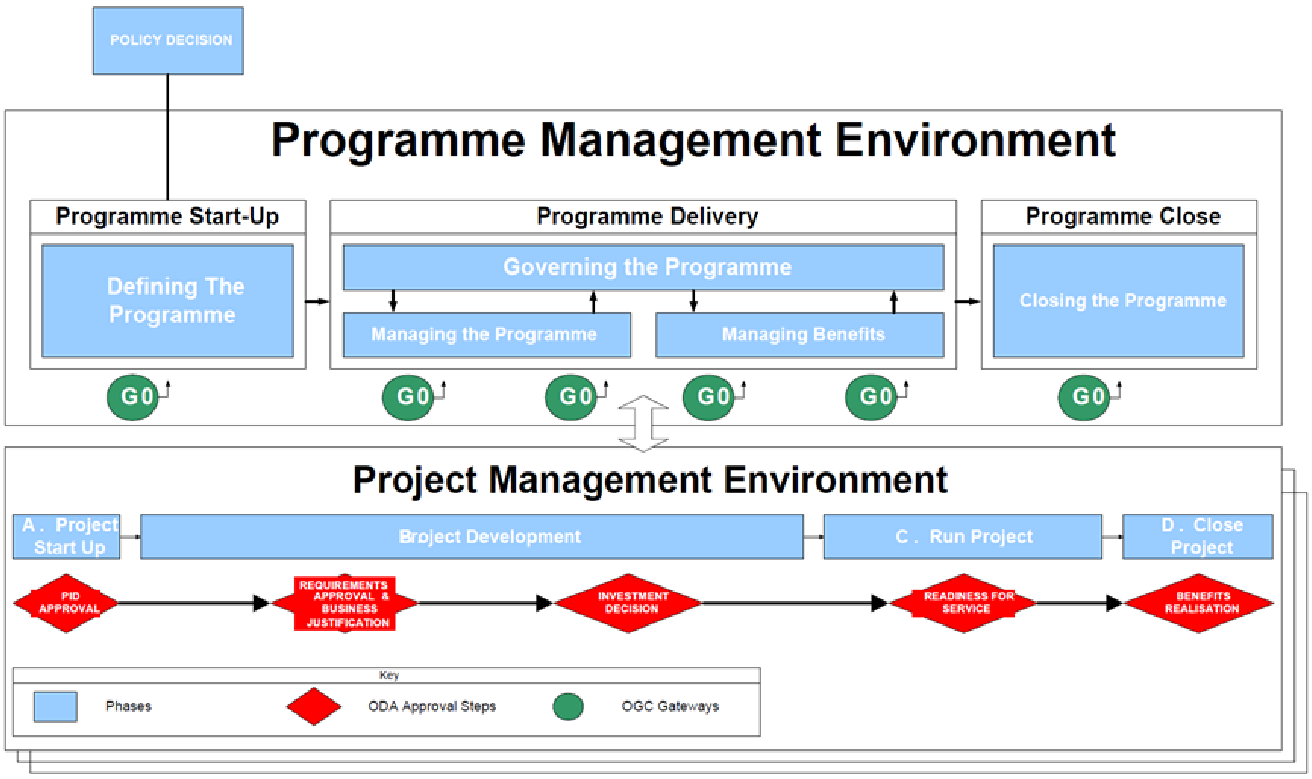

Figure 27 Programme Management Process (ODA and Authority, 2011).

The first phase entails programme start-up with detailed and expounded directives regarding the programme's objectives as highlighted in the programme brief. This phase also involved the creation of the ODA Lifetime Corporate Plan which provides relevant information on the portfolio of projects that are already initiated in the plan. The portfolio of projects also manifests the agreed-upon costing, anticipated risks, and the organisational and governance structures that are subsequently reported annually and included in the ODA plan. For this case, a programme definition plan was formulated by utilising the approach of the Programme Baseline Report that further expounded on the programme's requisites that were set and approved by the OPRG in November 2007. Nevertheless, this document was subjected to continuous update processes throughout the entire life of the programme (ODA and Authority, 2011). Hence, this shows the importance of defining the project scope from the outset and the provision of associated documents such as scope baseline.

The second phase in the process was dominated by the prospects of programme delivery through the time where the project was evaluated and the delivery plan is drawn out to match the expectations of the strategic focus of the programmes. This phase was further divided into three crucial areas identified as follows;

- governing the programme
- managing the portfolio of projects
- managing the benefits.

The last phase involved the process of closing down the programme with numerous tasks undertaken. The procedures in this last stage involved accomplishing what was constituted in the agreement, for example, the acceptance criteria and the successive confirmation of what was achieved followed with the handover process.

5.2.2.3 Programme Management Timeline

The ODA Programme made pertinent progress towards the success of the bid with the formation of the interim ODA by the LDA in July 2005. Figure 28 shows the timeline of programme management (ODA and Authority, 2011).

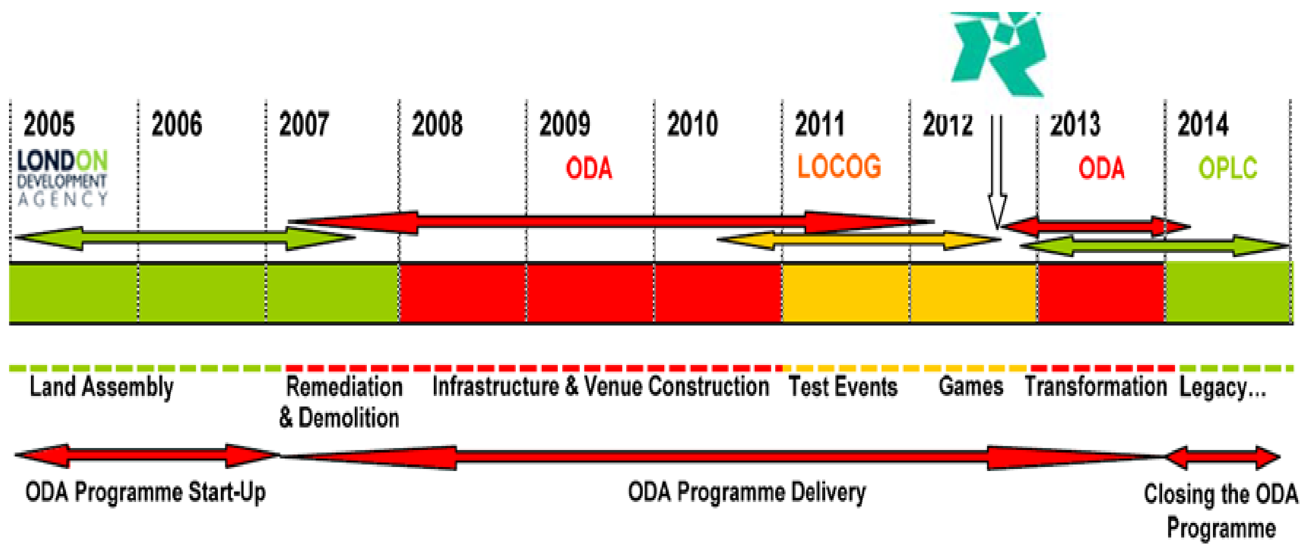

Figure 28 Programme Management Timeline (ODA and Authority, 2011).

5.2.2.4 Risk, Opportunity & Issue Management

During the execution of this programme, it was vital to understand that managing risk took a central role in the Olympic Programme. The purposes of the risk, opportunity and issue management include the following:

- Provision of a platform that elicits critical decision making
- Manage and control risk effectively; and
- Protect ODA's interests including those of the other stakeholders.

Risk management is a key component in the management of projects. The process of managing risks entails the roles of each and every person involved in that particular project. In its plan, the ODA formulated and put into action a Risk & Opportunity Management Policy that has not only outlined ODA's tactics but also the relevant strategies for managing risks. The 3 Lines of Defence model presented below in Figure 29 outlines ODA's approach towards risk management.

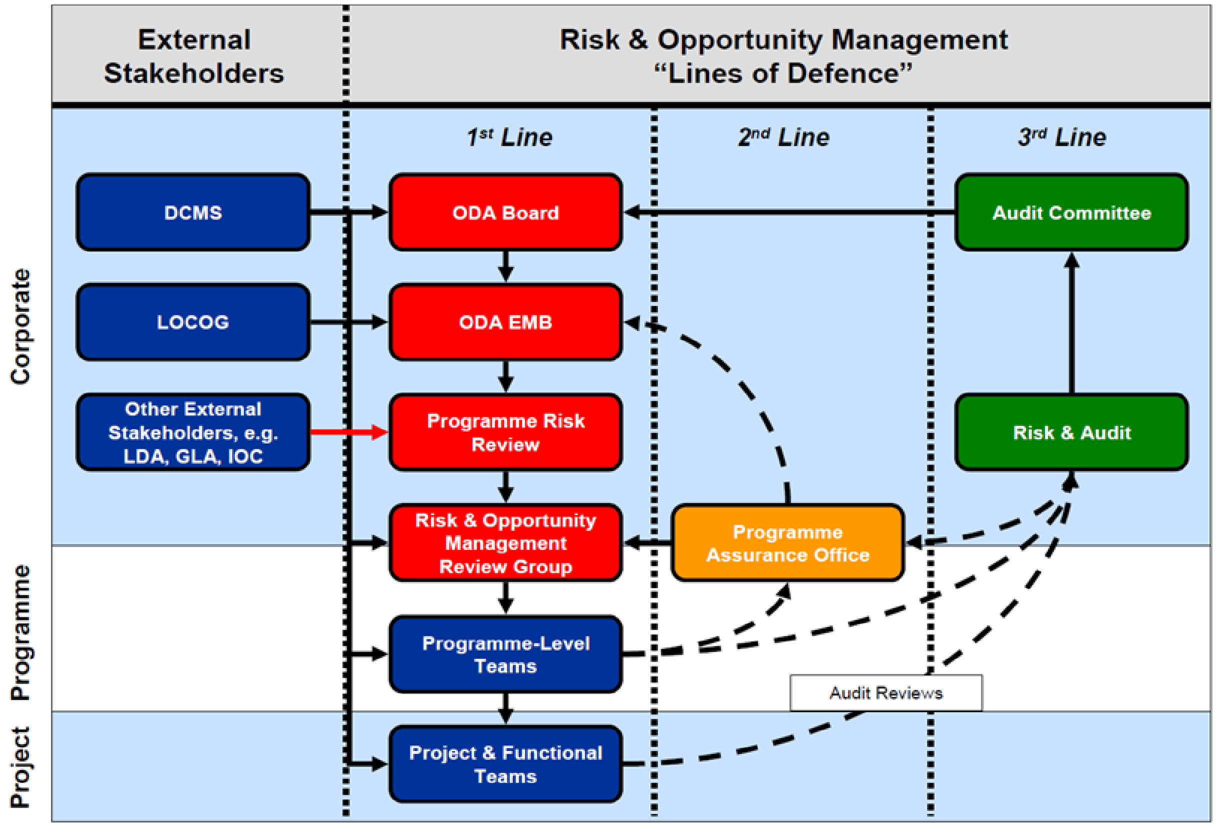

Figure 29 Risk Management Framework (ODA and Authority, 2011).

The ODA established three distinct lines of defence as the risk management strategy which included the following (ODA and Authority, 2011):

- Detailed analysis of programme risks
- Compliance and quality reviews as a mean of programme assurance
- Policy reviews and external audit

The Program Risk Register and the Project Risk Registers were owned and fostered by the Program Risk Review and individual projects respectively. Whereas the Program Risk Register was reviewed by the Program Risk Review, the Project Risk Registers were reviewed by the programme-level management teams which formed the first line of defence as manifested in the model. This first line of defence played a crucial role in updating each of the programme-level teams presented in the organisation structure, for example, the Delivery Partner and the ODA Transport. For this programme, ODA has envisioned and created a Risk and Opportunity Management Framework that guides all those involved in the programme. The role of the framework was to ensure that risk management was implemented throughout the ODA's programme (ODA and Authority, 2011).

On the other hand, the Programme Assurance office was tasked with the responsibilities of monitoring the processes and the delivery by the programme-level teams. The delivery outcomes were measured through the involvement of the teams at the executive level, programme, and project-level risk management reviews. As such, this formed the second line of defence. The ODA Risk & Audit Group reviewed and provided independent expertise in the management of risks, control and governance, an aspect that formed the third line of defence. It is imperative to note that the ODA Risk & Audit and the Programme Assurance Office usually engaged the programme-level teams through the Risk & Opportunity Management Group on numerous occasions (ODA and Authority, 2011).

The Olympic Delivery Authority (ODA) was given a timeline to have the deliverables completed and the venues prepared 12 months before the London 2012 Olympic and Paralympic Games kick-off within the estimated budget of £7.2 billion. However, there was more to the achievement of this deadline as there existed multiple risks that ranged from the dilapidated and contaminated site coupled with the deteriorating economic conditions. Other problems involved the increased competition fostered by multiple stakeholders and the watchful eyes of the world media. Despite the challenge posed, the success of the ODA's approach involved the resilience provided by the risk management process and the streamlined risk hierarchy where different people were given roles to undertake in managing risks. A quantified risk analysis was embraced that was geared towards addressing any contingency through the provision of an extensive assurance and audit process. These processes aimed to promote a remarkably honest culture of risk awareness(ODA, 2012a).

The risk management policy set by the ODA was subsequently divided into three distinct lines of defence. Programme Delivery involved a comprehensive analysis of risks, with the Programme Assurance enhancing the quality of the deliverables and the compliance reviews. Moreover, the Corporate Control carried out external audit and policy review to close down the gap on quality and compliance. Consequently, risk management took the initial role in controlling change and promoted the application of the change control processes (ODA, 2012a).

A risk hierarchy was established before the commencement of the processes. The risk hierarchy consisted of the following (ODA, 2012a):

- Project – risks present in the project scope;
- Programme – risks located externally that cannot be controlled by project, but evidenced within programme scope;
- Funders – risks involves political, for example, the change in a VAT, and other external factors that are not within the domain of the programme and those that can impact the scope changes.

The use of this approach enabled easy management of risks at different levels. The resulting outcomes indicated that project teams could redirect the efforts on project risks with the executive given the opportunity to focus on the wider risks that could emanate during the execution of the programme. On the other hand, the funders had the chance to pay attention to external programme risks that could impact the programme negatively. Concisely, this approach elicited teamwork in the management of risks throughout the programme (ODA, 2012a).

The programme and project risk registers were recruited from a group of stakeholders both internal and external and subsequently recorded in a central database. Records entered into the database had the ownership defined and the action responsibility outlined clearly (Olympic Delivery Authority, 2011).

All the risks with a cost and time impact identified throughout the project were quantified and subjected to a Quantitative Risk Analysis (QRA) at the project, programme, or funders level. The results of the QRA for the project and program was taken into consideration as per contingency requirement towards the anticipated final cost. This was vitally important as the final evaluation was conducted to ascertain the relevance of each of the risks defined across the programme. During each quarter, the contingency was adopted whereupon risks were reduced with the processes being carried out throughout the programme. The implementation of the risk process proved to be integral for the projection of the programme's outturn cost which resulted in an estimated savings of £470 million (ODA, 2012a).

5.2.2.5 Stakeholders and Communications

ODA operated in a complex context that required crucial strategies to manage the functions of the business and various stakeholder groups to meet stipulated timelines and planned budgets effectively. Hence to obtain a better understanding of stakeholders in such a complex context, ODA developed its unique categorisation of stakeholders instead of using the traditional stakeholder typology. Accordingly, they identified the focus of stakeholders interests and categorised them into four groups of Specialist, Community, Business, and Government. The description of these four stakeholder groups and their assigned attributes are presented below in Table 26.

Table 26 Stakeholders Communication (ODA and Authority, 2011).

Political	Business	Community	Specialist
Interests wide and diverse	Opportunity and economic focus	Mitigation, opportunity and legacy focus	Reflects successes and where possible advances in industry and wider policy areas.
Government Parliament Greater London Authority London Assembly East London Olympic Boroughs UK Regional Devolved Administrations European Parliament	National Representative Groups/Regions & Nations London Representative Groups – LBB/CLP/LF/LCCI/CBI SMEs BAMEs Trade/Industry International	Local Residents Faith East London Host Boroughs Disability Accessibility Young People Older People Ethnic Communities Women Voluntary Sector Educational Establishments	Planning Sustainability Design Employment and Skills Inclusion and Diversity Construction/Health and Safety Procurement Industrial Relations Transport Legacy Venues Sports

As an organised public body, ODA established the Code of Construction Practice (CoCP) which laid down the requisite objectives and procedures that would be adopted during the course of the construction programme. The CoCP defined collaboration with the local community with measures drawn out to make limitation to the construction activities as far as the conditions of the environment and the communities are concerned. ODA strived to provide the best standard and best practice through public participation and community engagement. The ODA adopted further strategies that involved dialogue and open engagements with various stakeholders with processes geared towards minimising community impacts (ODA and Authority, 2011).

Since the inception of the London 2012 construction project, there was continuous scrutiny from the public. The approach embraced by ODA was aimed at improving their relations with concerned local communities through various consulting meetings and engagement with stakeholders with diverse contributions expected from the wide members of the communities. Managing these communities also involved the implementation of communication tools and the establishment of programmes planned for public participation as handled by ODA. The ODA also expected feedback from the community after carrying out the above-mentioned programmes. The implementation of these programmes included; archaeological and history forums, engagement meetings, local school participation, and planned visitation programmes of the Olympic Park open to the general public (ODA and Authority, 2011).

The engagements and the structured consultation model was centred on key components of inclusion and communication with the stakeholders. The inclusion aspect allowed ODA to carry out consultation meetings with stakeholders with diverse communities on the issues surrounding the Olympic Park and venues. These preparations and processes were designed to play a crucial role in the bidding process for the 2012 Games. In addition to exceeding the statutory requirements for stakeholder engagements, ODA'S Olympic, Paralympic and Legacy Facilities Planning Applications was the final product for the bid. One of the examples rising from this case includes numerous types of planning application necessitated a statement of participation, which showcased the involvement of different parties in the dialogue process before the submission of the planning application. Additionally, the ODA also got involved in the non-statutory consultation that involved different stakeholders(ODA and Authority, 2011).

Table 27 below highlights different types of consultation and stakeholders involved in the process. As can be seen from the Table 27, ODA designed a What, Who and Why framework for engaging stakeholders.

The ODA strengthened the communication channels to enhance the communication processes with the communities living close to the construction sites. In this case, the strategy fostered had the communication tools that provided the hierarchical ranking of the community collaboration with the CoCP. On the other hand, the Community Relations team not only fostered the delivery of the communication tools but also played the intermediary role between the construction and project teams and the local community. The crucial role of the Community Relations team included acting as the central point of information flow where they coordinated with projects in addressing issues and complaints raised from different members of the public. Whereas the Community Relations team was communicating to the community on information regarding the construction activities, the project team were also involved in delivering feedback to the project team throughout the construction phases. Some of the communication tools used include a 24-hour hotline, notification letters, on-site signs and Newsletters(ODA and Authority, 2011).

Table 27 Type of Stakeholders and Objective of Consultation(Sharpe, 2012).

Consultation	Who	Why
– Policies – Masterplan – Detailed planning applications – Transport plans – Business plans – Design of venues – Parklands and public realm – Road closures	– **Statutory consultees** eg: The Environment Agency, local planning authorities – **Business** eg: Business organisations – **Community** eg: Voluntary and community sector organisations, local community representatives – **Specialist** eg: Technical experts – **Political** eg: Government agencies, local authorities (including MPs/Councillors) – **General public** eg: Residents	– Shape objectives – Evaluate impact, fairness, transparency, equality – Mitigate negative impacts – Understand local priorities and issues – Engage local communities and groups – Accountability – Project information – Environmental monitoring and management

5.2.2.6 Internal Stakeholders Engagement – the ODA Staff Forum

The ODA was a time-bound and service delivery organisation that was driven by the need to achieve stipulated objectives through critical decision making and high levels of cooperation and engagement from the staff involved in the project. Most of the ODA's staff recruited for the project were employed directly and included professional staff and non-union members. The representation of the non-union members employed by ODA detailed diverse experience with the employees being selected from different sectors and industries. The Olympic Delivery Authority (ODA) created the Staff Forum as the staff consultation unit. Their inclusion in the process was important particularly during periods like organisational change, for example cases of Games-time, and the closeout period by the organisation. The finding of success revealed that employee engagement measured at an estimate of 92% as postulated in the Employee Survey for cases on the unplanned average attrition rate in the industry.

Directors and the Leaders of Functions were identified as possible candidates as representatives of the forum. The meetings involved discussion on project start-up and subsequent construction phases. These meeting further addressed; policies and procedures, pension arrangements, health and safety, and equality instances as they will be evidenced in the project. The focus of the Staff Forum was directed towards the practical accomplishment of the construction by 2011 and have some time slated for the restructuring processes.

Also, the Staff Forum representatives had received pertinent training on ways to handle and deal with cases of redundancy. In the course of facilitating this role, they offered support to individuals members and subsequently fostered policies and processes that were associated with redundancy(ODA and Authority, 2011).

5.2.2.7 ODA's People Strategy (collaborative working)

A flexible and agile people strategy was needed to be quickly developed due to the mobilisation of the programme and fast pace nature of the project to provide a structured approach and consistency. The People Strategy was defined as a key tool for aligning the activities of human resource with the changing needs of the business by ODA. It comprised 10 priority areas which allowed organisational performance monitoring and clear accountability in HR teams. Despite the need for adjusting the strategy during project execution to emphasise the position of some elements more strongly; It passed the test of time during the project lifecycle and supported the successful delivery of the construction programme(ODA, 2012b).

The HR team collaborated with a consultancy organisation in developing the ODA People Strategy through consultations with the Executive team on key business matters, employee suggestions, and relevant information from other key stakeholders, for example, strategic partners and the ODA Board. Accordingly, the People Strategy addressed the business challenges and specified the priority areas, business drivers and HR principles together with the HR strategies for each priority area. Hence, the People Strategy is presented in Figure 30 (ODA, 2012b).

The people are placed at the centre of the strategy that was surrounded by the collaborative working with interlinkages to managers, employees, HR, and ODA's key stakeholders.

The HR team joined forces within business areas and ensured that the strategy was not only embraced but also exploited effectively. The HR team ensured that the strategy was utilised in the required areas as mandated by the organisation through the HR Team activities.

Figure 30 The People Strategy Comprised 10 Priority Areas (ODA, 2012).

In this regard, the strategy provided employees with the needed direction and helped them meet the HR team's work throughout the phases of their undertakings. The delivery of the HR Team was plotted on the People Strategy. In the execution of their activities, each individual was tasked with activity within the team and a tracker adopted to monitor progress against the milestone set on the People Strategy frequently. The results from these activities were published through the Executive Management Board annually. There was the use of the Red/Amber/Green (RAG) system to communicate progress and elicit attention to the business areas that had issues that needed to be addressed.

Figure 31 RAG Diagram (ODA, 2012).

For example, the RAG status manifested areas that needed more attention as outlined by the mapping of the achieved prospects against the targets of the project. Figure 31 below manifests a RAG derived from the years 2009/2010.

The communication of the people strategy to the stakeholders of the project was carried out in many ways, namely; staff briefings, the Staff Forum, and mostly through team meetings. This communication was carried out through face to face sessions between individuals and their managers.

5.2.2.8 Programme Baseline Report (Scope)

ODA produced documentation on the programme scope and presented it alongside a comprehensive budget to the Ministerial Funders Group (Funders) and the Olympic board for review and approval. The resultant product of the Programme Baseline Report (PBR) provided an extensive description of the scope, programme, budget, and imminent risks. The PBR published in November 2007, recognised different aspects that ODA had placed into its delivery list, the identified allocation of the risks, and other vital items that were not within the scope of the project.

The compilation of this document highlighted the scope and the uncertainty of the programme at its early stage, an aspect that gave ODA a firm ground towards the delivery of the programme. The scope of the document accounted for the programme baseline report that included the following; site work contexts, infrastructure, venues, legacy transformation, and transport. The document also contained the detailed statement of the works matched with the budget for the delivery of the activities. Subsequently, the approval of the document meant the start of the project followed by monitoring the delivery of the works against the designed baseline with the management of change processes. After two years, the report was updated to reflect the position of the programme and the achievement of the ODA's Games-time scope(Olympic Delivery Authority, 2011).

The detailed scope provided by ODA included the following(ODA and Authority, 2011);

- Demotion works, earthworks, site remediation, construction of utility tunnels on stipulated Olympic Park platform, and construction of ducts, bridges, new road networks and highways.
- The building of venues both the Olympic Park and the non-Olympic Park.
- Constructing the International Broadcast and the Main Press Centres.
- Collaborating with the Programme Site Establishment and Logistics towards the delivery of the Olympic Park Development, and subsequent construction of the venues.
- Supervisory of the Olympic Park and the Public Realm works.
- Outlining general projects, the Masterplan, Section 106, project insurances and the needed security that are linked to the construction phase.
- Specifications of the projects – Capital projects, capital facilitation of the Network Rail, DLR, and the inclusion of the operational projects for the Games time.
- The changeover practice that would be adopted after the games in the course of establishing a platform for legacy development later in the future.

Key aspects that excluded from budget and scope include the following:

1.The following projects are excluded from the ODA's detailed budget.

A. Visitors centre.

B. Cross rail scope and interface.

C. Dredging of the Olympic Park Waterways.

2.Works that leads to the venues, transport, and security planned to be addressed by LOCOG.

3.The costs to cater for security requirements, for example, amounts to cover vehicle protection from hostility and other bomb-related requirements.

4.Green Guide and the changes based on the design parameters.

5.Landfill and total tax.

These exclusions include a range of aspects that are not under the scope to be delivered by ODA. The deliverables will be addressed and provided by other organisations, for example, the LCOG and others to supplement the ODA's deliverables.

The detailed scope document for every project identified in the programme embraced the following structure in Table 28.

Table 28 The detailed structure of scope document for every project identified in the programme (ODA, 2011).

Title	Description
Scope Summary	Highlighting the scope and deliverables of the project.
Scope details	Provision of comprehensive information regarding what will be delivered including the costings.
Assumptions	Key assumptions based on the scope will be provided here. However, this section is not mandatory.
Exclusions	As discussed above, this section will provide information on those components not included in the ODA's budget nor delivered by ODA. Moreover, this section will not be mandatory.
Interfaces - transformation and legacy	This section details the project relating to transformation and manifests the end of the project before the closeout by ODA. This section will be optional.

Plus, the Work Breakdown Structure (WBS) entailed the scope of work involved in managing the delivery of the programme, with individual projects defined and directed to a single venue, for example, the Olympic Stadium.

5.2.2.9 Integrated Planning for the London 2012 Programme

The London 2012 Olympic programme was comprised of around 50 individual projects and it was challenging to integrate plans and prevent surprises during delivery. Therefore, a level 2 schedule was established for gradually building the plan and capturing key interfaces. Also, for identifying, apprehending and coordinating integration across the programme, a thorough and concurrent process was established. Besides, detailed monthly issues analysis of interfaces were undertaken which led to the increased cost-effectiveness of solutions with coordinated, proper and timely mitigation.

In this regard the main identified issues were:

- Dependence of key programme milestones on the inputs from other projects.
- On-site cross-project interfaces caused by decisions made during the design process.
- Aligning project plans to resolve boundary clashes due to limited on-site space.
- Proactive management of works by others in a principal contractor area to avoid disruption and reworks.
- Dealing with known interfaces in the Bidding documents and contract incentives, forecast dates, design documents before awarding the contract.

In the early stages, the principles of the integrated plan were created; however, the detail had to be built gradually as the scopes and contracts were defined and outlined. A collection of processes, meeting outlines, reports and the assurance framework were developed gradually to accomplish the following:

- Being conversant with the interface at the strategic level (understanding the effects on programme delivery, stakeholders being impacted and responsibility of resolving the interface).
- Detailed understanding of the interfaces (drawings, scope documents and the drivers for the key deliverables).
- Reviewing the interface(s) and capturing new ones (monthly & weekly meetings).

- Grasping the timing of interface, costs, schedule, and evaluating the impact on subsequent activities or projects.
- Monitoring the overall programme in a single and integrated plan with the projects remaining responsible for their defined areas.
- Creating rigorous tracking, monitoring and structure of reports.

A culture enriched with great communication and cooperation is the necessity of effective integration, therefore to capture the interfaces, construction integration teams were created. Design managers and Construction Integration engineers were involved in these teams when the complexity of interfaces was high. All the team members collaborated in monitoring and managing the interfaces through reporting and on-going coordination meetings.

Also, to improve the effectiveness of integration teams in identifying interfaces and performing required programme changes, they were required to work in project delivery teams. So, the interactive and focused dialogue could take place which let to a better and earlier definition of interfaces and consequently more efficient delivery.

The growing complexity manifested in the Level 2 schedule entailed difficulty in maintaining the logic in the forecast schedules and the baseline. Hence, to simplify the baseline, all vital milestones were captured by using change control. Accordingly, the progress was updated every month and the forecast schedule remained updated on daily basis; so whenever detail became available activities, logic and milestones were updated.

The culture within the programme encouraged planning teams to act proactively on interfaces and the potential issues that caused the interfaces.

It proved difficult to define and resolve all the interface and integration issues in the initial stages of the programme. However, it was easier to deal with known issues first and resolve the unknown through the risk process as it was a more efficient approach for forecasting outcomes. Issues that could not be resolved at the local level were eventually redirected to senior management.

5.2.2.10 3D Model Creation and Its Use on the Olympic Park

A 3D visualisation model of the Olympic Park was integral to the inclusion of the other venues combined with the Parklands that interacted harmoniously with the surrounding community. This was not only cost-effective but also a systematic way of producing physical models, simulations, and video animations. A programme-wide approach was embraced to create a digital model that provided an illustration of varied projects from existing designs. However, the problem was collecting information from each designer and organising them into a Park like a model without interfering with the cost of the programme. This was achieved through planned and quality well-ordered steps, namely(Authority, 2012):

- Contractors were expected to create 3D visualisations. They chose 3D studio as the ultimate tool for the Park-wide model;
- All designers handed in their 3D Studio model in a folder that was customised for the model based on a ProjectWise in a Computer-Aided Design (CAD) collaboration tool.
- The modelling team took the role of putting together each of the designer's model into a park-wide model.
- The park-wide model was then availed on the ProjectWise for the project teams to utilise for their planning approvals and presentations.

The model was used in three distinct ways as presented in Figure 32;

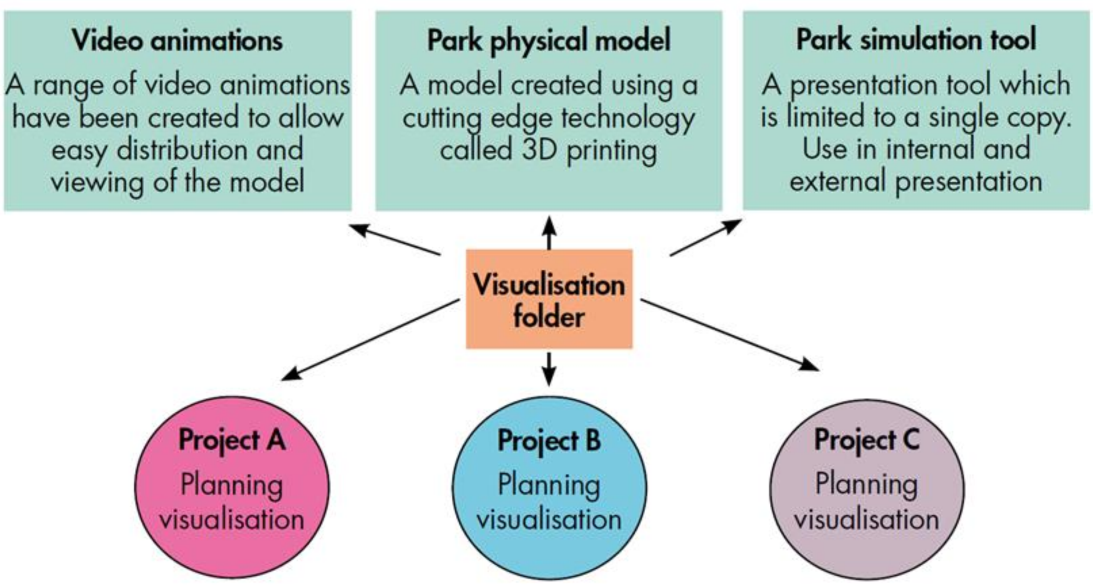

Figure 32 Uses of Park Wide Model(Timmis, 2011).

1. Simulator

In this case, users utilised the simulator to fly around and paused to take pictures before proceeding with the exercise. This was used widely in the design and construction phases in a bid to understand the connection between structures and buildings. Nevertheless, the model had the details with spatial extent as the hardware had to receive support from the simulator. Therefore, a balance was sought between the levels of detail given the manifestation of the tool's speed. The optimisation was achieved by reducing the polygon count of the model(ODA and Authority, 2011).

2. Physical model

Whereas multimedia visualisations remained the preferred method, there was also the need for the physical model masterplan. A model was tailored for the LPA for utilisation during public consultations. The timeline required the planning approval needed for the master plan was approved before the detailed design and public consultation was accomplished. The new technologies took into consideration numerous changes alongside the 3D printing adopted during design development. All these were undertaken at an affordable cost, thus reducing the cost of the legacy transformation modelling significantly. The master plan developed with the small details being reprinted at an affordable cost and faster when compared to the traditional models (ODA and Authority, 2011).

3. Video animations

Given the huge public interest that had been developed towards the project, there was a need for the accurate video animation of the park as a requisite for the public media. The visualisation for the Olympic Delivery Authority and the CLM Delivery Partner was developed using the Park-wide 3D digital model with clear visualisation. Key lessons and benefits included the following (ODA and Authority, 2011):

-A 3D-visualisation model with a good resolution that provided LPA that enhanced confidence in the project with few queries and timely approval decisions.

-A high-quality model that was adopted in the public media and used effectively throughout the public consultations that were relevant in high profile projects. This was also a good tool that was utilised in stakeholder and community engagement.

-It was imperative to identify all the crucial components in the modelling that would be utilised for the project at the early stages of project. This also included all the potential stakeholders that would be interested in the cost-sharing processes, for example, the case of the 3D modelling or the mapping identified areas.

Conclusively, this research study has provided a comprehensive discussion of the key identified factors that harnessed and fostered the London 2012 construction programme. Moreover, this research has elaborated on the approach adopted by the overall management that handled the programme with the inclusion of the management of individual projects.

5.2.2.11 Findings From London 2012 Olympic construction program

By analysis and investigation of reports published by Learning Legacy the key success factors can be identified for developing the 'Process Framework'. One of the key success factors in this programme is a robust and comprehensive programme and project management through precise partner selection, definition and allocation of roles and responsibilities and managing interfaces between projects for their ultimate delivery. In this regard, rigorous supervision had a crucial role in ensuring partners perform in compliance with ODA's procedures, policies and standards to deliver projects on time and within budget. The problem resolution process helped identify problems and provided the way towards solutions sought with the involvement of the DP outlining significant instances to work with the Tier One Contractor. Even at the planning stage, time was taken to identify unforeseen problems and options were evaluated with the best solution.

Accordingly, consideration and analysis of programme objectives and documenting them in programme brief was an important element. Consequently, a lifetime corporate plan was produced containing agreed projects portfolio outlines and high-level schedule, cost, risks and organizational structures. In this regard, another key factor was the creation of a programme baseline report in which the requirements of the programme was further defined and was updated on an on-going basis. Also, the acceptance criteria for validating the scope deliverables were defined and agreed upon during the closing phase of the programme.

Furthermore, to deliver Olympic Programme and accomplish its benefits, a programme management framework was designed including steps like governance, risk and issue management, stakeholder and communication, programme planning, change control, monitoring and reporting structure. Besides, a set of programme support functions were designed for the provision of expert help and support to various projects during the project lifecycle.

The next success factor is risk management as an essential part of Olympic programme management. For this purpose, a risk and opportunity management policy was developed by ODA that included the approach and strategy for risk management. The focal element of this approach was the 3 lines of the defence model. Also, a framework of risk and opportunity management was developed by ODA defining the guidelines for risk management implementation across projects. The ODA's approach was successful due to flexibility brought forth by the risk management process and efficient risk hierarchy in which roles and responsibility of people were defined clearly. Also, quantitative risk analysis was undertaken by ODA to address any contingency by providing a comprehensive assurance and audit process. The risk hierarchy established by ODA comprised consideration of risk in 3 levels of project risk, programme risk and funders' risk.

The programme and project risk registers were recruited from a group of stakeholders, both internal and external and subsequently recorded in a central database. Records entered into the database had the ownership defined and the action responsibility outlined clearly.

Identification and categorising stakeholders in four categories including their key interest and developing an external relations strategy to manage external stakeholders are some of the ODA's success factors in managing stakeholders. Engaging and communicating with various stakeholders like local communities about the planning, design and construction and involving them from early stages are other important elements in their management of stakeholders to obtain their contribution and reduce their impacts. Accordingly, ODA employed different communication tools and engaging programmes including history and archaeological forums, meetings, events and visit programmes and local school participation. Mandating the statement of participation for some planning applications is another method they used for stakeholder involvement.

Also, communications with stakeholders were strengthened by ensuring the effectiveness of communication channels through building a community relations team and using communication tools as part of the strategy for community liaison, which was some of the key factors in their successful communication management. Also sharing information by the Community Relations team about the complaints and conflicts in the project with other team members was another important element. Employed communication tools included: a 24-hour hotline, Notification letters, on-site signs and Newsletters.

In terms of internal stakeholders establishing a staff forum by ODA as a mechanism for staff consultation and engagement is a remarkable factor. Policies and processes, pension provisions, health and safety issues, and inclusion and equality issues are some of the topics discussed in the forum during the planning and construction phases.

In terms of collaborative working, the ODA developed a people strategy in order to provide a structured and cohesive approach by taking into consideration business issues and people implications. Collaborative working was at the core of this strategy demonstrating an important interface between ODA's and HR primary stakeholders, employees and managers.

Another vital success factor was the provision of Programme Baseline Report (PBR) which is documentation of programme scope and includes a description of associated programme, scope, risk and budget. Identification of deliverables, risk allocation and scope inclusions and exclusions are some of this document's contents. The compilation of this document highlighted the scope and the uncertainty of the programme at its early stage as an aspect that gave ODA a firm ground towards the delivery of the programme. Also, a work breakdown structure (WBS) was created and used in this programme to manage the monitoring and delivery of the programme and structure the scope of works for each element of infrastructure and single projects.

Plus, another factor leading to the success of the Olympic project was using integrated planning, chosen due to the complexity and scale of projects involved. It was during the early stages that establishing the principles of the integrated plan were undertaken and the details were created as the programme progressed. The formation of construction integration teams for capturing and understanding interfaces was another important factor in this regard. Excellent communication and cooperation between team members was performed for this objective through regular coordination meeting and reporting.

Another success factor in the construction of the Olympic programme's project was using 3D model of Olympic Park as a vital tool to ensure the cohesive interaction of various venues with the broader surrounding community and their integration with parklands. A flexible and cost-effective approach for the production of simulation, video animation and physical models was provided, which resulted in support for the process of public consultation and taking into consideration the broader urban context for durable legacy and making appropriate decisions on planning approvals.

The success factors in delivering London 2012 Olympic Games projects are demonstrated in Figure 33.

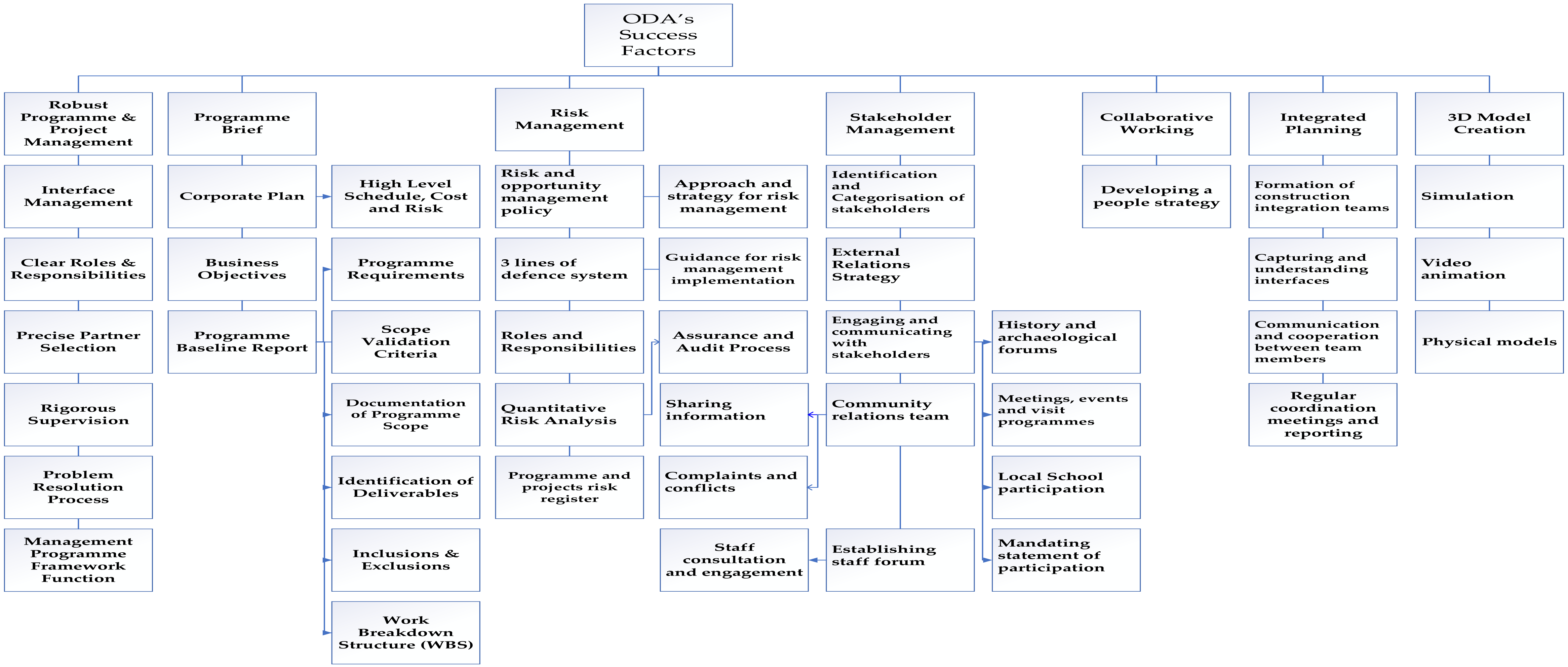

Figure 33 ODA's success factors for delivering the London 2012 Olympic construction programme.

5.3 Summary

This chapter described the implementation of secondary data analysis, which was based on the design described in Chapter 4. The implementation was introduced in section 5.1. Moving to the next section (5.2.1) the secondary data were analysed on the five case study projects which confronted difficulties in managing the scope, stakeholders and risks during their lifecycle. In this regard, the reports published by the National Audit Office (NAO), the House of Commons and other government bodies such as Learning Legacy were used together with scientific articles. Consequently, the problematic issues were identified, mapped, interpreted and translated into project management terms based on the terminology and processes defined in PMBOK GUIDE (PMI, 2017b) and the result was presented in Table 25. In section 5.2.2 the management of the London 2012 Olympic Games construction programme was investigated as a successful project which had been delivered within planned time and budget. The main aim of this part was to identify the successful and beneficial approaches and techniques during the execution of this programme for the development of the process framework.

In the next chapter the development of the process framework for managing the influence of stakeholders on the scope of projects and preventing scope creep via BIM methodology will be described.

Chapter 6 Process Framework Development

6.1 Introduction

Chapters 4 and 5 described the design of research methodology and implementation of secondary data analysis. This chapter discusses development of a Process Framework for managing the influence of stakeholders on project scope by using BIM management concepts and essential project management processes. However, the functionality of the framework is not limited to this and besides improving the comprehension of BIM application within the project management sphere, it can be used for general management of uncertainties and risks in projects and particularly the ones caused by stakeholders. The chapter is organised as follows: Section 6.2 introduces the procedure used for the development of the Process Framework and describes associated themes. Section 6.2.1 provides an overview of the meta-synthesis of the relevant project management processes defined in the PMBOK GUIDE(PMI, 2017) to identify their interdependencies, interaction and the sequence of essential activities. The analysis, interpretation and synthesis of BIM processes and documents including Collaborative Working and Integrated Project Delivery (IPD) are presented in section 6.2.2. Plus, the interaction and relationship between the main project management processes in this research (Stakeholder, scope, communication and risk management) with Building Information Modelling (BIM) is investigated from two perspectives in section 6.2.3. Finally, the developed primary process framework is presented in section 6.2.4, followed by section 6.2.5 which discusses the primary stages of the framework and the description of the main stages and supporting elements in sections 6.2.6 and 6.2.7.

6.2 The Procedure for The Development of The Process Framework

In the literature review chapter, it was explained that the participation of stakeholders is essential for appropriate project scope management; therefore, these two areas are linked and complement each other. Plus, it was understood that due to the scarcity of scope management literature and because the available approaches are fragmented and segregated, there is a need for developing a comprehensive framework for efficient management of stakeholder influence, particularly their impact on the scope of projects. Since the occurrence of new technologies and methodologies such as BIM affects the management of projects and brings forth new opportunities and challenges, it is included in the development of this process framework, along with its associated themes of Collaborative Working and Integrated Project Delivery (IPD).

Three preliminary themes of Building Information Modelling (BIM), Collaborative Working and Integrated Project Delivery (IPD) and four project management themes of scope, stakeholder, communication and risk management, are determined for developing a practical Process Framework with aim of improving the process of stakeholder and scope management and preventing scope creep in construction projects. In this regard, scope creep or deviation is deemed as an uncertain event that may result in risk and BIM with its associated concepts as part of the communication management process of managing projects. The Process Framework is created by undertaking a circle of iteration as follows in Figure 34.

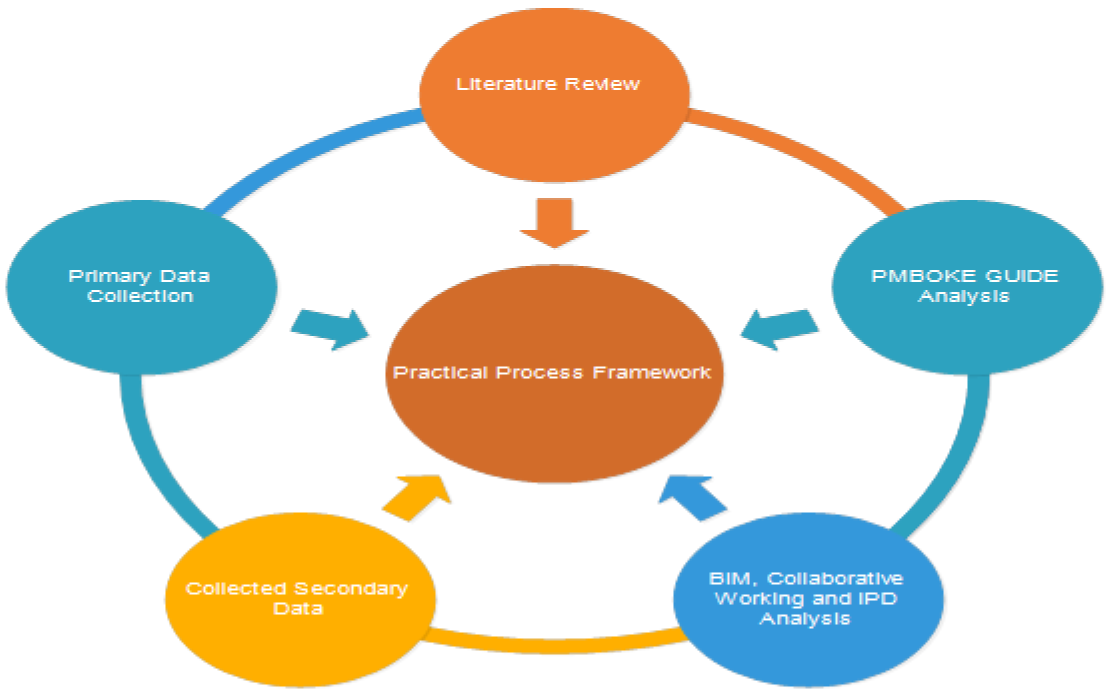

Figure 34 Circle of Iteration for Developing Process Framework.

6.2.1 PMBOKE GUIDE Meta-Synthesis

Extensive and detailed analysis of PMBOK GUIDE's (PMI, 2017) processes of scope, stakeholder, communication and risk management, as one of the major conceptual references/handbooks of project management, is done by creating detailed flow charts for each process to understand relationships between them, particularly between stakeholder and scope management, their interactions, sequence and essential activities for developing the main stages of the developed Process Framework. Thus, the main purpose of analysis of PMBOK GUIDE (PMI, 2017) processes and elements were as follows:

- First, to comprehend the interactions between project management processes and how they influence each other, particularly the scope management and stakeholder management processes. This would help in justifying the chosen project management themes in this study and capturing the most critical interaction points and interacting sub-processes and documents.

- Second, this analysis would assist in capturing the essential steps and the sequence of activities for developing the main stages of the process framework in this research.

Hence, to achieve the aforementioned objectives the analysis of PMBOK GUIDE (PMI, 2017) processes was undertaken by performing the following steps:

- Firstly, the processes presented in the PMBOK GUIDE (PMI, 2017) were converted into flow charts.
- Secondly, their subprocesses, inputs, and outputs were analysed and filtered to comprehend their interdependencies and interactions.
- Third, the sequence of subprocesses and essential activities relevant to this research were captured, and a conclusive flow chart was developed through detailed analysis and interpretation of each process' flowchart according to the PMBOK GUIDE (PMI, 2017) as presented in Figure 35.

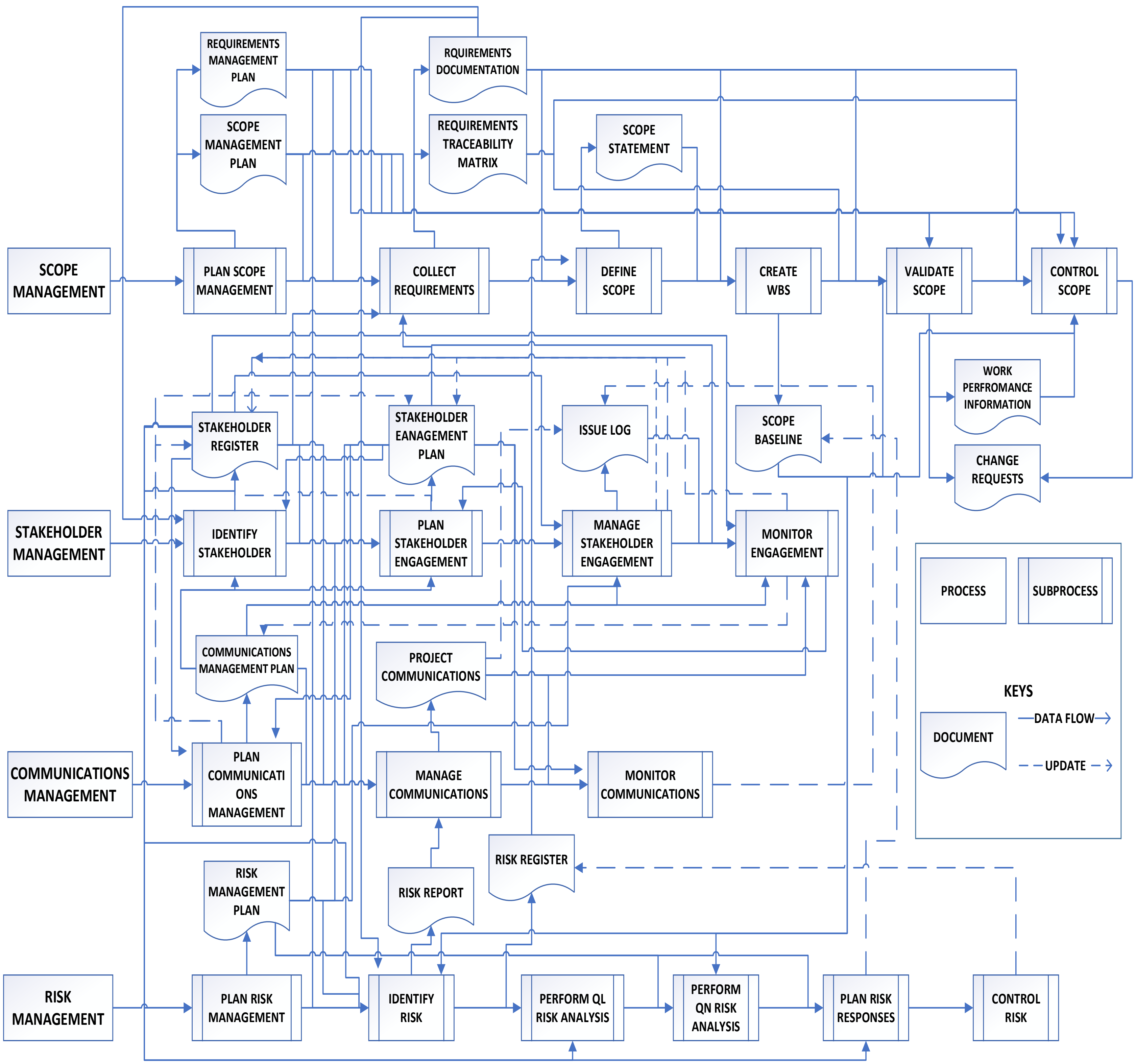

Figure 35 Visualised points of interactions between project management processes based on PMBOK GUIDE (PMI, 2017) processes

For ease of consideration, the main linking points and areas of interaction are summarised in Table 29. Also, a detailed illustration of relationships and interdependencies is provided for each process in the flow charts presented in Appendices 13–16. The list of essential activities and their sequence will be provided in the process framework developed in chapter 6. The Table below shows the interactions and connections between scope management and stakeholder management, communication management, and risk management processes and their associated documents, inputting each other based on definitions and processes in the PMBOK GUIDE (PMI, 2017). The Table 29 includes five columns: process, point of interaction, document inputs from other processes, and origin of inputs. In short, the Table 29 shows how the different processes of project management influence each other. Also, it facilitated the identification and comprehension of essential activities and stages for managing different aspects of projects, along with the sequence of these activities. Thus, the identified processes and their sequence are used for developing the stages of the developed "Process Framework" in this research.

Table 29 lists 66 rows, each detailing the input of one project management document into a particular project management process. For saving time and ease of understanding, the internal interactions between sub-processes of the same process are highlighted and excluded from the discussion. However, they are still useful for comprehending the interconnectedness of project management processes, and particularly the sequence of activities in each process and associated sub-processes. In the following, a brief example is provided, containing an interaction with other external processes.

Table 29 Points of interaction between project management processes

Process	No.	Point of Interaction	Document Inputs from Other Processes	Origin of Inputs
Scope Management	1.	• Collect Requirements	• Requirements Management Plan	• Plan Scope Management
	2.	• Collect Requirements	• Scope Management Plan	• Plan Scope Management
	3.	• Collect Requirements	• Stakeholder Engagement Plan	• Plan Stakeholder Engagement

	4.	• Collect Requirements	• Stakeholder Register	• Identify Stakeholder
	5.	• Define Scope	• Scope Management Plan	• Plan Scope Management
	6.	• Define Scope	• Requirements Documentation	• Collect Requiremens
	7.	• Define Scope	• Risk Register	• Identify Risks
	8.	• Create WBS	• Scope Management Plan	• Plan Scope Management
	9.	• Create WBS	• Project Scope Statement	• Define Scope
	10.	• Validate Scope	• Scope Management Plan	• Plan Scope Management
	11.	• Validate Scope	• Requirements Management Plan	• Plan Scope Management
	12.	• Validate Scope	• Scope Baseline	• Create WBS
	13.	• Validate Scope	• Requirements Traceability Matrix	• Collect Requirements
	14.	• Control Scope	• Scope Management Plan	• Plan Scope Management
	15.	• Control Scope	• Requirements Management Plan	• Plan Scope Management
	16.	• Control Scope	• Scope Baseline	• Create WBS
	17.	• Control Scope	• Requirements Documentation	• Collect Requirements
	18.	• Control Scope	• Requirements Traceability Matrix	• Collect Requirements
Stakeholder Management	19.	• Identify Stakeholders	• Communications Management Plan	• Plan Communications Management

	20.	• Identify Stakeholders	• Stakeholder Engagement Plan	• Plan Stakeholder Engagement
	21.	• Identify Stakeholders	• Requirements Documentation	• Collect Requirements
	22.	• Plan Stakeholder Engagement	• Communications Management Plan	• Plan Communications Management
	23.	• Plan Stakeholder Engagement	• Risk Management Plan	• Plan Risk Management
	24.	• Plan Stakeholder Engagement	• Risk Register	• Identify Risk
	25.	• Plan Stakeholder Engagement	• Stakeholder Register	• Identify Stakeholder
	26.	• Manage Stakeholder Engagement	• Communications Management Plan	• Plan Communications Management
	27.	• Manage Stakeholder Engagement	• Risk Management Plan	• Plan Risk Management
	28.	• Manage Stakeholder Engagement	• Stakeholder Engagement Plan	• Plan Stakeholder Engagement
	29.	• Manage Stakeholder Engagement	• Stakeholder Register	• Identify Stakeholder
	30.	• Monitor Stakeholder Engagement	• Communications Management Plan	• Plan Communications Management
	31.	• Monitor Stakeholder Engagement	• Stakeholder Engagement Plan	• Plan Stakeholder Engagement
	32.	• Monitor Stakeholder Engagement	• Project Communications	• Manage Communications

	33.	• Monitor Stakeholder Engagement	• Risk Register	• Identify Risk
	34.	• Monitor Stakeholder Engagement	• Stakeholder Register	• Identify Stakeholder
Communications Management	35.	• Plan Communications Management	• Stakeholder Register	• Identify Stakeholder
	36.	• Plan Communications Management	• Stakeholder Engagement Plan	• Plan Stakeholder Engagement
	37.	• Manage Communications	• Communications Management Plan	• Plan Communications Management
	38.	• Manage Communications	• Stakeholder Engagement Plan	• Plan Stakeholder Engagement
	39.	• Manage Communications	• Risk Report	• Identify Risk
	40.	• Manage Communications	• Stakeholder Register	• Identify Stakeholder
	41.	• Monitor Communications	• Communications Management Plan	• Plan Communications Management
	42.	• Monitor Communications	• Project Communications	• Manage Communications
	43.	• Monitor Communications	• Stakeholder Engagement Plan	• Plan Stakeholder Engagement
Risk Management	44.	• Plan Risk Management	• Stakeholder Register	• Identify Stakeholder
	45.	• Identify Risk	• Requirements Management Plan	• Plan Scope Management

	46.	• Identify Risk	• Risk Management Plan	• Plan Risk Management
	47.	• Identify Risk	• Scope Baseline	• Create Wbs
	48.	• Identify Risk	• Requirements Documentation	• Collect Requirements
	49.	• Identify Risk	• Stakeholder Register	• Identify Stakeholder
	50.	• Perform Qualitative Risk Analysis	• Risk Management Plan	• Plan Risk Management
	51.	• Perform Qualitative Risk Analysis	• Risk Register	• Identify Risk
	52.	• Perform Qualitative Risk Analysis	• Stakeholder Register	• Identify Stakeholder
	53.	• Perform Quantitative Risk Analysis	• Risk Management Plan	• Plan Risk Management
	54.	• Perform Quantitative Risk Analysis	• Scope Baseline	• Create Wbs
	55.	• Perform Quantitative Risk Analysis	• Risk Register	• Identify Risk
	56.	• Perform Quantitative Risk Analysis	• Risk Report	• Identify Risk
	57.	• Plan Risk Responses	• Risk Management Plan	• Plan Risk Management
	58.	• Plan Risk Responses	• Risk Register	• Identify Risk

	59.	• Plan Risk Responses	• Risk Report	• Identify Risk
	60.	• Plan Risk Responses	• Stakeholder Register	• Identify Stakeholder
	61.	• Implement Risk Responses	• Risk Management Plan	• Plan Risk Management
	62.	• Implement Risk Responses	• Risk Register	• Identify Risk
	63.	• Implement Risk Responses	• Risk Report	• Identify Risk
	64.	• Monitor Risks	• Risk Management Plan	• Plan Risk Management
	65.	• Monitor Risks	• Risk Register	• Identify Risk
	66.	• Monitor Risks	• Risk Report	• Identify Risk

For example in Row 3, the stakeholder engagement plan is created to comprehend stakeholder communication requirements and level of involvement in order to evaluate and modify stakeholder participation during the requirements activities. The plan is produced through the stakeholder management process and is utilized to regulate stakeholder communication, which is an essential part of the communication management process (PMI, 2017).

6.2.1.1 Findings from PMBOKE GUIDE Meta-Synthesis

Based on the Table 29 above, there are several relationships between scope management and stakeholder management processes and documents. Firstly, both scope management and stakeholder management processes involve the outputs of "Identify Stakeholder" process. In scope management, the Identify Stakeholder process is part of the Collect Requirements process, while in stakeholder management, it is a standalone process. Secondly, the "Plan Stakeholder Engagement" process is common to both scope management and stakeholder management. In scope management, this process is part of the “Collect Requirements” process, while in stakeholder management, it is a standalone process. Thirdly, the "Communications Management Plan" process is also utilised in the stakeholder management process and is employed to plan how to communicate with stakeholders. In stakeholder management, it is used as part of the "Identify Stakeholders," "Plan Stakeholder Engagement," "Manage Stakeholder Engagement," and "Monitor Stakeholder Engagement" processes. Lastly, the "Risk Register" and "Identify Risks" processes are also related to both scope management and stakeholder management. In scope management, the "Risk Register" is used as part of the "Define Scope" process, while in stakeholder management, it is used as part of the "Plan Stakeholder Engagement" and "Monitor Stakeholder Engagement" processes.

Considering the findings from the flow chart and the table 29 above, interactions between project management processes involved in this research and their sequence of occurance were analysed. Consequently, 15 essential stages for management of project scope and the influence of stakeholders through communication and risk management are captured and organised as follows:

- MS1.Identify Stakeholders:
- MS2.Plan Communication Management
- MS3.Plan Stakeholder Management
- MS4.Plan Scope Management
- MS5.Plan Risk Management
- MS6.Collect Requirements
- MS7.Define Scope
- MS8.Create WBS
- MS9.Identify Risks
- MS10.Qualitative Risk Analysis
- MS11. Quantitative Risk Analysis
- MS12. Plan Risk Reponses
- MS13. Manage Stakeholder Engagement

- MS14. Manage Communications
- MS15. Validate Scope

Overall, these relationships show that scope management and stakeholder management are closely related and often involve similar processes and documents. Effective management of stakeholders is crucial for successful project management, and it is important to consider stakeholder needs and requirements when defining the project scope and managing project risks. Consequently, the findings from this section facilitated the process of developing the main stages of the process framework along with their sequence of occurrence, which will be discussed in the following sections.

6.2.2 Collaborative Working, IPD and BIM Meta-Synthesis

In the next phase, analysis, interpretation and synthesis of processes and components of Collaborative Working, Integrated Project Delivery (IPD) and BIM documents are done by filtering irrelevant and overlapping elements and focusing on steps and the parts concerning the purpose of current research and including them within the framework.

Collaborative business relationships 1&2 Standards (BRITISH STANDARD, 2010, 2011) provide a strategic framework that addresses the requirements for collaborative relationships to ensure they are effective, optimized and deliver enhanced benefit to the stakeholders. The framework presented in this standard follows the three-phase approach (Strategic, Engagement, Management) containing eight stages. The first three stages of Awareness, Knowledge and Internal Assessment, provide the strategic foundation that links collaborative approaches to the overall business operation. These stages focus on the capability of an organization to collaborate. Therefore, they will be adopted at the early stages of the project and before the beginning of planning and execution.

When the strategic elements of collaboration have been addressed, the organization will be ready to commence engaging with others. The three stages of the Engagement phase are partner selection, working together and value creation. The management of the relationship is covered by the Staying Together (through delivering the agreed and expected services/benefits, including continual value creation) and Exit Strategy stages, which focus on an individual relationship. These two latter phases will be undertaken during the planning and execution of the project. The overall collaboration framework presented in BS 11000-1:2010 (BRITISH STANDARD, 2010) is shown in Table 30.

Each aforementioned stage of three phases includes several steps. Elements, details and tasks within each step are explained by answering ‘What’, ‘Why’ and ‘How’ questions in BS 11000-2:2011 (BRITISH STANDARD, 2010, 2011). These steps and their details are analyzed, irrelevant and overlapping areas with processes and components of the main themes are filtered and the most relevant ones are included within the developed process framework for this research. This has been done by creating a concept map by using MindGenius software for ease of identifying relevant elements and filtering irrelevant ones which are presented in a collapsed view in Appendix 17.

The integrated Project Delivery (IPD) approach presents several issues that must be considered when setting up an integrated project. These issues will be addressed during the pre-project stages of the developed process framework and include (National AIA, 2007):

• IPD Team Building and Functioning

• Defining Roles, Responsibilities and Scopes of Services

• Defining and Measuring Project Outcomes

• Legal Considerations

The ‘Legal Considerations’ part is excluded from the framework since it is a widespread topic and out of this research domain.

Also, AIA provides a guide on how to implement IPD in projects. IPD implementation redefines project phases by moving design decisions upstream as far as possible to where they are more effective and less costly. Also, early input from constructors, installers, fabricators, suppliers and designers are integrated; and the ability to model and simulate the project accurately using BIM tools is developed. A list of outcomes and primary responsibilities for each project phase is provided by IPD guide which is adopted in the current research’s framework through analysis, interpretation, filtering and focusing method by creating a concept map for segregation of all aforementioned aspects of IPD guide using MindGenius software. The concept map is presented in collapsed view in Appendix 18.

Table 30 Overview of Collaborative Working framework (BRITISH STANDARD, 2010, 2011)

Strategic	Awareness (Clause 3)	Establish executive responsible and organizational policy	Identify business objectives and value proposition	Identify and prioritize relationships	Establish resources, competencies and behaviours	Undertake initial risk assessment	Relationship Management Plan
	Knowledge (Clause 4)	Develop specific business strategy	Establish knowledge management process	Establish objectives, strategy, business case and identify potential collaborative organizations	Establish initial exit strategy	Incorporate relationship management with risk management processes	
	Internal assessment (Clause 5)	Undertake self assessment	Establish collaborative profile	Establish collaborative leadership	Establish partner selection criteria	Establish and implement action plan	
Engagement	Partner selection (Clause 6)	Nominate potential partners	Evaluate potential partners	Establish partner selection plans	Create joint objectives and negotiation strategy	Select partner	
	Working together (Clause 7)	Establish governance, joint objectives and leadership	Establish organizational structure, roles, responsibilities and processes	Establish performance measurement	Establish joint risk management and exit strategy	Establish contract arrangements	
	Value creation (Clause 8)	Establish value creation programme	Define value drivers	Establish improvement team	Establish learning from experience	Implement innovation process	
Management	Staying together (Clause 9)	Ongoing management, monitor and measure the relationship	Continual innovation	Maintain behaviours and trust	Manage delivery and performance	Manage issue resolution and monitor joint exit strategy	
	Exit strategy (Clause 10)	Develop and maintain joint exit strategy	Establish boundaries for the relationship	Monitor and evaluate changes	Manage business continuity and transition	Evaluate future opportunities	

6.2.3 BIM and Project Management Processes

As discussed before the interdependencies and interactions between the main themes project management processes were investigated and demonstrated in Table 29 and Figure 35 to comprehend their interactions and sequence and identify the essential activities for the stages of the developed Process Framework. Hence, the interaction and relationship between the main themes, stakeholder, scope, communication and risk management, and Building Information Modelling (BIM) can be investigated from two perspectives namely BIM Dimensions/ Project Management Processes and BIM documents & Processes/ Project Management Processes. In the first one, the relationships between the project processes according to PMBOK GUIDE (PMI, 2017) and different dimensions of BIM are analyzed. For this purpose, the points in which project management processes and BIM dimensions interact are studied.

These additional dimensions of BIM include 4D (time), 5D (Cost) and 6D (as-built operation). The simulation analysis of construction activities is facilitated by linking data and information in 3D object model with the scheduling process in 4D BIM. In 5D the cost data like prices, schedules and quantities are integrated with all of that information. Finally, the applicability of 6D model or as-built is during the operational stages of the facility (Smith, 2014). For the aim of this research the first two, 4D and 5D, are considered. Figure 36 shows how BIM dimensions and project management processes interact and link together.

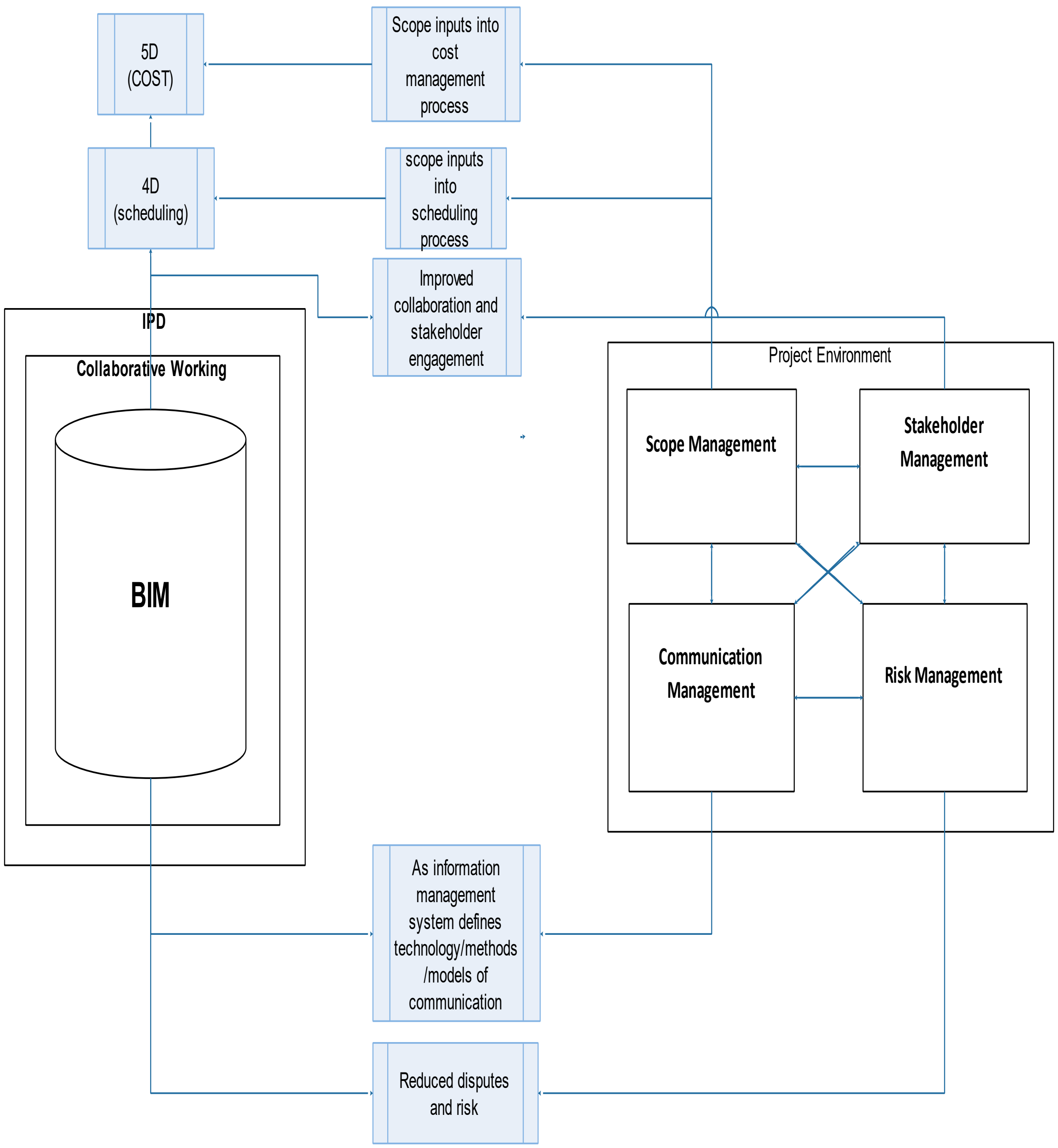

Figure 36 The relationship between project management processes and BIM dimensons

As it is shown in Figure 36, the scope management process contributes to 4D and 5D modelling through its inputs into time and cost management processes. This contribution is captured by using PMBOK GUIDE (PMI, 2017) and tracking scope management processes' outputs into the 'Time Management' and 'Cost Management' processes and visualizing them in Figure 37.

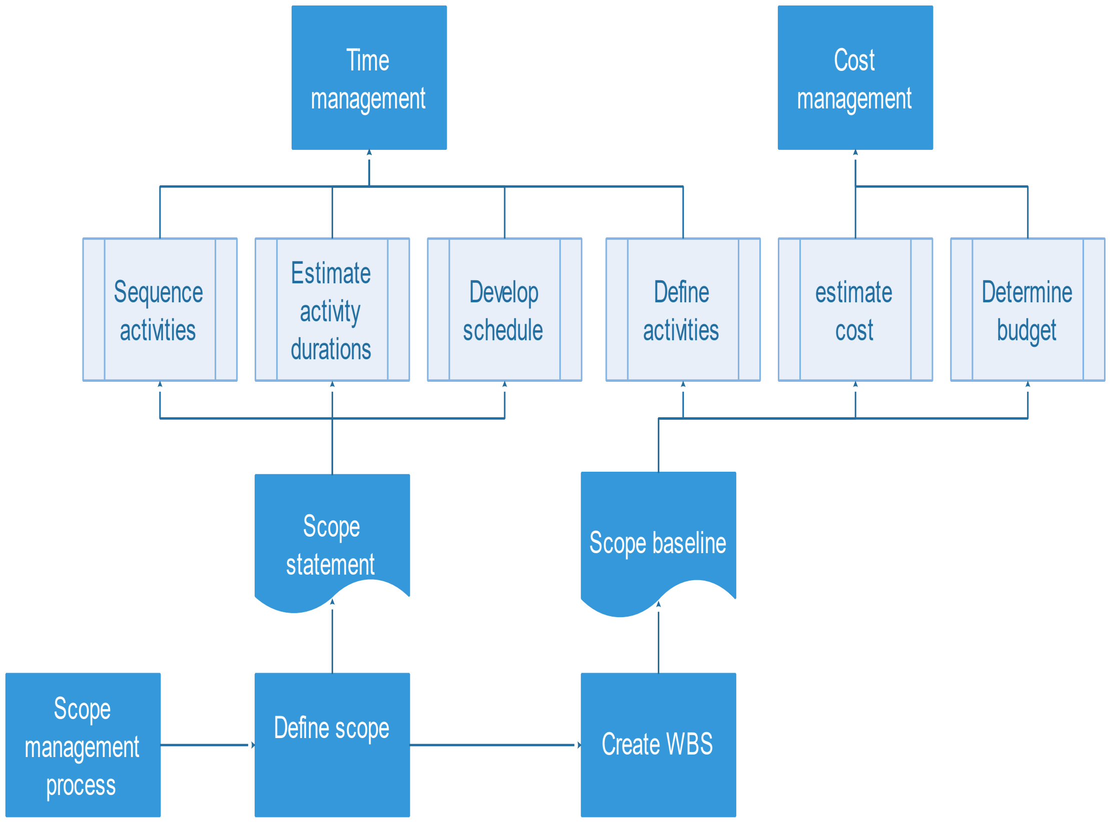

Figure 37 The input of the scope management process into cost and time management processes

The second perspective from which these interactions can be reviewed is from the point of view of BIM processes, through the extraction and analysis of information from the PAS 1192-2 standard (British Standards Institution, 2013). PAS1192-2 (BSI, 2013) is the most important document among BIM documents, primarily focusing on the information delivery cycle. Further details on the information delivery cycle are presented in chapter 3, along with select definitions from the Standard to facilitate comprehension.

In current study, the BIM procedure as explained in this standard and the components of the documents to be produced are analysed and demonstrated by creating a flow chart. By doing this, the BIM processes and the components of documents like the "Employer

Information Requirement (EIR)" can be interpreted and linked to the relevant project management processes according to the PMBOK GUIDE (PMI, 2017). Figures 38 and 39 show these interactions. The specific advantage of this flow chart will be helping to understand the contribution and role of BIM documents and plans such as Employer's Information Requirements (EIR), Building Information Modelling Execution Plan (BEP), Master Information Delivery Plan (MIDP), Project Information Model (PIM), etc. in this research and per chosen main themes of project management, as well as their applicability and usage within the developed process framework and during the primary stage. Also, considering the flow chart in Figures 38 and 39 can help project managers comprehend how BIM processes and the provision of associated documents fit within the sphere of project management and the relationships between BIM components and project management processes and documents. Therefore, the provision of BIM documents and the implementation of its processes will be facilitated for project managers. Also, the definitions of documents in the aforementioned Figures, according to PAS 1192-2 (British Standards Institution, 2013), are presented in chapter 3. In the next sections, detailed description, the interactions between BIM processes and documents and project management processes and documents are presented for each stage.

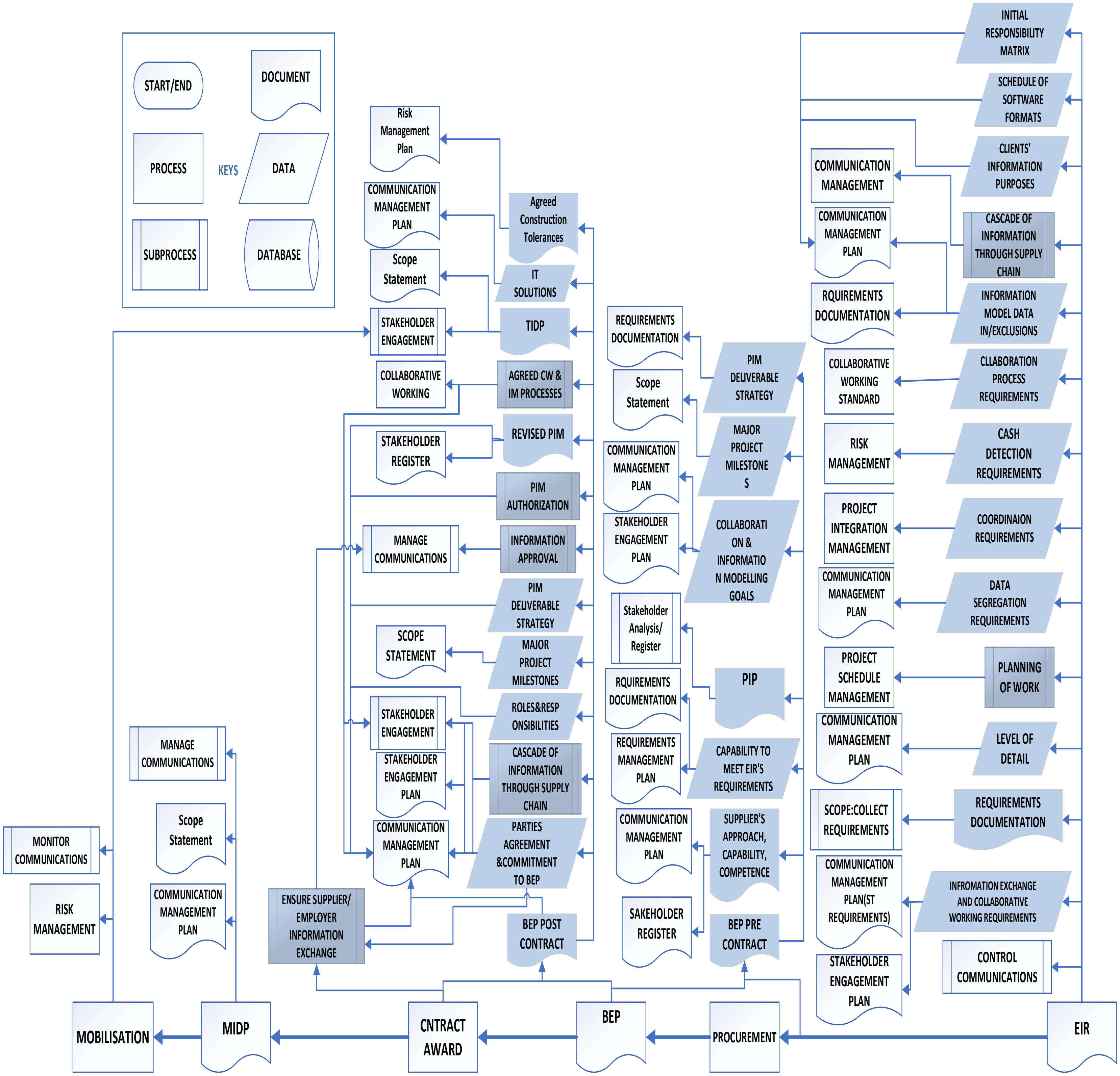

Figure 38 Interactions between BIM processes & documents and project management processes and documents

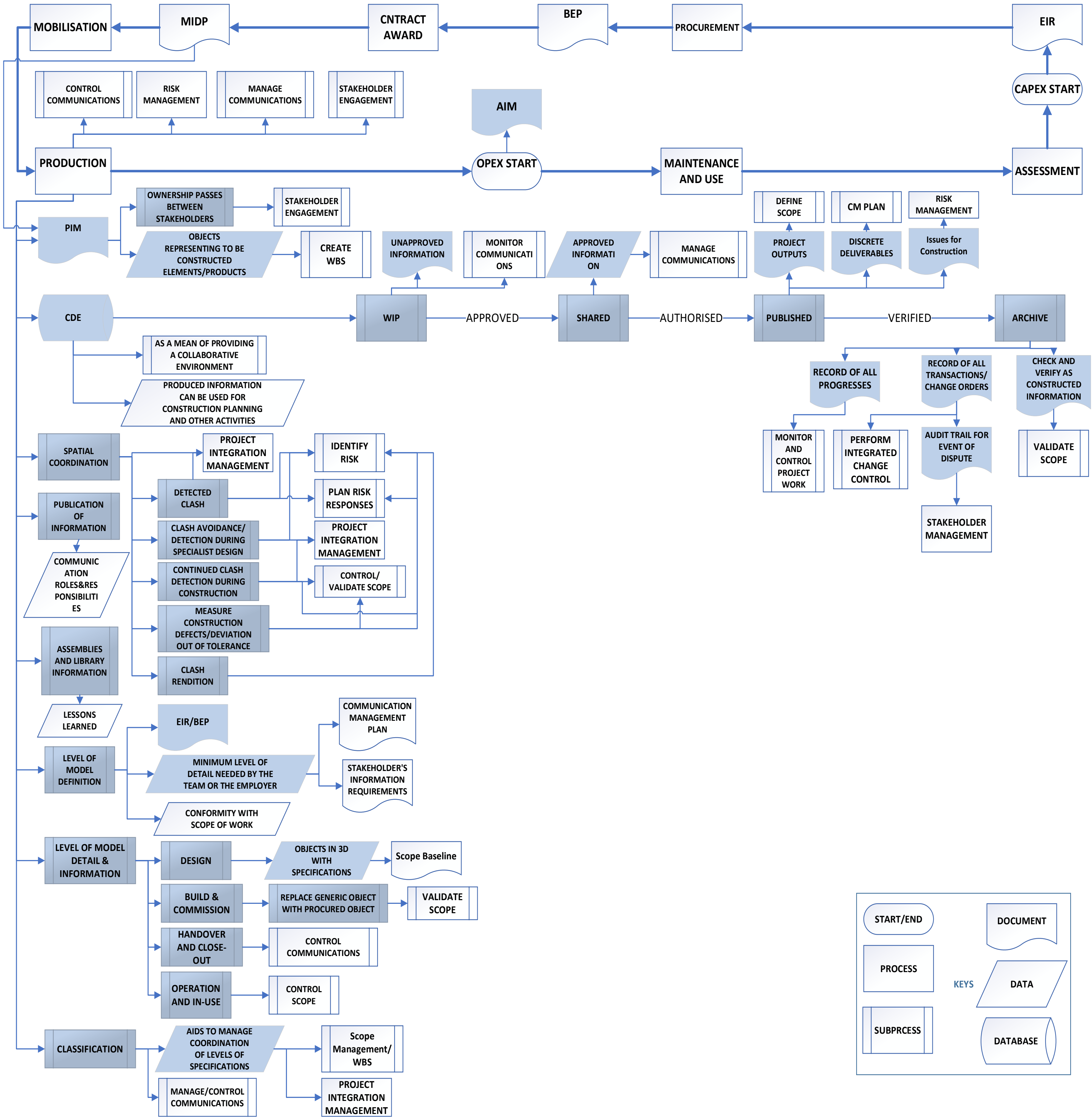

Figure 39 Interactions between BIM processes & documents and project management processes and documents (continue)

6.2.3.1 The Information Delivery: Assessment and Need

The Table 31 below shows the relationship between BIM components and project management processes during the “Assessment and need” stage of the BIM lifecycle according to PAS 1192-2:2013 (BSI, 2013). The data in this Table are captured from Figures 38 and 39, specifically the relationship between Employer Information Requirements (EIR) components and project management processes. A detailed description of each row in the Table 31 below can be captured by conducting a binary analysis of the cells using PAS 1192-2:2013 (BSI, 2013) and PMBOK GUIDE (PMI, 2017).

The Table shows 19 rows with four columns each. The first column is numbered from 1 to 19, and the second column lists various BIM Employer Information Requirements (EIR) components, such as information exchange requirements, level of detail, etc. The third column lists relevant project management documents, such as the communication management plan, requirements documentation, etc. The fourth column lists relevant project management processes, such as Plan Communications Management and Collect Requirements. Each row of the Table 31 specifies a particular Employer Information Requirement (EIR) component and the relevant project management document and process that can be used to address that component. In summary, the Table 31 provides a helpful reference for understanding how BIM Employer Information Requirements (EIR) components and project management processes and documents relate to each other.

Table 31 The interaction between Employer Information Requirements (EIR) and project management processes

	Employer Information Requirements (EIR)	Relevant Project Management Document	Relevant Project Management Process
1	Information Exchange Requirements	• Communication Management Plan (Stakeholders’ Requirements)	• Plan Communications Management
2	Information Exchange Requirements	• Requirements Documentation	• Collect Requirements
3	Level of Detail	• Communication Management Plan	• Plan Communications Management
4	Planning of BIM Activities	• Work Breakdown Structure (WBS)	• Create Work Breakdown Structure (WBS)

5 Planning of BIM Activities	• Communication Management Plan	• Plan Communications • Management
6 Data Segregation Requirements	• Communication Management Plan	• Plan Communications Management
7 Coordination Requirements	• Integrated Project Delivery (IPD) Guide (AIA, 2007)	• Project Integration Management (PMI, 2017)
8 Clash Detection Requirements	• Risk Management Plan	• Plan Risk Management
9 Collaboration Process Requirements	• Collaborative Working Standards (Collaborative Business Relationships 1&2 Standards Bsi, 2010, 2011)	• -
1 Information Model Data In/Exclusions	• Requirements Documentation	• Collect Requirements
1 Information Model Data In/Exclusions	• Communication Management Plan	• Plan Communications Management
1 The Cascade of Information Through the Supply Chain	• Communication Management Plan	• Plan Communications Management
1 The Cascade of Information Through the Supply Chain	• Project Communications	• Manage Communications
1 Client's Information Purposes	• Communication Management Plan	• Plan Communications Management
1 Client's Information Purposes	• Requirements Documentation	• Collect Requirements
1 Client's Information Purposes	• Stakeholder Register	• Identify Stakeholders
1 Schedule of Software Formats	• Communication Management Plan	• Plan Communications Management
1 Initial Responsibility Matrix	• Communication Management Plan	• Plan Communications Management

1 Initial responsibility matrix	• Stakeholder Register	• Identify Stakeholders

For instance, the first row, information exchange requirements, refers to the requirements for exchanging information among project stakeholders. The BIM Employer Information Requirements (EIR) component in this row is Information exchange requirements. The relevant project management document is the Communication management plan (stakeholders' requirements), which specifies how communication should occur between project stakeholders. The relevant project management process is Plan Communications Management, which involves creating a plan for communication activities and managing the execution of the plan.

6.2.3.2 Information Delivery: Procurement

The Table 32 below shows the relationship between BIM components and project management processes during the "Procurement" stage of the BIM lifecycle according to PAS 1192-2:2013 (BSI, 2013). The data in this Table are captured from Figures 38 and 39, specifically the relationship between Pre-Contract BIM Execution Plan (BEP) components and project management processes. A detailed description of each row in the Table 32 below can be provided by conducting a binary analysis of the cells using PAS 1192-2:2013 (BSI, 2013) and PMBOK GUIDE (PMI, 2017). For example in row 1, the PIP serves as the Pre-Contract BEP component that outlines the project implementation strategy, while the Communication Management Plan serves as the relevant project management document that outlines how communication will be managed on the project. The Plan Communications Management process is used to create the Communication Management Plan, which includes the strategies and methods for managing communication among the project team members and stakeholders.

Table 32 The interaction between Pre-Contract BIM Execution Plan (BEP) and project management processes

Pre-Contract BIM Execution Plan (BEP)	Relevant Project Management Document	Relevant Project Management Process
1 Project Implementation Plan (PIP)	• Communication Management Plan	Plan Communications Management
2 Supplier's Approach, Capability, Competence (PIP)	• Communication Management Plan: ○ Expert Judgment	Plan Communication Management

		◦ Communication Requirements Analysis ◦ Communication Technology ◦ Communication Models ◦ Communication Methods ◦ Interpersonal And Team Skills	
3	Supplier's Approach, Capability, Competence (PIP)	• Stakeholder Register	Identify Stakeholders
4	Supplier's Approach, Capability, Competence (PIP)	• Requirements Management Plan	Plan Scope Management
5	Supplier's Approach, Capability, Competence (PIP)	• Requirements Documentation	Collect Requirements
6	Collaboration & Information Modelling Goals	• Communication Management Plan	Plan Communications Management
7	Collaboration & Information Modelling Goals	• Stakeholder Engagement Plan	Plan Stakeholder Engagement
8	Major Project Milestones	• Project Charter	Develop Project Charter
9	Major Project Milestones	• Project Management Plan	Develop Project Management Plan
1	Major Project Milestones	• Scope Statement	Define Scope
1	Project Information Model (PIM) Deliverable Strategy	• Scope Management Plan	Plan Scope

			Management
1	Project Information Model (PIM) Deliverable Strategy	• Project Scope Statement	Define Scope
1	Project Information Model (PIM) Deliverable Strategy	• Communication Management Plan	Plan Communications Management

6.2.3.3 Information delivery: Post contract-award

The Table 33 below shows the relationship between BIM components and project management processes during the "Post contract-award" stage of the BIM lifecycle according to PAS 1192-2:2013 (BSI, 2013). The data in this Table are captured from Figures 38 and 39, specifically the relationship between Post-Contract BIM Execution Plan (BEP) components and project management processes. A detailed description of each row in the Table 33 below can be captured by conducting a binary analysis of the cells using PAS 1192-2:2013 (BSI, 2013) and PMBOK GUIDE (PMI, 2017).

For instance, the element of project management in PMBOK GUIDE (PMI, 2017)that can address the 'roles, responsibilities and authorities' of Post-Contract BIM Execution Plan (BEP) in PAS 1192-2:2013 (BSI, 2013) document is the "Human Resource Management" knowledge area. This knowledge area focuses on identifying, acquiring, and managing the project team, including defining roles, responsibilities, and reporting relationships. It also includes developing and managing the project team through training, performance evaluations, and rewards/recognition programs. By applying the human resource management processes, project managers can ensure that the right people are in the right roles with the necessary skills and authority to successfully execute the Post-Contract BEP.

Table 33 The interaction between Post-Contract BIM Execution Plan (BEP) and project management processes

	Post-Contract BIM Execution Plan (BEP)	Relevant Project Management Document	Relevant Project Management Process
1.	Roles, Responsibilities and Authorities	• Resource Management Plan	• Plan Resource Management
2.	Major Project Milestones Consistent with The Project Programme	• Milestone List	• Define Activities (Schedule Management)
3.	Project Information Model Deliverable Strategy	• Scope Statement	• Define Scope Process
4.	Survey Strategy Including the Use of Point Clouds, Light Detecting and Ranging (LIDAR) Or Global Navigation Satellite Systems (GNSS)	• Plan Procurement Management	• Procurement Management Plan
5.	Existing Legacy Data Use	• Requirements Management Plan	• Collect Requirements
6.	Approval Of Information	• Quality Management Plan	• Control Quality
7.	PIM Authorization Process	• Change Request	• Monitor And Control Project Work
8.	Revised PIP Confirming the Capability of The Supply Chain	• Procurement Management Plan	• Plan Procurement Management
9.	Agreed Project Processes for Collaboration And Information Modelling	• Communications Management Plan	• Plan Communications Management
10.	Agreed Matrix of Responsibilities	• Project Team Assignments	• Acquire Resources

	Across The Supply Chain	• Responsibility Assignment Matrix (Ram) • Project Team Assignments Updates	• Plan Resource Management • Develop Project Team
11.	TIDP	○ Schedule Management Plan ○ Activity List, Activity Attributes, Milestone List	• Plan Schedule Management • Define Activities
12.	MIDP	• Communications Management Plan	• Plan Communications Management
13.	The Volume Strategy;	• Project Scope Statement	• Define Scope
14.	PIM Origin and Orientation	• Scope Management Plan	• Plan Scope Management
15.	File Naming Convention;	• Configuration Management Plan	• Develop Project Management Plan
16.	Layer Naming Convention	• Scope Statement	• Define Scope
17.	Agreed Construction Tolerances for All Disciplines	• Quality Management Plan	• Plan Quality Management
18.	Drawing Sheet Templates	• Scope Management Plan • Scope Statement	• Plan Scope Management • Define Scope
19.	Annotation, Dimensions, Abbreviations And Symbols	• Scope Management Plan	• Plan Scope Management
20.	Attribute Data	• Requirements Documentation • Procurement Management Plan	• Collect Requirements • Plan Procurement Management
21.	Software Versions	• Configuration Management Plan	• Develop Project Management Plan

22. Exchange Formats	• Communication Management Plan	• Plan Communications Management
23. Process And Data Management Systems	• Resource Management Plan • Project Management Information System (PMIs)	• Plan Resource Management • Direct And Manage Project Work

6.2.3.4 Information delivery: Mobilization

The Table 34 below shows the relationship between BIM components and project management processes during the "Mobilization" stage of the BIM lifecycle according to PAS 1192-2:2013 (BSI, 2013). The data in this Table are captured from Figures 38 and 39, specifically the relationship between Mobilization Stage components and project management processes. A detailed description of each row in the Table 34 below can be provided by conducting a binary analysis of the cells using PAS 1192-2:2013 (BSI, 2013) and PMBOK GUIDE (PMI, 2017).

Table 34 The interaction between the elements of Mobilization stage and project management processes

Information delivery – Mobilization Stage	Relevant Project Management Process
Communicating The Agreed BEP and Any Subsequent Changes	• Project Integration • Management
Implementation, and Testing of The Selected Software, It Systems, and The Common Data Environment (CDE)	• Project Procurement Management
Training and Education Needs of All Members	• Project Resource Management
Risks Of Information Management Solution, Processes, and Technology	• Risk Management

The Mobilization stage of the Information delivery cycle in PAS 1192-2:2013 (BSI, 2013) emphasizes the importance of ensuring that the information management solution works before any design work is started. The PMBOK GUIDE (PMI, 2017) provides several processes and documents that can address various elements of this stage.

For instance, the Project Integration Management process can help in communicating the agreed BEP and any subsequent changes to all members of the project delivery team. The Project Procurement Management process can assist in the procurement, implementation, and testing of the selected software, IT systems, and infrastructure, including the Common Data Environment (CDE).

Additionally, the Project Resource Management process can address the training and education needs of all members of the project delivery team who are involved in the production, analysis, and review of the Project Information Model (PIM). Finally, the Risk Management process can help in identifying and mitigating potential risks related to the information management solution, processes, and technology.

6.2.3.5 Information delivery: Production

The Table 35 below shows the relationship between BIM components and project management processes during the "Production" stage of the BIM lifecycle according to PAS 1192-2:2013 (BSI, 2013). The data in this Table are captured from Figures 38 and 39, specifically the relationship between Production Stage components and project management processes. A detailed description of each row in the Table 35 below is provided by conducting a binary analysis of the cells using PAS 1192-2:2013 (BSI, 2013) and PMBOK GUIDE (PMI, 2017).

Table 35 The interaction between the elements of Production stage and project management processes.

Information delivery – Production	Relevant Project Management Document	Relevant Project Management Process
Project Information Model (PIM)	Scope Statement	Scope Management Process
	Project Schedule	Schedule Management Process
	Cost Management Plan	Cost Management Process
	Quality Management Plan	Quality Management Process
	Risk Management Plan	Risk Management Process
	Communications Management Plan	Communications Management
	Procurement Management Plan	Procurement Management Process
The Common Data Environment (CDE)	Project Charter	Develop Project Charter
	Project Management Plan	Develop Project Management Plan
	Project scope statement	Define Scope
	Stakeholder register	Identify Stakeholders
	Stakeholder engagement	Plan Stakeholder Engagement
	Project communications	Manage Communications
	-	Monitor Communications
File and Layer Naming Conventions	Scope Management Plan	Plan Scope Management

Spatial Co-Ordination	Scope Statement	Define Scope
	Quality Management Plan	Plan Quality Management
Publication of Information	Communications Management Plan	Plan Communications Management
Design for bespoke manufacture	Scope Statement	Define Scope
Using Assemblies and Library Information	Scope Statement	Define Scope
Levels of Model Definition	Scope Management Plan	Plan Scope Management
Levels of model detail and model information	Scope Management Plan	Plan Scope Management
	Work Breakdown Structure (WBS)	Create WBS
Classification	Scope Management Plan	Plan Scope Management
Asset Information Model (AIM maintenance)	Project Management Plan	Project Plan Development
	Change Management Plan	Project Plan Development
	Team Resource Management	Plan Resource Management
	Risk Management Plan	Plan Risk Management

For example, in the production stage of information delivery cycle in BIM PAS 1192-2:2013 (BSI, 2013), the Project Information Model (PIM) development element can be addressed by several project management processes and documents in PMBOK GUIDE (PMI, 2017). The following are some examples:

- Scope Management process: The Project Scope Statement document can outline the scope of the PIM Development activities, including what needs to be accomplished and the deliverables required.
- Schedule Management process: The project schedule document can identify the timelines for completing the PIM Development activities, including start and end dates.
- Cost Management process: The Cost Management Plan document can outline the budget allocated for PIM Development activities.

- Quality Management process: The Quality Management Plan document can define the quality standards that need to be met for PIM Development activities.
- Risk Management process: The Risk Management Plan document can identify the risks associated with PIM Development activities and the strategies to mitigate those risks.
- Communications Management process: The Communications Management Plan document can define the communication channels and protocols to be used for PIM Development activities.
- Procurement Management process: The Procurement Management Plan document can outline the procurement strategy for acquiring the necessary tools and resources for PIM Development activities.

Overall, several project management processes and documents in PMBOK GUIDE (PMI, 2017) can help ensure effective PIM Development in the production stage of information delivery cycle in BIM PAS 1192-2:2013 (BSI, 2013).

A detailed description of each row in the Table 35 can be provided by conducting a binary analysis of the cells using PAS 1192-2:2013 (BSI, 2013) and PMBOK GUIDE (PMI, 2017).

6.2.3.6 Information delivery: Asset information model (AIM maintenance)

In this section, the relationship between BIM components and project management processes are analysed during the "Asset information model (AIM maintenance)" stage of the BIM lifecycle according to PAS 1192-2:2013 (BSI, 2013). The data for this purpose are captured from Figures 38 and 39, specifically the relationship between Asset Information Model components and project management processes. A detailed description of this stage is provided by conducting a binary analysis of the cells using PAS 1192-2:2013 (BSI, 2013) and PMBOK GUIDE (PMI, 2017).

The project management process and associated document in PMBOK GUIDE (PMI, 2017) that can address the 'Asset information model (AIM maintenance)' stage of information delivery cycle in BIM PAS 1192-2:2013 is the "Project Integration Management" process area, specifically the "Project Plan Development" process, which involves developing the project management plan that guides the execution, monitoring, and controlling of the project. Within this process, the "Project Management Plan" document includes the "Change Management Plan" which outlines how changes to the project scope, schedule, budget, or other components will be managed, including the maintenance of the Asset Information Model (AIM) over time (Hardin and McCool, 2015).

Additionally, the "Project Resource Management" process area, specifically the "Team Resource Management" process, can also address the maintenance of the AIM. This involves identifying the resources needed to maintain the AIM, including personnel, equipment, and software, and ensuring that those resources are available as needed throughout the project and after completion. Furthermore, the "Project Risk Management" process area can also play a role in the maintenance of the AIM (Hardin and McCool, 2015). This involves identifying potential risks to the AIM, such as changes in technology, personnel turnover, or other factors that could impact the accuracy or usefulness of the model. The "Risk Management Plan" document can outline strategies for mitigating these risks and ensuring the ongoing maintenance and usefulness of the AIM (BSI, 2013; PMI, 2017).

Overall, the effective management of the AIM throughout the project and beyond requires a coordinated effort across multiple project management processes and documents in PMBOK GUIDE (PMI, 2017).

6.2.3.7 Fidnings from Analysis of Interactions Between BIM and Project Management Processes

In conclusion, considering the information and findings from the BIM flowchart and tables presented above facilitated understanding of the interactions and relationships between BIM life cycle stages and documents with project management processes in the PMBOK GUIDE (PMI, 2017). This justified the use of BIM in the "Process Framework" developed in this research and helped with comprehension of the way in which BIM stages and documents fit within the project management sphere. So, the primary process framework can be developed by Meta-synthesis of findings from the literature review, the aforementioned phases, and secondary data collected on case studies.

6.2.4 The Process Framework

Hence, through undertaking the above procedure a process framework is developed by using the findings from the literature review, secondary data analysis, analysis of BIM and its associated concepts and project management processes defined by (PMI, 2017b). The primary Process Framework is presented in Figure 41. The main purpose of this framework is to provide a comprehensive and integrated approach for the management of the influence of stakeholders on the scope to prevent scope creep by using BIM management concepts and essential project management processes.

The developed Process Framework is comprised of three primary stages, 15 project management stages and four supporting elements. The primary stages include BIM documents, collaborative working and Integrated Project Delivery (IPD) and their associated checklist of activities. The main stages of the framework include the project management processes of stakeholder, scope, risk and communication management and a checklist of activities. Finally, the supporting elements are comprised of Control and Monitor, Engagement and Management (Collaborative Working), IPD Implementation and Common Data Environment. Each of these stages and elements will be discussed in the following sections.

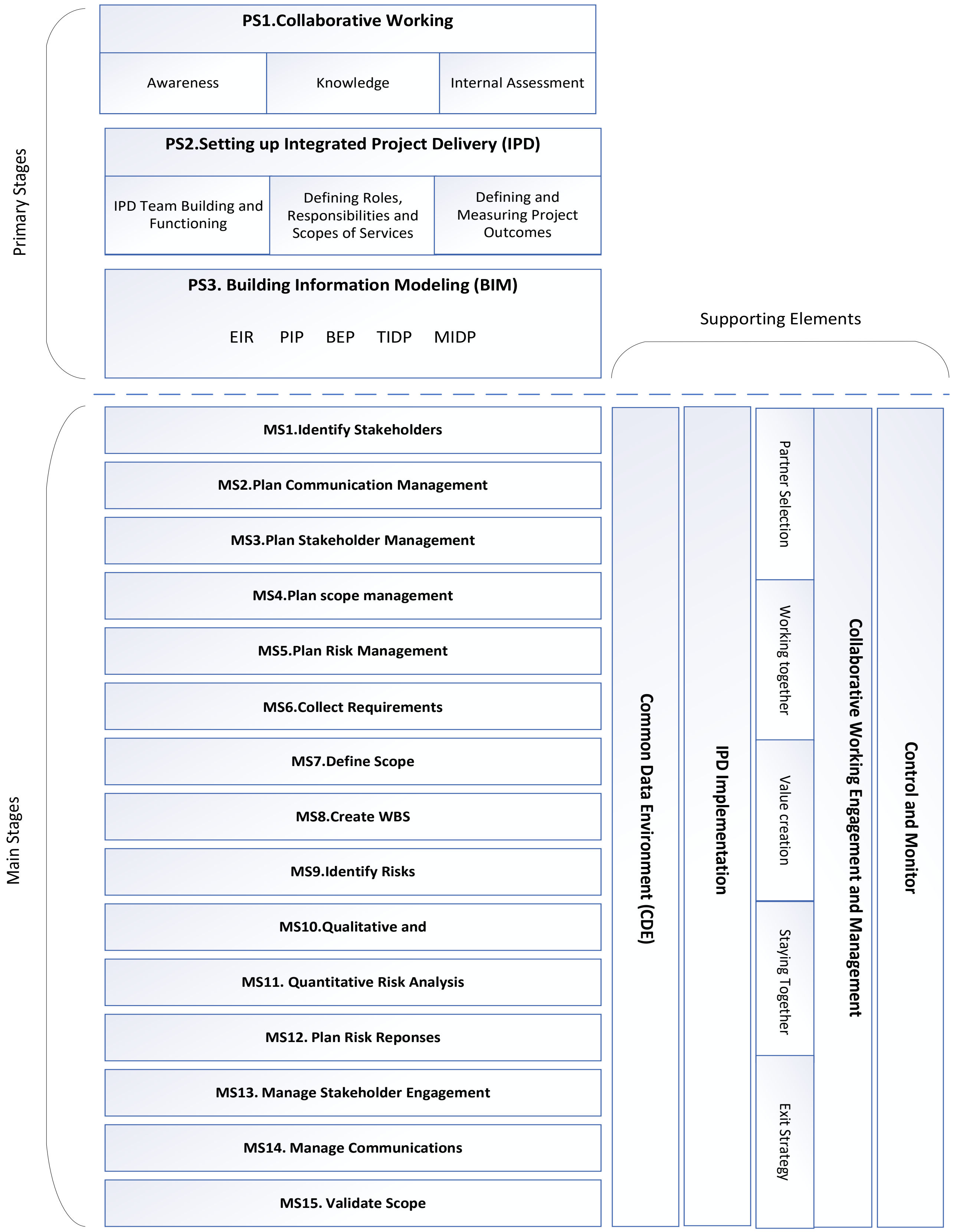

Figure 40 Developed Process Framework.

6.2.5The Primary Stages of The Process Framework

Three primary stages include Collaborative Working, Integrated Project Delivery (IPD) and Building Information Modeling (BIM). For determination of these stages the processes, phases, components, outcomes, tasks and responsibilities presented in BIM related British Standards are analysed, interpreted, irrelevant ones are filtered and concentration is made on the most relevant ones in accordance with four main project management processes and the topic of current research. The analysed documents, British standards and guidelines are as following:

1-BIM: BS 1192:2007 and PAS 1192-2:2013(BRITISH STANDARD, 2008, 2010; British Standards Institution, 2013)

2-Collaborative Working: BS 11000-1:2010 and BS 11000-2:2011(BRITISH STANDARD, 2010, 2011)

3- Integrated Project Delivery (IPD): The American Institute of Architects(AIA): A Guide (National AIA, 2007)

Also, by doing this, the checklists of tasks and activities to be undertaken for collaborative working and IPD within this framework are developed and presented in Tables 36 and 37. BIM adoption in this framework includes two phases. Phase one is during the primary stage and through delivering essential pre-project documents and plans such as EIR, PIP, BEP, TIDP and MIDP presented in **PAS 1192-2**:**2013** (British Standards Institution, 2013). The relevant components of these documents to this research's topic can be identified by using the flow chart in Figure 38 and 39. The second phase of utilizing BIM in this framework includes using Common Data Environment (CDE) as a tool for managing and sharing information.

Collaborative working and integrated project delivery approaches are chosen because these work hand in hand with BIM and are two fundamental aspects of this as they improve the effectiveness of BIM application, trust, open communication and deliver many other benefits in projects such as better stakeholder engagement and identification of their requirements (National AIA, 2007). Hence, these three conduct the primary stages of the framework during which the capability and competence of the organisation for deploying BIM are evaluated and the project is prepared for moving forward and taking advantages of using these three dimensions.

Table 36 Primary Collaborative Working Activity Checklist.

Stage	Activity
Awareness	Assign SENIOR EXECUTIVE RESPONSIBLE (SER)
	Define and authorize the organization's policy for collaborative working
	Identify strategic business objectives of collaboration
	Identify potential value from collaborative working
	Identification and segmentation of business relationships
	Establish resources, competencies and behaviours
	initial risk assessment associated with collaborative business relationships
	Document defined procedures
	Initiating the relationship management plan RMP
Knowledge	Establish a procedure to capture, create and manage knowledge within collaborative relationships.
	Establish guidelines for sharing knowledge between organizations.
	Establish procedure for developing a strategy and business case for each opportunity
	Define a procedure for assessing risks associated with relationships and identifying opportunities
	Review and update RMP
Internal Assessment	Define, review and update all policies and processes for collaboration (self assessment)
	Establish the required profile to assess potential collaborative partner
	Identify the level of knowledge and skills that exist
	Undertake regular reviews to ensure suitability and effectiveness of collaborative approaches (SER)
	Update the RMP

Table 37 IPD Primary Stage Activity Checklist.

Stage	Activity
IPD Team Building and Functioning	Form project team early in project in two categories of primary and key supporting
	Consider capability, team dynamics, compatibility, communication, trust building and commitment to an integrated process.
	Define decision making methods and processes that each team member accepts
	decisions are made unanimously by a defined decision making body instead of a single body
	Facilitate sharing of information between team members
	development and use of an overarching communication protocol
	Consider using BIM as a tool
	Careful participant selection and contract drafting for using confidential information
	Use methods of compensation that tie the participant's success to the overall success of the project
	Make effort to maintain the continuity of the team
	Resolve disputed internally and project's decision-making body
Defining Roles, Responsibilities and Scopes of Services	Ensure that the individual participant's tasks and responsibilities are clearly set out and understood at the earliest possible stage
	Use of A carefully crafted matrix of parties, roles and responsibilities
	Make extensive pre-construction efforts for identifying and resolving potential design conflicts
	provide numerous iterations of design documents to other team members for their evaluation and input by designer
	Early involvement of constructors in design process and project
	Involve owner in evaluation design options, establishing project metrics and resolving issues in earlier stage
	Share risk of non-performance across all direct parties
Defining and Measuring Project Outcomes	clearly spell out project goals and the consequences of success or failure
	includes project metric values like overall scope performance and measurements
	Define reporting intervals to monitor progress of the project
	Define project goals and standards to judge project's success
	Establishment of performance criteria for major building systems

6.2.6 Main Stages of The Process Framework

As presented in the Figure 41, the main processes of stakeholder, scope, risk and communication management processes conduct the main stages of the framework. The information for developing the main stages of the framework are gathered by analysis of processes in PMBOK GUIDE (PMI, 2017b) which provides a conceptual guideline for managing project management processes and literature review. Accordingly, the main stages are determined by dividing four main project management processes (scope, stakeholder, communication and risk management) into 15 components to address the issue of stakeholder influence on the scope of projects to preventing scope creep. Each of these 15 sub-processes includes its own activities and tasks which are extracted from project management processes, their outputs and interactions and critical points mentioned in section 6.2.1. However, the findings from the literature review or any other tools and techniques can be applied in these stages. For instance, the stakeholder attributes based on salience theory (Mitchell, Agle and Wood, 1997b), Stakeholder Circle tool (Bourne and Walker, 2006) or the Power/Interest Matrix (Olander and Landin, 2005) can be used during the first stage of 'Identify Stakeholders' to identify the characteristics, power and potential influence of stakeholders. Likewise, the PDRI (CII, 2013) can be used in the 'Define Scope' stage or SHAMPU (Ward and Chapman, 2003) framework in the 'Plan Risk Management' stage for determining the overall structure of managing risks in the project. Also, the identified stakeholder influence strategies will help in the 'Identify Risk' stage whilst the identified firm's response strategies can be applied in the 'Plan Risk Responses' stage. The sequence of these main stages is determined precisely by tracking and analyzing processes, inputs and outputs of chosen main processes of project management as described previously in section 6.2.1. Also, a comprehensive checklist of activities and tasks is presented in Tables 39 for this part of the framework.

The 15 procedures of the main stages and their brief definitions according to PMBOK GUIDE (PMI, 2017) are as follow:

MS1.Identify Stakeholders

The term "Identify Stakeholders" refers to the regular process of identifying individuals who have an interest in, dependence on, influence over, or impact on the success of a project. The key advantage of this approach is that it helps the project team determine the most effective means of involving each stakeholder or stakeholder group. This process should be conducted periodically throughout the project and is often first implemented when the project charter is being developed or approved. It should also be performed at the outset of each project phase and when a significant change occurs in the project or organisation. To identify the most relevant project stakeholders, the components of the project management plan and project documents should be examined at each iteration of the identification process (PMI, 2017). Expert judgment, Questionnaires and surveys, Brainstorming, Stakeholder analysis, Document analysis, Stakeholder mapping/representation. Mapping stakeholders and their respective roles and influence is known as stakeholder mapping. Knowing the stakeholders' underlying political agendas is also helpful. It emphasises the significance of two matters: How invested each stakeholder or group is in having its needs met by the project How much influence each stakeholder or group has over the project (CIOB, 2014).

MS2.Plan Communication Management

Information demands of all stakeholders and groups, available organisational resources, and project requirements inform Plan Communications Management, the process of designing a suiTable methodology and plan for project communications activities. The main advantage of this procedure is having a systematic plan for efficiently and successfully involving stakeholders through the timely presentation of pertinent information. This procedure is carried out at regular intervals during the project. The timely and cost-efficient dissemination of pertinent information to all stakeholders is a critical component of every project's success. Effective communication is essential for accomplishing any given objective. Communication is generally defined as the process by which meanings are exchanged between individuals through the use of a common system of symbols, a vocal or written message, or a method of conveying ideas clearly (Kerzner, 2017). The tools and techniques useful for this process include, but are not limited to, communication requirements analysis, communication technology, models, methods, a stakeholder engagement assessment matrix, etc. (PMI, 2017).

MS3.Plan Stakeholder Management

Plan Stakeholder Engagement refers to the process of creating strategies for involving project stakeholders based on their requirements, expectations, interests, and potential impact on the project. The primary advantage of this process is to generate an implemenTable plan for interacting with stakeholders in a productive manner. This process should be performed periodically throughout the project as required (CIOB, 2014; PMI, 2017). A successful approach to catering to the diverse information needs of project stakeholders involves creating a strategy early on in the project life cycle and continually reviewing and adapting it as the stakeholder community evolves. The initial stakeholder engagement strategy is developed after the Identify Stakeholder process, and stakeholder engagement plans are updated regularly to account for changes in the stakeholder community. Trigger events for updating the plan include the start of a new project phase, alterations to the organizational structure or industry, the addition of new stakeholders, or the recognition of certain stakeholders' significance to the project's success (PMI, 2017). Benchmarking, assumption and constraint analysis, root cause analysis, a stakeholder engagement assessment matrix, and meetings are some of the tools and techniques that can be used in this stage (CIOB, 2014; PMI, 2017).

MS4.Plan Scope Management

Planning scope management involves outlining the steps to be taken to define, verify, and control the scope of a project or product. The main advantage of using this method is that it establishes a road map for managing project scope. This procedure is carried either once or at certain intervals during the project. The useful tools and techniques for this stage may include expert judgment, data analysis, alternatives analysis, meetings (Kerzner, 2017; PMI, 2017).

MS5.Plan Risk Management

In comparison to numerous other industries, the construction sector is prone to a greater degree of risk owing to the unique characteristics of its operations. These include prolonged duration, intricate procedures, fluctuating environmental conditions, financial pressure, and dynamic organizational features (CIOB, 2014). Plan Risk Management is the process of creating and documenting a systematic, all-encompassing, and collaborative approach to risk identification, analysis, and resolution, as well as monitoring and regulating the evolution of risks (Kerzner, 2017). Creating a risk management plan is the first step in managing risks in a project. The primary advantage of this method is that it makes it possible to tailor risk management efforts to the specific kind and severity of threats faced by a project while still maintaining transparency and accountability. This procedure is carried out either once or at certain intervals during the project (PMI, 2017).

MS6.Collect Requirements

To achieve goals, it is necessary to identify, record, and manage the requirements of all relevant stakeholders. The primary advantage of this method is that it serves as a foundation upon which the product scope and project scope may be defined. This procedure is carried out either once or at certain intervals during the project. To satisfy a contract or formal standard, a product, service, or result must fulfil specific conditions (CIOB, 2014). The requirements of sponsors, customers, and stakeholders are identified and documented. These requirements are comprehensively gathered, evaluated, and recorded to be incorporated in the scope baseline and monitored during project implementation. The Work Breakdown Structure (WBS) is formed based on the requirements. These criteria influence project cost, timeline, quality, and procurement. Some of the applicable tools and techniques in this stage are brainstorming, interviews, focus groups, questionnaires, surveys, benchmarking, etc. (PMI, 2017).

MS7.Define Scope

Define Scope involves detailing the project and product. This process defines product, service, or outcome boundaries and acceptance criteria, which is its main advantage. The Define Scope procedure chooses the final project requirements from the Collect Requirements documents since not all of them may be used. It then details the project, product, service, or result. A thorough project scope statement builds on the primary deliverables, assumptions, and restrictions outlined before the project's beginning. When project information becomes available, the project scope is defined and stated more precisely. Risks, assumptions, and restrictions are reviewed and modified. Define scope is iterative. In iterative life cycle projects, a high-level vision is created, but the precise scope is decided one iteration at a time, and the next iteration is planned while work advances on the current project scope and deliverables (PMI, 2017).

MS8.Create WBS

During the Create WBS process, the deliverables and project tasks are decomposed into smaller, more manageable units. The primary benefit of this process is the framework it provides for the required deliverables (PMI, 2017). This process is executed either once or periodically throughout the project. The Work Breakdown Structure (WBS) is a hierarchical decomposition of the complete scope of work that the project team must perform to achieve the project's objectives and produce the required deliverables (PMI, 2017). The work described in the current approved project scope statement is presented in an organized and understandable way in the WBS. The foundation of the WBS is the work packages, which is where all expected work is grouped. A work package comprises of tasks that can be scheduled, estimated, monitored, and controlled as a single unit. In the WBS, the term work refers to the outputs or results of an activity rather than the activity itself (Kerzner, 2017).

MS9.Identify Risks

The Identify Risks process involves documenting potential risks and sources of risk in a project to aid in risk management. It is performed throughout the project and involves various individuals and groups. Involving the project team is critical to ensuring they take responsibility for the risks, overall project risk, and response activities (PMI, 2017). According to the risk management process, the risk register serves as a record of the identification, evaluation, and mitigation of risks (CIOB, 2014). The risk register consists of two sections: generic risks that are inherent in any project, and project-specific risks that may be discovered during a team risk assessment session. The risks that cannot be entirely eliminated or avoided are called residual risks, and a contingency plan is necessary to manage them. The adequacy of the contingency plan can be determined by assessing the financial impact of residual risks, along with considering the timing aspects (CIOB, 2014). Brainstorming, checklists, interviews, root-cause analysis, assumption and constraint analysis, SWOT analysis, and document analysis are some of the available tools and techniques for this stage.

MS10.Qualitative Risk Analysis

By weighing the likelihood of occurrence, impact, and other attributes, Perform Qualitative Risk investigation prioritises individual project risks for further investigation or action. The main advantage of this procedure is that it allows you to concentrate your efforts where they will do the most good, namely, on the highest priority risks. This procedure is carried out at various stages of the project (PMI, 2017).

Plan Risk Responses is informed by the relative prioritisation of specific project risks established in Perform Qualitative Risk Analysis. Each risk is assigned a "owner" who is accounTable for developing and implementing a strategy to deal with it. If necessary, Perform Quantitative Risk Analysis can be built upon by first completing Perform Qualitative Risk Analysis. As specified in the risk management plan, the Perform Qualitative Risk Analysis procedure is carried out at regular intervals during the project life cycle. Perform Qualitative Risk Analysis is typically done before the beginning of each iteration in an agile development setting (PMI, 2017). There are several tools and techniques available for implementing Qualitative Risk Analysis including interviews, risk probability and impact assessment, assessment of other risk parameters, risk categorization, probability and impact matrixes, and hierarchical charts.

MS11. Quantitative Risk Analysis

Performing a quantitative risk analysis entails calculating how different risks and other sources of uncertainty might affect the project as a whole. The main advantage of this method is that it provides numerical estimates of potential losses, which may be used in risk response planning (Kerzner, 2017). Not every project needs a quantitative risk analysis. High-quality data on project risks and other sources of uncertainty, as well as a solid project baseline for scope, time, and cost, are prerequisites for conducting a thorough analysis. Information on specific project risks that have been identified as having a high potential to impact the project's goals is used in Perform Quantitative Risk Analysis (PMI, 2017). Plan Risk Responses takes into account the results of Perform Quantitative Risk Analysis, particularly with regards to recommending actions to be taken in light of the amount of overall project risk and important individual risks. After completing the steps in Plan Risk Responses, you may decide to conduct a quantitative risk analysis to assess the likelihood that your proposed countermeasures would be successful in mitigating the project's overall risk exposure (PMI, 2017). Expected value, decision tree analysis, payoff matrices, modeling, and simulation are just a few examples of quantitative methodologies. Rather than relying on a more subjective approach, which may produce ambiguous and/or inaccurate outcomes, it is crucial to follow a formalized, standardized, and repeaTable methodology instead (Kerzner, 2017).

MS12. Plan Risk Reponses

"Plan Risk Responses" is a process that involves identifying and selecting effective strategies to handle overall project risk exposure and specific project risks (PMI, 2017). During this phase, tasks are added to the project management plan, and resources are allocated. The process reduces overall project risk, maximizes opportunities, and mitigates risks by applying effective and appropriate responses. The risk owner should develop plans to mitigate each significant risk that has been prioritized by the project team. The response to each risk must be proportional, cost-effective, feasible, agreed upon, and assigned to an accounTable person. Structured decision-making techniques can aid in identifying the best course of action for each risk. For large or complex projects, mathematical optimization or real options analysis can be used to enhance economic analysis of various risk response techniques (PMI, 2017).

After agreeing on a risk response strategy, it should be implemented with contingency plans in place. In case the response fails or the risk becomes a reality, an alternative plan may be developed. However, implementing a risk response plan can introduce secondary risks, which should also be evaluated. It is advised to allocate funds or time for contingencies, and establish the conditions for activating a contingency plan (PMI, 2017).

Table 38 summarises potential courses of action in the face of various risks and opportunities. The steps are as follows: accept, avoid, mitigate (control), and transfer in the case of risks; accept, enhance, exploit, and share in the case of opportunities (Kerzner, 2017). For both risks and opportunities, contingent responses are also feasible.

Table 38 Response Options For Risks And Opportunities (Kerzner, 2017, p.784)

Response	Risk or opportunity	Description
Avoidance	Risk	Accepting a different option, altering the design, or modifying a requirement are all ways to remove risk. Changes the likelihood and/or impact.
Mitigation (control)	Risk	Take preventative efforts to lessen the likelihood of risk happening or to mitigate its effects.
Transfer	Risk	Reduce the likelihood of an event and its potential impact by shifting responsibility for the risk to another party, implementing a redesign across hardware/software interfaces, etc.
Exploit	Opportunity	Take advantage of opportunities.
Share	Opportunity	To increase the likelihood and/or magnitude of potential benefits by sharing with a third party.
Enhance	Opportunity	Boost the likelihood and effect of an Opportunity.
Acceptance	Risk and opportunity	Adopt a cautious approach and only take action when certain triggers are met, in order to mitigate risks or take advantage of opportunities.

MS13. Manage Stakeholder Engagement

Managing Stakeholder Engagement entails conversing with and working with stakeholders to fulfil their requirements, solve problems, and encourage the right amount of participation. Principally, this method helps the project manager garner greater support from stakeholders while suppressing any opposition. This procedure continues all through the project (Kerzner, 2017). The process of managing stakeholder engagement encompasses various activities. These activities include involving stakeholders at the appropriate stages of a project to obtain, confirm, or retain their ongoing dedication to the project's success. Additionally, this process involves negotiating and communicating to manage stakeholder expectations effectively. It also involves identifying and addressing any risks or potential concerns associated with stakeholder management and anticipating any future issues that stakeholders may raise. Finally, this process requires clarifying and resolving any issues that have been identified to ensure smooth stakeholder engagement throughout the project's lifecycle (PMI, 2017; Kerzner, 2017). There are number available methods for managing stakeholder engagement such as feedback, conflict management, cultural awareness, negotiation, observation/conversation, political awareness, and ground rules.

MS14. Manage Communications

To Manage Communications is to plan for and execute the project's information gathering, production, distribution, storage, retrieval, management, monitoring, and final disposal in a timely and effective manner (PMI, 2017). This method is used all during the course of the project. The Manage Communications procedure recognises all components of efficient communication, such as selecting appropriate technologies, methods and approaches. Furthermore, it must facilitate adaptability in communication activities, enabling modifications in techniques and methods to suit the evolving requirements of stakeholders and the project (PMI, 2017).

Approaches and considerations for managing communication effectively encompass a broad range of techniques, including but not limited to (PMI, 2017):

- Sender-receiver models, which incorporate feedback loops to encourage interaction and participation while eliminating barriers to communication effectiveness.
- Media selection, which involves deciding when to use different communication artifacts, such as written or oral communications, informal memos or formal reports, push/pull options, and selecting appropriate technology.
- Writing style, which involves using the appropriate voice, sentence structure, and word choice.
- Meeting management, which involves preparing an agenda, inviting key participants, and ensuring their attendance, as well as addressing conflicts that may arise within or after the meeting due to inadequate follow-up or attendance of the wrong people.
- Presentations, which require an understanding of the impact of body language and visual aids design.
- Facilitation, which involves building consensus and overcoming obstacles such as difficult group dynamics while maintaining group members' interest and enthusiasm.

- Active listening, which entails acknowledging, clarifying, and confirming understanding while removing any barriers that may adversely affect comprehension.

MS15. Validate Scope

Validate Scope refers to the formalization of the approval process for completed project deliverables. The primary advantage of this process is that it imparts objectivity to the acceptance process, which, in turn, enhances the likelihood of product, service, or result acceptance by validating each deliverable. The verified deliverables that have undergone the Control Quality process are assessed with the customer or sponsor to verify their satisfactory completion and secure formal acceptance of the deliverables. The Validate Scope and Control Quality processes differ in their primary objectives. The former is primarily focused on securing acceptance of the deliverables, whereas the latter aims to ensure the accuracy of the deliverables and adherence to quality requirements. While Control Quality typically precedes Validate Scope, the two processes may be executed simultaneously (PMI, 2017).

6.2.7 Supporting Elements of The Process Framework

Plus, the primarily developed Process Framework includes some supporting elements which facilitate the implementation of main stages and help to take maximum advantage of utilizing this practical framework. These are represented vertically in the framework and are as following:

- Control and Monitor
- Engagement and Management (Collaborative Working)
- IPD Implementation
- Common Data Environment

In this regard, ‘Control and Monitor’ is the process of monitoring overall stakeholder relationships and adjusting engagement plans and strategies, the status of the project and product scope and managing changes to baseline, communication throughout the project lifecycle to ensure meeting stakeholders information needs and finally implementation of risk response plans, tracking risks, monitoring residual risks, identifying new ones and evaluating the effectiveness of risk management process.

'Engagement and Management' are continuations of the collaborative working stage during the implementation of the framework. Engagement is the process of engaging organisation with others (collaboration partners) when strategic elements of collaboration are addressed and include the following steps:

- Partner Selection: identify appropriate partners for collaboration, evaluate their capabilities and skills to bring complementary strength to the relationship and create joint objectives in compliance with the overall strategic objectives of the collaboration.
- Working together: establish the right environment and sound foundation to support collaborative working through governance, joint knowledge management plan, effective joint communication strategies, joint risk management, joint business process review, jointly establishing contracting arrangements and performance measurement.
- Value Creation: establish approaches that seek to build additional value out of joint relationship through operational performance improvements, resource optimization, process enhancement and waste and cost reductions.

Table 39 Main Stages Checklist of Activities.

Stage	Activity
Identify Stakeholders	• Identify people, groups or organizations • Identify major requirements and main expectations • Identify interest, influence or potential impact • Classify stakeholders • Identify stakeholder interrelationships
Plan Communication Management	• Develop appropriate approach and plan for communications • Identify stakeholder communication requirements • Identify information to be communicated • Reason, time frame and frequency of distribution • Roles and responsibilities • Methods, models and technologies to convey information • Methods for updating and refining the plan Communication • constraints and escalation process
Plan Stakeholder Management	• Define strategies to effectively engage stakeholders • Desired and current engagement levels • Method for updating and refining stakeholder management plan
Plan Scope Management	• Establish the process for preparing detailed scope statement • Establish process to create, maintain and approve WBS • Establish process for formal acceptance of deliverables • Describe how requirements will be analyzed, documented and managed • Establish requirements prioritization process and product metrics
Plan Risk Management	• Define approaches, tools and data sources for performing risk management • Define roles and responsibilities • Produce risk categories • Define risk probability and impact scale for scope of project • Revise stakeholders' risk tolerances • Establish the process to document, analyze and communicate outcome of risk activities
Collect Requirements	• Determine, document and manage stakeholder needs and requirements • Involve stakeholder for discovery and decomposition of needs into requirements • Elicit, analyze and record requirements in enough detail • Classify requirements • Link requirements to the business and project objectives and track them
Define Scope	• Develop a detailed description of project and product • Describe major deliverables, assumptions and constraints • Describe the works required to create deliverables • Define which of collected requirements will be included and excluded • Define acceptance criteria
Create WBS	• Subdivide project deliverables and work into smaller more manageable components • Provide detailed deliverable, information and scheduling information about each component
Identify Risks	• Determine which risks may affect the scope and document their characteristics • Encourage personnel and involve stakeholders in risk identification process • Provide list of identified risks and their root causes • Provide lis t of potential responses
Qualitative Risk Analysis	• Assess and combine the probability of occurrence and impact of risks • Prioritize risks for further analysis or action • Assess organization's risk tolerance associated with project constraints of scope • Evaluate quality of available information on project risks
Quantitative Risk Analysis	• Numerically analyze effect of identified risks on overall project objectives
Plan Risk Reponses	• Develop options and actions to enhance opportunities and reduce threats to objectives • Determine the mechanism by which the response will address the risk • Identify and assign one person as an owner for risk response
Manage Stakeholder Engagement	• Engage stakeholders at appropriate project stage • Manage expectations through negotiation and communication • Address potential concerns and anticipate future problems that may be raised by stakeholders • Clarify and resolve identified issues • Update stakeholder notification, reports and feedback
Manage Communications	• Create, collect, distribute, store and retrieve information • Ensure appropriate generating, receiving and understanding of information by stakeholders • Sender-receiver models, choice of media, writing style, meeting, presentation, facilitation and listening techniques
Validate Scope	• Formalize the acceptance of completed project deliverables • Review deliverables with customer or sponsor to ensure they are completed satisfactorily
Control Stakeholder Engagement	• Monitor overall project stakeholder relationships • Adjust strategies and plans for engaging stakeholders • Provide work performance information
Control Communications	• Monitor and control communications throughout lifecycle • Ensure information needs of stakeholders are met • Evaluate impact and repercussions of project communications • Trigger iteration of plan and manage communications processes
Control Risks	• Implement risk response plans • Track identified risks • Monitor residual risks • Identify new risks • Evaluate risk process effectiveness
Control Scope	• Monitor the status of project and product scope • Manage changes to scope baseline

‘Management’ of relationship is covered by ‘Staying Together’ and ‘Exit Strategy’. Staying together is addressed through ensuring the sustainability of relationships and continuous value creation by effective performance monitoring and measurement, monitoring appropriate policies and processes, maintaining behaviours and conflict resolution. Requirements for a joint exit strategy is addressed in the ‘Exit Strategy’ stage by clearly defining disengagement rules.

Integrated Project Delivery (IPD) implementation depicts fundamental differences from traditional models in project phasing or execution. Design decisions should be moved upstream as far as possible to where they are less costly and more effective. Therefore, the cost of design changes will be minimized while the opportunity to influence positive outcomes is maximized. Also, early input from installers, constructors, suppliers and fabricators as well as from designers should be integrated and accurate utilization of BIM tools should be performed to model and simulate the project.

‘Common Data Environment (CDE)’ is the key to well-structured data in projects. This is an online place for collecting, managing and sharing information among project participants and can be in many forms like a project server, an extranet or a cloud-based system (British Standards Institution, 2013). Client’s authorization of Employer’s Information Requirements (EIRs) is the starting point of data flow in CDE. The information that should be provided by the project team to the client for decision making at key points is included within this document. Project contributors will be able to perform in their own ‘Work in Progress Area’ to develop their graphical or non-graphical information. After checking and approving the information will be moved to the ‘Shared’ area where other parties can access that information and use it for developing their contributions. The power to change and ownership of information remains with its originator. At key decision points like the end of work stage, the employer will approve and sign off information for moving it to the ‘Published’ area. Specialists such as manufacturers or tier 2 or 3 contractors can be engaged by using published information. After meeting project milestones, the information will be moved to the ‘Archive’ area for future use (BRITISH STANDARD, 2008).

An example of the Common Data Environment (CDE) is presented in Figure 42.

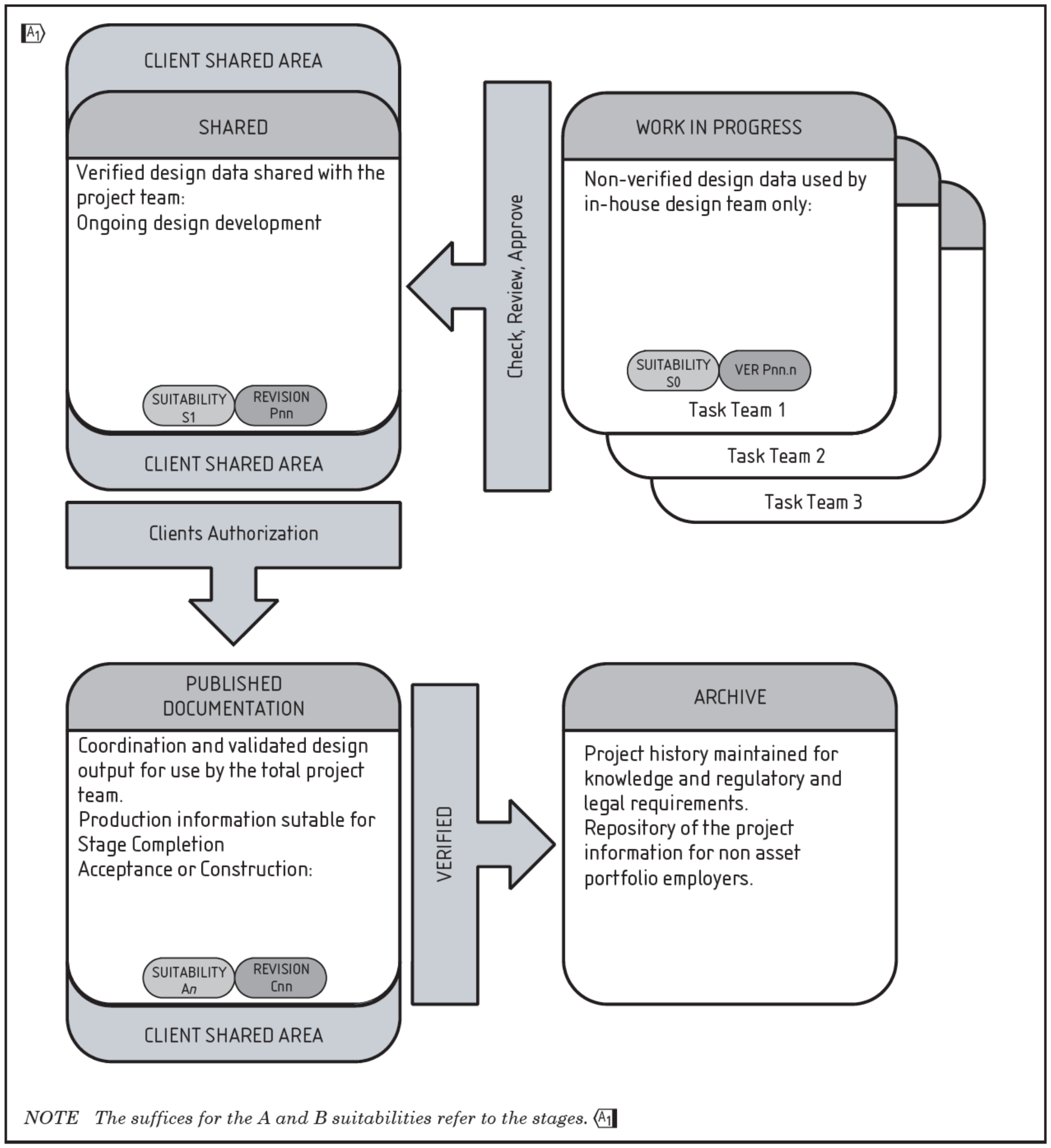

Figure 41 Common Data Environment (BRITISH STANDARD, 2008)**.**

Accordingly, the CDE can be used in line with the purpose of this research as well. For instance, managers can use CDE for capturing work in progress about stakeholders like identifying their information, requirements, expectations, interests, power and influence. The produced information about stakeholders can then be shared with the experts working on the scope management process like designers for capturing project specifications and work packages. Consequently, both of these set of information can be used by risk managers for the identification and management of stakeholder's uncertainty, scope changes and potential impact on the project and preventing scope creep. The key issue here is the confidentiality of information and clarification of the exact recipients of this information.

6.3 Summary

In summary, the procedure for the development of the Process Framework was explained in this chapter and the primary version of it was presented. Different elements and associated stages of the Process Framework were explained including the three primary BIM-related stages, main project management stages and the supporting elements. Also, it was explained how the Common Data Environment (CDE) can be used by project managers for efficient management of various project aspects. Hence, the main aim of the developed Process Framework is to provide a comprehensive and integrated approach for managing the influence of stakeholders on the scope of projects by using BIM management concepts and essential project management processes to prevent risky events such as scope creep in projects.

Chapter 7 Validation of the Developed Process Framework

7.1 Introduction

Whilst Chapter 1 provided a brief introduction, Chapter 2 and 3 reviewed the literature on scope and stakeholder management issues and Building Information Modelling (BIM). Chapter 4 reviewed the design and structure of research methodology and techniques, strategies and instruments used for data collection and analysis. In Chapter 5 the secondary data collected on the case study projects were analysed, and the development of the Process Framework was described in Chapter 6. This chapter describes the analysis of the primary data collected during interviews to validate the developed process framework in chapter 6.

7.2 Sampling and Primary Data Collection

As mentioned before both secondary and primary data are used in this research. The secondary data collection and analysis for developing the primary Process Framework are described in previous chapters.

As discussed in section 4.10 of the chapter 4, Creswell's (2013) non-probability or purposive sampling approach is adopted in this research due to the qualitative nature of the data being gathered. As per Patton's (2002) argument, the main objective of probability sampling is to attain generalisation, while the primary goal of purposive sampling is to obtain a comprehensive understanding of the topic under investigation. Also, for this research, the criteria for participant selection were restricted to professionals who are currently employed in construction organisations based solely in the United Kingdom. The research focused on individuals working for diverse organisations located within the geographical boundaries of the United Kingdom (UK). Although some of these organisations were global conglomerates, they all had a presence in the UK.

Knowledge of stakeholder management and building information modelling (BIM) and the scope creep phenomena in projects was also required, following Creswell's (2013) methodology. In this regard, the individuals who were thought to have relevant experience and knowledge were selected with the help of the supervision team as mediators for selecting and approaching participants. It was also checked that the interviewees had a solid grounding in these topics before proceeding with the interviews. Their subject matter expertise was acknowledged, and they held positions of prominence within their respective organisations. Furthermore, the selection criteria for this study mandated the inclusion of experts who possess practical experience in the institutional and industrial contexts of the research, in addition to the required academic and professional qualifications. An additional condition for inclusion was that the participants should hold managerial positions or higher, including roles such as project directors, project managers, or BIM managers, in their respective companies. The justification for this criterion was to ensure that the selected individuals were accounTable for or actively involved in overseeing BIM and various project management processes and tasks. The minimum level of experience required was five years, and all the interviewees had over a decade of experience.

In accordance with Creswell's (2013) qualitative sampling strategies, a researcher can select from a range of techniques depending on the study's research question and objectives. The current study has adopted Snowball sampling as a strategy to identify information-rich cases. This approach involves referrals from individuals who are familiar with the cases, and it was chosen to achieve the research objectives.

Creswell (2013) explains that phenomenology studies can have varying numbers of participants, ranging from as few as one participant to as many as 325 participants. While Dukes (1984) recommends a range of 3 to 10 participants, Riemen (1986) studied 10 individuals for their phenomenological study. Crouch and McKenzie (2006) argue that the researcher's orientation and objectives are relevant, and small sample sizes can be beneficial for qualitative researchers, particularly in interview-based studies, as they allow for closer interaction with participants and the generation of more detailed data. According to Bryman (2016), small sample sizes for qualitative research are typically less than 20.

Primary data are collected through conducting semi-structured interviews with practitioners from areas of project and construction management and BIM management to validate many elements of the developed process framework, which are the results of interpreting findings from literature reviews and case studies and document analysis. Using a high number of participants for the interviews seems impractical because interviewing more participants will increase the complexity and reduce the clarity of the collected data. This, in turn, makes qualitative analysis of the data time-consuming and hinders the ability to compare and evaluate the findings. For this purpose, potential participants are identified through gathering information on construction and infrastructure companies through web search and networking by supervisory team assistance. In total, 10 construction and infrastructure companies in the UK were identified and invitations for participation were sent to the identified potential participants amongst whom 5 of them from 5 different companies responded positively and agreed to participate. This is equivalen to 50% of the target population of samples. Hence, the identified potential participants were contacted by sending online participation invitation via their email addresses. The emailed invitations included the researcher's information, the topic of research and a brief explanation on the aim of research and participation requirements together with an information sheet and a consent form for participation. Once, they agreed to participate by responding to the sent emails, they were approached again to set up the time and location of interviews according to their preferences. To keep participants anonymous their names are removed and alphabetized for data analysis. Table 40 provides a summary of the participants' profiles involved in the study, comprising their work experience, which varied from 14 to over 30 years. The most experienced participants were C and A with a minimum of 21 years of experience, while participant D was the least experienced with 14 years of experience. The average experience of the participants was 20.6 years. Moreover, the participants belonged to different organizations and held different job titles, ranging from BIM and Revit developers to project directors. This diversity in job titles and experience levels allowed for a broad range of perspectives to be collected and ensured that common themes were identified.

Table 40 Participants Information.

Participant	Position	Experience
A	Director	21 Years
B	Principal Advisor – Structures Delivery / Structures Team Leader	19 Years
C	Projects Director	30 Years
D	Associate Director	14 Years
E	BIM and Revit Developer	19 Years

The Atlas.ti 8 software is used to analyse collected primary data through interviews. For doing this, the audio files in mp3 formats were uploaded into the software for accelerating the coding process. Also, transcription services are used to transcribe the audio files into MS Word files with .docx format for ease of analysing coded data. As mentioned before a scheme of codes is developed according to the themes of this research. The codes are categorized into several code groups which are designed to validate the primarily developed Process Framework. After taking into consideration collected data and the coded passages of interviews, some of the code groups were merged to provide a coherent basis for data analysis. To obtain this objective, the fewer addressed codes and code groups were embedded in the most addressed code groups with a similar background. For instance, the code group 'stakeholder communication' is merged with the 'stakeholder management' code group due to its low number of marked passages and to facilitate the process of analysis. Hence the final scheme of code groups is developed as:

- Scope management
- Stakeholder, uncertainty and communication management
- BIM, collaborative working and integrated project delivery

So the data will be analyzed according to the aforementioned codes in each code group, which are designed in relevance with the themes and elements of the primary process framework. For this purpose, the comparison is made between different codes and data gathered from interviewing participants to validate the aforementioned elements of the process framework by producing analytical reports using the Query Tool in Atlas.ti8 software. It should be mentioned that data are analysed to validate process framework elements according to themes used for its development rather than each individual stage involved in it because otherwise, it would increase complexity and bias in the analysis process.

7.3 Scope management

In this section, collected primary data are analysed according to the first research question in this study, "Q1. What are the main causes of scope creep in major construction projects and what are the best solutions for its management in order to prevent its negative impact on project success?" In addition, this analysis addresses the scope management theme of this research to validate the following stages of the Process Framework:

Main stages:

- MS4.Plan scope management

- MS6.Collect Requirements
- MS7.Define Scope
- MS8.Create WBS
- MS15.Validate Scope

Supporting stage:

- Control and monitor scope

7.3.1.1 Scope Management Process

For managing the scope of projects it seems that the majority of participants use an on-going basis for this process to constantly amend the scope and make sure its ultimate delivery. Participant A states that whether it is change or request for additional work which may have an impact on what they do, they will do it by communication and meeting with stakeholders and using approaches like brainstorming:

‘Scope management is managed on an on-going basis whether it is change or request for additional work and may it has an impact on what we do so we constantly amend the scope to make sure its ultimate delivery. It will be done by communication and meeting with stakeholders and brainstorming.’

According to interviewee B, they start the scope management process after identifying the need and defining the outcomes and objectives. Then they start thinking about how they are going to deliver those outcomes and objectives and the required works to do so and this is the point where they make a decision about the scope.

‘In most of what we do, we start with the outcomes and objectives we want to achieve. The first question we ask ourselves is why we are doing this project so we are doing the project to achieve a certain outcome or a benefit. That is where the need starts and that is where I said you identified the need of something. Then you start to think about delivering the outcome or objective; So you need to do something and when you start thinking that you need to do something that is actually where you start deciding on the scope or what I need to do to deliver the outcomes or objectives I’m trying to achieve and then you start looking at the scope.’

Interestingly he mentions that they take the scope into consideration in two categories of core –or hard or fix- scope and soft scope. The core scopes are the features and functionalities which are needed to make project a success and are non-negotiable while the soft scope is the extra works that can be added to increase the quality or fully address the needs and expectation of stakeholders. It is stated that they define these two types of scope very initially before going into the feasibility stage and the benefit of this approach is providing the ability for adding or removing certain bits of scope as they engage with stakeholders later during the project. It is quite similar to the scope reduction list approach introduced by other authors in scope management literature. But the tricky part is taking budget, time and stakeholders opinion into consideration before making these changes in the scope to prevent scope creep.

'When we look at scope we look at it broadly in two categories one is the core scope which is definitely required to deliver the outcomes and benefits which we are trying to achieve. Those are the scope that needs to be delivered to make the project a success. There is something which is good to have since I'm doing this let's do the other things. So I could say one is the non-negotiable or hard bit of the scope which has to be done and the other bit is if we are doing this we can do it along with some other works as well. So that is defined very initially and obviously as the project develops and as we engage with stakeholders certain scopes could be added and certain scopes could be taken away. Now in most cases what happens is the core or the hard bit remains there because if that is not delivered there is no point in doing the project. But there are other scopes that are negotiable and there are other scopes that would come in as part of the stakeholder requirements or as part of stakeholder engagement. So that's how we define the Scope to retake the project to the feasibility stage. At the end of the feasibility stage, we would expect the scope to be frozen or as we say the scope would be completely defined. After feasibility obviously that scope develops.'

However, participant C points out that the scope management process after definition is poorly managed and he mentioned incidents caused by builders and workers as evidence for lack of supervision and control during the process stating that in some projects builders are self-managing themselves. So the scope specification and work packages may be properly defined but workmanship has a huge effect on this process.

'look at all the problems we've got now, walls falling down, people getting hurt and injured, so it's actually very poorly managed at the moment. In Scotland, all the walls fell down, and people were lucky they didn't get killed because they'd missed the wall out because when the design and build came about, suddenly builders are self-managing themselves and they're managing their own quality and it's failing. I'm saying it's workmanship, so you can get a fantastic specification, very defined scope of work but it comes down to the lowest common denominator.'

Interviewee D provides a great explanation of their scope management process. At the early stages and during the bid process they put in key deliverables and they outline a list of deliverables for each stage. For example, at stage zero to one, they would support the architects in defining the scope of the project, having a look at key strategic points, having a look at key design points and things like that. So they outline exactly what they understand their scope is in that phase in a few bullet points which allows them to define the scope as much as possible as he mentions:

'so we would outline exactly what we understand our scope is in that phase, but it would only be a few bullet-points that sort of allow us to define that as much as possible because normally the project starts off being a little bit undefined until the client knows actually what the scope is and everything, so you would actually start out with this is what we are participating in.'

After that initial stage when it is clear what the client actually wants, what they can afford and what the key parameters are they would put into place a matrix for defining each parties roles and responsibilities which is basically is in form of an Excel spreadsheet and used for assigning duties and tracking various work packages to make sure there is no underlap or overlap in roles and responsibilities. Also, the participant emphasizes the importance of keeping this process lean and structured:

'…because, you know, with projects, it's always less is more, but it has to be less as in it has to be quite structured to cover all the basics, and yes, there's a whole theory behind it, but in terms of making sure that everyone is buying into it, it should be very lean and very easy to understand, so if it's just line items with this is the task we're talking about, responsible is this person, participating is the rest of those, and then there might be a little explanation at the back which says what is…'

7.3.1.2 Scope Definition and Requirements Collection

As participant B explained, they define the scope into hard and soft scope by using MoSCOW method or analysis which basically says that there are few things that must have and there few things that should have or could have:

'Say for example the benefit which I am trying to achieve is to take people from this point to that point, that is the outcome which I am trying to achieve, now the core of scope is or could be that I need a crossing so I need a mean to take people from here to here, that has to be delivered to achieve the outcome. Now how I deliver it or whether or not you will have a green bridge or whether you have a technically pleasing bridge or you have a bridge that is fit for purpose is in the way secondary because the primary objective was to take people from point A to point B am I doing it if I have all the bits which are required to deliver that outcome for me is the core and the rest could be the soft scope ...'

He also mentions that after identification of the need for a project they engage a group of stakeholders who are behind that and they define the core of scope. As they go along what they do is creating a register in which they will define the core scope and the things they want to achieve and whenever something comes in they say 'can we actually achieve this base on what we know or can this be achieved with very little changes to finance and programme'. So, it is basically used to tabulate the core or primary and secondary scope. So, the primary scope is fixed and the secondary scope is used to keep adding on in case of financial constrain or stakeholder request for change:

'So the primary scope is there and the secondary scope we use to keep on adding because what needs to happen is that say for example if we are in financial constrain and we can't undo it, we can't do everything so what happens is the first thing which ... probably is secondary scope. Or say for example a new stakeholder comes in and tells you i will support your project why do not you plan increasing to it in which case if it is easy and when it does not affect that project programme...'

Participant D explains that at a very early stage when they do the bid they would put in key deliverables and they would outline a deliverable list for each stage for example at stage zero to one they would support the architects in defining the scope of the project because the stage one for them is defining the scope. So basically in contrast with other interviewees, they start this process from listing deliverables. So have a look at key strategic points and key design points they would outline exactly what they understand their scope is in that phase but it will only be a few bullet points which allows them to define that as much as possible because as he says :

'…normally the project starts off being a little bit undefined until the client knows actually what the scope is and everything, so you would actually start out with this is what we are participating in. And then normally after that initial stage when it's clear what the client actually wants, what they can afford and what the key parameters are for the client, you would then put into place a matrix that sort of outlines the key influence of each party…'

As he continues they use this matrix of responsibilities to assign each work package like fire design or structural design to each stakeholder so it would clearly outline who is driving what and who is responsible for making sure it is done and if there is a meeting on a particular work package who is needed to participate. It will be in the form of one Excel spreadsheet so it will be quite easy to overview because as he expressed with projects always less is more so it has to be less and quite structured to cover all the basics and to make sure that everyone is buying into it should be very lean and easy to understand.

Regarding the definition of initial scope, participant D states that normally they would use the outline scope on the RIBA stages because they would know what level of detail is needed on each stage and it is a well-known tool. So the expectations on both sides will be the same because if you talk about RIBA stage two design, everybody roughly knows what to expect from deliverables:

'…so the expectation on both sides is the same, if you talk about the RIBA stage two design, everyone roughly knows what to expect from the deliverable and you then only need to outline the number of meetings and the time involved that you spend defining and coordinating things because that might be different from project to project and from the complexity of projects that might be different.'

Likewise, interviewee E mentions that before the creation of EIR and consequently BEP they use RIBA work stages as well so the scope is already pretty defined in what is expected from whom in what stage in terms of managing the client early on in the project.

However, the RIBA plan of work is not included within this research as we studied these issues from more theoretical and conceptual perspectives, so PMBOKGUIDE could provide a better conceptual baseline for this research and the majority of details and terminologies used in this research does not exist in RIBA plan of work. But we will discuss it briefly in the following sections.

7.3.1.3 Occurrence and Management of Scope Creep

Participant A says that the majority of changes they experience tends to appear with changing circumstance and that is horribly generic for them. A lot of their projects are private developments in which there is the change from sequence point of view to change in ultimate end user and when the tenancy agreement is signed there would be change as a result of tenant's requirements. Because they are customer-focused firm most of the time they desire to adapt to these changes. Also, according to what he mentions, they manage the scope on an on-going basis and they constantly amend the scope for its ultimate delivery if there is a change or request for additional work which may affect what they do. So, as he confirms the stakeholders may instigate change on the scope via meeting or other ways of communication and their responsibility is to react to that and investigate the purpose of proposed changes. They as member of the team will identify what the additional work is, what the resource requirements are and how much it takes and whether they got the resources available. Then they will confirm back to the client what they understand to be changed, how it impacts delivery and scope and the implications on finances. In addition, he points out that the main reason for scope creep in projects is not fully understanding the scope of the project at the outset and lack of information. Regarding scope creep, he believes that its impact is mostly negative and the most likely negative impact of scope creep is on the programme and associated cost with that. Therefore, he believes that at time of experiencing scope change having access to the right information is crucial in order to understand what the implications and consequences are.

As participant B mentioned before they split the scope of the project into two categories of core or hard scope and soft scope. The hard scope is the non-negotiable features and functionalities which are definitely required to deliver the outcomes and objectives that they are trying to achieve and make the project a success, while the soft scope is the extra works or features and functionalities which can be added or be taken away as the project develops and they engage with stakeholders as part of stakeholder requirements. So it seems that his company shows flexibility in implementing changes into the scope by using this approach. Although it can give them the ability to benefit from advantages brought forth by adding or reducing the scope, it can be risky because unplanned changes or too many scope changes without adjustments to time and cost and without proper stakeholder engagement can jeopardize the whole project.

It is expressed by interviewee B that scope creep may appear even after the scope definition phase due to factors that are not in their control like inadequate data or quality of data based on which the scope was defined or the decision are made and that can affect the scope or result in changes:

'There could still be scope creep after definition because of the facts which are beyond your control like inadequate data or the quality of data based on which the scope was defined or based on the list of decisions were taken could differently influence or change the scope.'

He continues if someone comes and start challenging the core or hard scope and they cannot deliver core scope elements then the project does not exist and there is no point in doing anything. Regarding the causes of scope creep, participant B states that inadequate stakeholder engagement and inadequate information for decision making are two of the key reasons. So people may take decision based on the best available information and not necessarily understanding and appreciating what are the potential impacts of lack of information. This again shows the importance of information sharing in the projects and admits the role of stakeholders in this issue.

'The main cause for scope creep is inadequate stakeholder engagement as we discussed it, the other key reason which I have seen is inadequate information in decision making. So people have taken a decision based on the best available information not necessarily understanding and appreciating what are the potential impacts of lack of information.'

In continue, he explains the meaning of lack of adequate or complete information as the unknowns unknowns which means there are things that we do not know but there are also things we do not know that we do not know. So those are the things that can throw your project scope out of the window very quickly. About stakeholder engagement, he emphasises its importance because if you don't know what are the expectations of stakeholder they can keep on adding a scope. Therefore, according to what he says the expectations of stakeholders can have a crucial effect on the scope of projects and causing scope creep.

He mentions the absence of clear scope definition as another cause of scope creep but he points out that the scope baseline should be defined and set at the right time when you are confident and provided the right information. So, in his view, it is very important that they get the scope baseline information right because if the baseline information is not right then the probability of scope creep is much or significantly higher.

Change in the requirements is mentioned as another reason for scope creep by participant B. He said before, that they start the project with identifying the needs but he describes that sometimes in the course of scheme or project people may either change their mind or they say 'since we are doing this why don't we do this as well at the same time'. So if have not completely thought through the stakeholders' needs or even if the stakeholders were engaged in the scope baseline definition process they may change their mind and change the project scope. He carries on by saying that there are also contractual obligations which are beyond their control, for example even with the best investigation and best survey they do to identify staffs and services, they may go onsite and be surprised to find things differently or may find things which were never under reconnaissance. This again reminds the importance of supervision and the role of workmanship as pointed out by another interviewee.

Heritage and historical stuff are mentioned as other sources linked with this issue by participant B, where during the process of project they come across something which delays the project because it effectively changes the scope and they need to resolve it. As an example he provides, particularly for digging inside part of the country where they then come up with agricultural remains then they have to stop and deal with them and he states that these sorts of things contribute to scope creep. So in the researcher's opinion, it can be taken into account as on-site issues too.

In participant's B opinion another important thing which is needed to understand is planning of the actual delivery of scope because without adequate planning the possibility of scope creep will be increased and if the activities are not well planned then you will spend more time and resources in delivering those things. So the fundamental sequencing of the works and fundamental planning and allowing for the right level of resources to do the job is crucial for them. So it shows the importance of stakeholder management plan and work breakdown structure (WBS) in avoiding scope creep in the projects.

Participant B explains they have a change control process in place so if there is a change in the scope they follow the change control procedure set up as part of their project and programme management delivery and this includes change identification, review, time and cost evaluation, approval and authorisation for execution:

'The way it starts is that someone identifies the change and then it is raised as the change to the appropriate authority to view it and once that authority has reviewed and approved it then the change is executed. Once the change goes to authority to review obviously there is an issue which needs to be evaluated and there are aspects of programme and cost which needs to be looked at. So it basically goes through the proper evaluations process before it is authorised.'

It is affirmed by participant B that there are several examples where scope creep has happened because of unplanned events and extra works. Then as an example of an unknown event, he described that you may be doing some repair of an asset and all of a sudden you realise that condition of that asset is far worst than what you have assumed or what the reports told you, in which case you need to do more work to actually mitigate that situation so it puts a lot of pressure on finances and programme. Again it triggers another series of stakeholder engagement because of reworks that may affect those stakeholders.

'…for example, if it is a bridge or a tunnel or a road the road users get affected and if you need to divert them again there are more resources required.'

So from the researcher's point of view, in addition to the impact of unplanned extra works on the scope, it shows the importance of stakeholder engagement and the influence of extra works on the stakeholders too.

In regards to positive effects of scope change in the situation like aforementioned example, interviewee B declares that they may be doing a piece of work and they may come to the situation where the condition of the asset is far better than what they have planned in which case they can complete the work quicker and so it has a positive effect on the plan.

Despite participant B emphasise the negotiability and fixture of core or primary scope, he states that primary scope can also change as long as adequate funding and programme allowance and resources are in place. So he expresses that they do not only deal with secondary scope change but the primary scope can also change, however secondary scope change is much easier than the primary scope change.

'Your primary scope can also change. For example, you are trying to build a single-track rail between A and B, halfway through the project, someone says 'you know you should build two-track instead of single track' and that is a significant change in scope and it is your primary scope which has changed but as long as adequate funding and the program allowance and resources are there we can deal with that, so your primary scope can also change so it is not that we only deal with secondary scope change. I think dealing with secondary scope change is much easier than the primary scope change.'

Regarding the scope change or change control, it seems that interviewee's C's company perform a well-structured process. He describes this process as a formal change request document would come through and they send It to the constructor would put his impact for time and cost, then it will come back them, the company, and they send it to the rest of the team and it will come back again and cost estimation will be done and then it would be sent to the client and then the client would authorise it.

'Nowadays, that's still the mechanism actually we're using now, or what's happening in the background for the Ministry of Defence, on more sophisticated jobs, we're using something like a BIW or a full project system where it automatically goes out to all parties, where they'll put on their cost impact, time impact, whole lifecycle impact and so forth. That's the system that will be involved in.'

Participant C believes that the contract is the key in managing the influence of stakeholder and particularly internal ones in managing changes to the scope. So they can set up in the contract that certain stakeholders can have certain influence at certain points during the project lifecycle like signing off the floor plan, seating areas, soft furnishing, carpets, etc. or certain things that stakeholders are not allowed to influence. He continues by declaring that there may be someone along the line who can suggest a variation, so it will go through the process in which they clarify who proposed the variation, what the impacts are, how shall they take it on board and who is the responsible person to authorise it. So in the researcher's view it is quite similar to the approach other participant use in form of hard and soft scope. But the interesting point mentioned by him is the importance of stakeholders' position in authorising or denying the scope change. He confirms that if the changes are proposed by the client or end-user they will investigate the impacts of changes in terms of time, cost and programme and then they will send the results to the client and this is the client who makes the decision on either authorise it or not.

Plus, he believes that workmanship can be another reason for extra work and consequently scope creep in the projects because in many projects that he was involved the builders were self-managing themselves and they were managing their own quality and it was failing. In his opinion, you can get a fantastic scope specification and the scope can be defined completely but it comes to the lowest level denominator. In addition, he admits this happens because of the lack of proper control and supervision of work packages on site.

'You get a builder, a main contractor, a client contractor, they'll let it out to fifteen different packages, 20 packages…, they let it out to someone else and so forth, so what happens, you get some cheap labour, and they'll be the lowest cost and they just are not managed No one's managing their work. You know, the main contractor isn't managing their work, so you end up with things thrown together and then you get these problems. That's what happens, that's the reality.'

So he added it is to do with close supervision on-site to supervise the work and It does not happen as it should be and that has been going on for many years hence they have all these problems in the building and mostly it is down to poor quality workmanship and lack of supervision. Then he uses Grenfell tower as an example that somewhere along the line there has been scope change and someone decided rather than using a non-combustible panel, they're going with combustible panelling.

Participant C believes that there is always a chance of scope creep in the projects, but the important thing is to be quite hard on it and build the project as per the specifications. So they force the stakeholders like the contractor to perform according to the contract otherwise it will be at their own cost and in order to prevent scope creep they mandate the scope and put governance in place.

Participant D points out the difference between new build and refurbishment projects. He states that when they start with a new build project the scope is fairly defined and they know there will not be that many surprises other than maybe surprise in the ground or they find unforeseen ground conditions so the variations over that project compared to refurbishment projects are tiny but in a refurbishment project they are working around an existing envelope and there are things that they will uncover onsite or in the process of design. He also affirms that the main cause of change in the scope is the clients changing their mind in terms of what they need to be delivered and that might be a commercial influence that they are finding like adding more retail or add something to give them back more value to make it a viable project.

Participant D also mentions that in time of scope change, they would define the proposed change, analyse its impacts on the initial scope, investigate impacts on time and update the price either there will be an increase or decrease.

'…sometimes we just have to throw more resources on it, yes, but that's all the analysis that needs to happen is basically look at the initial scope that was agreed, defining for ourselves what the change means and then sitting down with the client and the project manager to negotiate and say, look, this was our initial scope, this is what the new scope is, the timeline for the programme is X and has to accommodate this change, the effort to get there would be Y and therefore we would have to charge an extra cost or we would say, well, actually the scope has lessened or whatever, it could go both ways…'

He continues by saying it could be the additional scope and additional fee for them, or it could be less and both ways they have to make sure that they inform the client and project manager to make sure that this is well defined and they have security over their budget. Because if the scope is reduced and they do not negotiate they might over-deliver or they may not receive the fee that they expected and this can develop tensions if it is not managed properly.

Interviewee D also confirms that using reduction lists can be useful. If they have key milestones delivered then those features and things that come in are in a way nice to have because everyone in the design team needs to be aware that obviously, extra work needs extra time.

Regarding other sources of change in scope or requirements, he mentions that sometimes it is driven by the client when they give their matrix at the bid stage to say 'we want you to participate in the following activities' and that would be used as an extra baseline for them.

About the influence of other internal stakeholders, he explains that most of the time if they define it at the beginning of the project these guys would actually not be appointed yet, so they always progress the design to attend the stage where then these stakeholders come on board. It's very rarely, especially on major projects that they already know who preferred contractors are because normally they develop a design to a certain stage and then contractors come on board and then influence it.

7.4 Stakeholder, Uncertainty, and Communication Management

In this section, collected primary data are analysed according to the second research question in this study, "Q2. What is the role of stakeholder influence in the occurrence and management of scope creep in construction projects?" In addition, this analysis addresses the stakeholder management theme of this research including stakeholder management processes, stakeholder influence, communication and stakeholder risk and uncertainty to validate the following stages of the Process Framework:

Main stages:

- MS1.Identify Stakeholders
- MS2.Plan Communication Management
- MS3.Plan Stakeholder Management
- MS5.Plan Risk Management
- MS9.Identify Risks
- MS11.Quantitative Risk Analysis
- MS12.Plan Risk Responses
- MS13.Manage Stakeholder Engagement
- MS14.Manage Communications

Supporting elements:

- Control stakeholder management
- Control communications and engagement
- Control risk and uncertainty management

7.4.1 Stakeholder Management Process

Regarding stakeholder management processes within the construction and infrastructure industry, it seems that there is a lack of consensus in using an integrated and clearly established process for managing stakeholders. The majority of participants state, they perform this duty by learning from experience and using lessons learned as participant A mentioned:

'Regarding our interactions with third party stakeholders we learn from experience who to speak to within those organizations, how long it takes what their processes are that we need to bear in mind.'

Accordingly, interviewee D says they do not have such a process because they want to run their company quite lean due to variation in projects size. So, they just do generic meetings, discuss issues and plan solutions:

'A company of our size is run quite lean so we wouldn't have processes to run stakeholders because it's all more on a face to face basis as you have meetings. you run projects the way as in you meet, you discuss issues, you sketch solutions and you work that way. There is no process as in, oh, you have to meet the architect at least five times through the project, as a process you have to always do that because the project sizes vary quite significantly.'

Even interviewee C, with 30 years of experience states that in a lot of projects there is no stakeholder management process at all:

'So basically, a lot of projects there isn't any stakeholder management. It's very poor, it's very ad hoc, it just doesn't take place, you know? People are rushing around and people aren't clear who does what, where and when.'

Also, it can be understood from the answers that there is a difference between the ideal world in clients' minds and textbooks versus reality. The clients may ask for a particular way of working or certain duties to be performed, but in reality, things do not go as they wish since processes are not rigidly defined and other factors may affect the project.

7.4.1.1 Stakeholder Management and the Factor of Time

Another factor that affects project management processes is time management. Participant D explains that in bigger projects although the amount of stakeholders involved is higher but the process gets easier because managers will have more time in hand to manage this process while they do not have that much time or budget for this purpose in smaller projects:

'To be honest, the bigger the projects get, in a way the easier they get, not from an amount of stakeholders involved but from the time that you have available to manage all of them, because if you have a very small project, it is very, very tricky because you haven't got much time to set it up, to manage it, because the fee involved is much smaller than if you had a large project which has a large fee, you have more time to set it all up properly.'

However, interviewee C had another opinion about it and believes that reality does not work that way all the time and working on bigger projects may result in neglecting processes like stakeholder management:

'So you know what they should be doing but most of the time my client will say to you we want you to do this, this, this and most of the time it will be, in an ideal world, we want you to start, you have a one, a two, a three-month mobilisation period, during that period you'll develop all your project management processes and procedures and so forth, but actually, the reality is this job should have started three months ago, you're already three months late and you're straight into the doing.'

7.4.1.2 Stakeholder Management and the Factor of Budget

Plus, the budget can have a huge influence on the type of stakeholders which project managers are involving in the project:

'You know, a client will say we want a team of whatever amount of people, you know you've got a team of twelve people and they need to be experts in whatever they're doing, but the cost won't allow it, so you've suddenly got a team of six people, and rather than these people being in their forties or fifties, these people are 20, 25, so this is the reality, and this affects everything.'

7.4.1.3 Stakeholder Management Tools and Techniques

Although the participants could not demonstrate a step by step process for managing stakeholders in their companies, they mentioned using various stakeholder management tools like stakeholders Matrices and Tracker for recording their information and factor data and Mapping tools for their identification and categorization followed by a brief company strategy in dealing with stakeholders. So it can be concluded that most of the time it is done instinctively rather than professionally.

7.4.1.4 Stakeholder Management and the Factor of Project Size

According to interviewees' responses the size of projects plays a crucial role in undertaking the stakeholder management process properly. One of them, participant C, believes that in smaller projects you may start the project from the beginning but for bigger projects, they do not do the same because bigger projects are going on for many years and they have most of these things, project processes, in place already.

'it's not very often you're going into a project and you start at the beginning. It's not very often. You may do on small projects, but most projects, as I say, because they're going on for many, many years, and the value is so big, most of these things are up in place already.'

However, participant D believes that it is more efficient to undertake stakeholder management process in bigger projects and as mentioned before they intend to keep it simple in smaller projects*:*

'I think bigger companies where there are more stakeholders and there are bigger projects, there will be a different framework for that.'

Also, it has been mentioned that for projects over 100 million, the majority of the stakeholder management process is designed around the roles and responsibilities aspect of stakeholders through creating matrices and stakeholder maps. He, interviewee D, emphasises the importance of issues like overlapping responsibilities and improper role definition which may make bigger projects run into trouble due to their complexity:

'if I reflect back to my days working on much larger projects than we do now, everything that's above 100 million, you would definitely have roles and responsibility matrix, so you would look at…which is what you're referring to, I guess, in terms of a stakeholder plan, so you would have roles and responsibilities on the project, you would map out whose role is what on the project, and then what they're responsible for to make sure there is no under or overlap, and that's very key and I've seen it on projects where that wasn't mapped out sufficiently and projects run into trouble because the roles and responsibilities are not staked out clearly, and some people might take on a lot more responsibilities than they should have done in their role.'

7.4.1.5 Stakeholder Analysis

Participant A confirms that identification and analysis of stakeholders is very important for them in their company especially during the initial stages of the project. Although they consider external stakeholders analysis but the main focus of their analysis and identification is on their internal stakeholders and particularly the client's culture. So he believes that the client's culture is the key stakeholders' attribute which influences how they will run the project and therefore how much inspiration and changes they would expect during the project. They have different processes in place for this purpose because there are different needs for interaction with stakeholders. As mentioned before they use a tracker to record factor data on stakeholders information which can also be used for managing risks.

'As a consultant, it is very important to identify these stakeholders from the outset because we need to allow for time and effort before interacting with stakeholders the main focus tends to be on how you refer to external stakeholders those who sits aside the project team but we do consider internal stakeholders with more focus on clients' culture which influences how they run the project and therefore how much inspiration and

changes you would expect during the project. We have a different process for stakeholder management because there are different needs for interaction with stakeholders.'

As participant B explains their stakeholder identification process includes understanding the stakeholders' interests, what they are trying to achieve from the scheme and their level of influence or power. This is part of their initial stakeholder mapping. Another important part of their stakeholder analysis is identifying stakeholders' attitude towards the project in terms of supportive or opposing and designing strategies in their stakeholder management plan for managing them. Also, he admits that they categorise stakeholders into internal and external ones and both of them are equally important for their company. Regarding the internal stakeholders, they categorise them according to their discipline like operations and maintenance teams, engineering teams, etc.

Likewise, interviewee C states that they employ experts like stakeholder communications specialists for the identification of stakeholders. The specialists they use to start this process from scratch by running communication workshops to identify stakeholders. In addition, they also use the stakeholder mapping tool to understand which stakeholder should be involved and informed for the successful delivery of the project and which ones need more attention in comparison with others.

It is expressed by participant D that the minimum they do start off the project is an analysis of their client including the client's position and background and understanding not necessarily credit history but payment history and those sorts of things. Also if the clients are known to them and they have identified them properly before, they would take culture and previous relationship as a factor into consideration. So lessons learned and information from previous projects with similar clients possess a crucial role. As he explains at early stages the main focus of their analysis would be on internal stakeholders:

'So when you start with the project, the only participants that are there is the design team as in the client, the architect, the project manager and various other specialists that might be appointed at the early stages, and you would obviously look at all those stakeholders, check whether you have any previous relationships with them, as in we've worked with them before, we've worked reasonably well…'

In this regard interviewee D points out that in most projects they try to do stakeholder analysis to some degree during the start-up phase, however, in some projects there might be a quit fast turnaround and they may not go through this process which consequently may cause problems for the project:

'Most projects that I've worked on there is a start-up phase where you can do that(stakeholder analysis). In some projects, there might be quite a fast turnaround and this might not happen but then that might cause actual problems if you don't do that analysis as in knowing who you're dealing with and how you deal with them best. '

7.4.1.6 Stakeholder Needs and Expectations

Interviewee C states that they employ a communication specialist to capture stakeholders' needs and expectations. They start with a series of workshops with SRO, project director and managers and meeting with the client and that is how they start off. The client would advise them of who they need to engage with. So the workshops will start to come out and they do brainstorming exercise, they develop a stakeholder map of who they need to engage with and it continues developing from that point. As participant C describes, they choose an engagement strategy for each type of stakeholder:

'…so there'd be a strategy for each type of stakeholder, whether it's to say it's informed, or you need regular engagement, there's a whole sort of different approach for each one.'

It is mentioned by participant C that clients might be under pressure from their investors or other factors to start and finish the job within a particular duration, although it might not have been approved so the project management team that comes in have to adopt this and run with it to address the expectations of stakeholders and they are on the back foot from day one. So the participant believes that in reality, these processes do not take place properly.

7.4.1.7 Stakeholder communication and engagement

As participant B confirms, no matter you are focused on external stakeholders or internal ones, the same principles are applied for managing either of them. He emphasises the importance of information sharing and understanding stakeholder group's requirements especially in multidisciplinary projects in which different internal stakeholders like operations team, finance team and engineering teams are involved:

'Say for example if someone comes up with scheme but actually, to deliver scheme we need to take into account how it is maintained and operated so the operations teams come into the picture, do we have enough funding so finance comes into the picture and then usually the schemes are multi-disciplinary so you have more than one discipline of engineering working into it so civils mechanical electrical and how you bring all those aspects into together it is all about exchanging information and understanding each other's needs and requirements.'

Participant A mentions that they communicate with stakeholders through meetings and brainstorming in order to amend the scope of the project on an on-going basis. Their stakeholders use different methods like meetings, telephone conversation, emails and other ways to inform the company of their required changes in the scope.

'It will be done by communication and meeting with stakeholders and brainstorming. It is quite often that clients that they work with will instigate change via meetings, telephone conversation, email and lots of different ways.'

Also, it is expressed that because they are in the service industry they have little opportunity to influence how stakeholders communicate with them. Their clients communicate in the way they feel appropriate, so often they rely on the company to establish a more structured communication matrix. While they negotiate a lot of their works, the interesting thing is that usually they do not receive clear briefs they have a discussion and then they often have an obligation for the needs to ratify the brief. Although he confirms that they believe in open communication and sharing information, but it seems that they approach communications in a passive way because they do not believe in the assessment of communications quality and they are more focused on the need to establish a process that aligns with the level of communication they receive from stakeholders.

'We do not have a need to assess the quality of communication with stakeholders it is much more focused on the need to establish a process that aligns with the level of communication we receive.'

According to what participants B explains, interaction and communication with stakeholders are important in managing their influence and attitude towards the project. They do this in their company through meeting with stakeholders and sharing information on a weekly basis, showing them their plans and what they are trying to achieve, understand stakeholders' requirements and the reason for opposing or supporting the project. So in order to make sure stakeholders are well managed there is a need for lots of communication and common steam in the forms of information sharing, continuous formal and informal discussions for understanding, influencing stakeholders and finding solutions for different issues:

'So you have to have a very committed team to make sure that stakeholder is very well managed and they are still behind that scheme. Obviously, this process is supported by lots of communication and common steam, working in terms of sharing information, there is a lot of formal and informal discussions which goes on, trying to understand trying to influence trying to come up with solutions. Obviously, we try to be open and transparent as much as we can so people will confidence in the process and in what we say.'

Face to face meeting is the most used form of communication and public consultation in participant B's company. They also assign committees and subcommittees for communication with specific influential stakeholders who raised a particular issue. Another frequently used communication tool by this company is presentations and particularly the presentation of BIM models to reach a better understanding of the product and what they are trying to do by the stakeholders:

'Presentation is obviously is one of the keys to use. Towards the end of some of the schemes where we have managed to develop a 2d model, it is not the only thing in BIM, but what I have seen is that the models can be used as an effective presentation to help them visualise what we are trying to achieve and it can actually deliver a better understanding of the product.'

As he continues, lots of time the stakeholders' concerns just because they cannot visualise the scheme can be eliminated by this method, then stakeholders will see that their interests or benefits will not be affected so the firm can turn opposing stakeholders to neutral and consequently to supportive ones.

Regarding building a relationship with stakeholders, interviewee B confirms that this is one of the most important aspects of stakeholders engagement because if you are able to successfully build a good relationship the communication becomes much easier, the level of trust increases and people start trusting you about what you are saying and then it is much easier to work together and engage.

Also, the Stakeholder engagement strategy for them depends on where the stakeholder is in their analysis for example if someone has low interest and low influence they may take a very different approach and they may keep them in the loop or communicate with them indirectly through emails, letters or advertising in newspapers. So depending on where the stakeholder is the type and level of communication varies and they have to deliver their message to that particular audience:

'Say for example if I am going to construct a new bridge then I can send a letter to the community on both sides without necessarily engaging but if someone is influential and I want to meet that person in which case i will go and meet him in person and obviously try to get his buy-in for this project.'

He –participant B- continues that engaging with stakeholders at every level is important for them. He believes that stakeholder engagement is important because if you don't know what are the expectations of stakeholder they can keep on adding to scope. They also use communication between different groups of stakeholders as an approach for resolving issues. For example, they get some of the stakeholders who are supporting the project to talk to stakeholders who are opposing the project and mitigate their concerns.

As mentioned before the participant C described that they use stakeholder communications specialists for the process of stakeholder analysis and run communication workshops with clients, project directors and managers to understand which stakeholder needs more attention or needs to be engaged and as a result needs more communication and information sharing. He points out that for bigger projects like programmes they employ communication specialists, however for smaller projects there may not be a need for that, and they may even employ press officer to deal with all communications:

'so on a big project, most of them are programmes rather than projects, you've employed a communications specialist, in fact, one of the jobs we worked for a Local Authority, we actually employed a press officer, his profession was press, so he dealt with all the communications, the mapping and the…'

Another use of these communications specialists is capturing the needs and expectations of stakeholders. Likewise, he admits that they use different engagement approaches and level of communication for each stakeholder, whether they just need to be informed or regular meetings and engagement, according to their importance for the firm. Then they start with certain ones and run regular meetings and they use other forms of communication like sending flyers for the rest of the stakeholders:

'So there are all sorts. So we start with certain ones there'd be regular meetings with them, so Local Authority, you'd be really meeting councillors and you'd be briefing in the town hall, to residents where it would be a monthly flyer, that sort of thing.'

Also, he emphasises the importance of the size of the project and the budget in hand for communication and stakeholder engagement as bigger projects can spend more on this issue because they have to regularly communicate with locals being influenced and particularly local councils:

'… It's an industry in its own right, and if projects haven't got that much money, they can't be spending on a team of people and getting engagement. I mean, I've worked on one job, which was a 5Billion job, and I think we had a team of 20 people in communications, 20 people doing just that, running workshops, going running meetings all around local towns, affecting this infrastructure project, this bridge, and they were organising things regularly to get them on side, engaging with the local councils about getting planning permission, so this was a massive one. We're talking large infrastructure jobs which are impacting the whole of the country, massive pieces of work.'

As participant C explains, communication management varies from job to job because depending on how big it is, it will have a net effect on the number of resources deployed on it. So there are some jobs where they have little to no person doing communications like a side job and project manager gets involved with it on a more loose basis, while on the bigger jobs, the billion-plus jobs, they get a dedicated team for that and they look at it from a regular press release, portals, on-site cameras and web portals to the project where people can go on and see what is happening.

According to what participant D says, they try to engage internal stakeholders through undertaking regular meetings for various purposes like fire design, structural design, etc. They use the stakeholder matrix in which the roles, responsibilities and influence of each stakeholder are identified to determine the participations for each meeting.

7.4.1.8 Stakeholder Influence and Response Strategies

7.4.1.8.1 Stakeholder Mapping

Regarding the stakeholders' influence on projects, participant B states that in addition to stakeholder identification they take into consideration their interests, expectations and level of power/interest as well which is a good sign for a firm in managing stakeholders influence. They undertake this process during initial stakeholder mapping to demonstrate their level of power and interest and understand their position towards the project and reach the optimum outcome of the project:

'That is part of initial stakeholder mapping. And then what happens is once they have done that bit then they will put them in four boxes which they generally use. And then it is analysed in the sense that where they want the stakeholders to be for the optimum outcome of the project.'

Plus, if they have a key stakeholder who is not engaging enough at different points of the project but they want him in a different box of stakeholder mapping then what they do is to develop a strategy on how they can take that particular stakeholder from that box to where they want him to be. So it seems that as a firm they use the 'Influence' strategy to obtain their desired outcomes from stakeholders. For instance, if there is a stakeholder who is not supporting the scheme but they want him to support the scheme they develop a strategy and identify the subsequent steps for this purpose. For executing that strategy which is defined in their stakeholder management plan, they meet with that person, share information with him on weekly basis or show him what they are trying to achieve, share their plans, understand his requirements and try to understand why he is opposing or supporting. So they use interaction and communication as a mean for influencing stakeholders.

'For example, an individual is not supporting the scheme but we want him to support the scheme so what we need to do with the strategy is identify in the subsequent steps and there is a step of executing the stakeholder strategy which is a stakeholder management plan in which we say 'we are going to meet this person, we are going to share information on a weekly basis or we are going to show him what we are trying to achieve, share our plans, understand his requirements, try to understand why is he opposing or supporting. So that interaction and communication have to happen.'

Also, it is mentioned that due to the dynamic nature of the stakeholder management process it keeps on changing so it is important to have a very committed team in place to make sure that stakeholders are well managed and they are still behind the scheme. Again, he emphasizes on the importance of communication and common scheme, information sharing, formal and informal discussions to come up with solutions and being open and transparent to gain stakeholders trust in what they, as a firm, say or do. Therefore, since BIM facilitates information sharing and communication in projects and provides a basis for boosting trust among stakeholders, it can address the majority of these steps for managing stakeholders' influence within projects.

7.4.1.8.2 Stakeholder Influence Strategies and Impacts

Interviewee B confirms that companies need to be careful about people because they can form lobbies and can come together if they can share similar views especially if they are opposing the scheme. In explaining how stakeholders can block a project from the progress he says:

'people could absolutely act as a blocker they do not want you to progress and some people may not be even willing to listen to you so we have seen people forming lobbies, protesting in front of your doors and apply political pressure lot of time because they are individuals very well connected in the society so they could be basically applying pressure from wherever they can.'

He believes that stakeholders can use various ways to influence the project. They use a proactive approach to manage their influence by public consultation in order to provide the opportunity for the public to express their views:

'We do give the opportunity to the public to give us their feedback so a lot of people are quite blunt in sharing their views and they can be directly saying they do not like it or they like it.'

But it seems that the majority of their focus and concern is about external stakeholders, particularly public communities, as the influence of internal parties is neglected.

Regarding the effectiveness of strategies used by stakeholders, the interviewee expresses that it is very difficult to say which strategy is more effective or harmful because it all depends on how strong their case is for the project and how strong their argument is against the points or issues raised by stakeholders. So satisfying everyone at the same time may not be possible but he believes being transparent, trusTable and clear about what they are trying to achieve and being flexible to a point where they can meet some of the stakeholders' requirements and at the same time delivering the objectives and outcomes of their own scheme are important elements to reach mutual agreement on issues.

'Well, it is very difficult to say which strategy is more effective or harmful because it all depends on how strong your case is for the project how strong your argument is against the points or issues raised by stakeholders so you can not satisfy everyone at the same time but as long as you are transparent, honest and clear about what you are trying to achieve and you are flexible to a point where you can meet some of their requirements but and the same time deliver the objectives and outcomes of your own scheme you can meet hem halfway through.'

However, participant C thinks that the effectiveness of stakeholders' strategies depends on the type of stakeholder so everyone has to be handled in its own right and there isn't a model answer, as such:

'It depends on which stakeholders again. If it's residents, they can have a small amount of influence, if they're politicians; they have a greater influence…'

So, it can be interpreted that by the type of stakeholders he means their position in the project and their level of power or interest. Likewise about internal stakeholders they use the same approach for managing their influence on the project as he mentions:

'Again it depends on what that level is. Most of them will just be kept informed. If they actually have a real impact, if they're a budget-holder, you know, or the end-user who is going to sign something off, then obviously that's different, how we deal with those points.'

Taking these into consideration their method of communication with stakeholders can differentiate according to their position as well:

'Everyone is absolutely totally different. Some it literally is a cursory email and others it's regular sit-down meetings with them, regular briefings. So everyone is totally different.'

Interestingly, it is mentioned that the contract can be used as one of the key factors for managing the influence of stakeholders. So in the contract, they may set up that certain stakeholders can have certain influence:

'so it might be that at certain points they have to sign off the floor plan, the seating areas, the soft furnishings, the carpets, those things you allow them to influence and other things you don't allow them to influence. In that scope, we're allowing you to have an influence on this, this and this. Other than that, you have no influence, because we've got to deliver it at that particular price.'

However, sometimes there may be someone along the line who can suggest a variation but actually, they haven't got to accept that variation, that is why it goes through that process of:

'…okay, who suggested the variation, what's its impact, how shall we take it on board, and who has the final say whether it's going to be implemented or not?'

As this interviewee explains the relationship between stakeholders and the position of the firm within the network of relationship is an important factor in the ability to influence the project. For example, because of their position in the project, the only one who can influence their work is the client because they work for the client-side. So if the client needs them to execute something and it is not within the scope of project works then their firm takes it into consideration as a variation. Then they get it priced up and check the impacts on cost, lifecycle and program and ask for client approval. So he confirms that the response that they give to those influencing their project is depending on the position of that particular stakeholder, for instance, that internal party's power, legitimacy of the request and the urgency of the request clients are making and how much power they have.

The interesting thing that is mentioned is the role of team members or workers influence on the project. According to one of the interviewees, the majority of rework being done nowadays is because of incidents caused by inexperienced or as he says 'cheap labour' coming on board and poor execution of project work packages. Although the workmanship has been off the map in stakeholder theory studies they could be taken into account as internal stakeholders. So managing and controlling these team members can have a remarkable influence on the scope of projects, although this issue can be viewed from the quality control perspective as well.

Another issue about stakeholders influence is the influence of decisions made by different parties involved in the construction process which may have various reasons like 'value engineering' but without investigating the impacts of these decisions they may result in negative effects. The interviewee uses Grenfell tower for explaining this issue:

'Obviously, with the Grenfell tower, I mean, there's this thing that somewhere along the line there's been some value engineering. Someone decided, didn't they, rather than using a non-combustible panel, they're going with combustible panelling.'

The interviewee mentions the users and governments as two stakeholders who can influence their work and project the most. The users usually impose changes on the project while governments can influence the project by making changes in funding rules:

'I mean, a stakeholder, the ones I see as stakeholders are the users, which they try to impose changes, they're the ones that really affect me on a day to day basis, if I've got a live operational job on, but it could also be government, where it's this funding and suddenly they change the funding rules, or there are some projects where you get funding at certain points, and if they stop the funding and the project folds, it will close, … I did work in Qatar and I was on a twelve-month, billion-dollar healthcare programme, which suddenly, the oil price dropped, suddenly no project, so as a stakeholder, the very highest level, suddenly the programme gets put on hold, there's no more programme.'

The size of projects plays a crucial role in communicating with stakeholders so there are projects where they have a small team to no person doing communications and it is almost a side job and the project manager gets involved with it on a more loos basis. However in bigger projects like billion-plus jobs, they have got a dedicated team for that and they use different methods of communication like a press release, flyers through people's doors, web portal and even using cameras on some of the sites where people can go on and see what is going on. As an example, the interviewee mentions his experience in the construction of a school in a residential area where people in that area were upset because of the traffic and parents offloading their children resulted in blocking the drives of residents and caused numerous confrontations between parents and residents. So they used flyers sent to the neighbourhood saying this is going on in your neighbourhood and somehow they could engage the parents and they asked for wardens around for this issue they even paid for one of those cars that go around with a camera on to discourage parents. For the resolution of this issue they also did the following:

'…So that type of stuff, you have to deal with. In that instance, we did employ, as I say, a full-time communications press person, and we engaged with the planners about what we could do about it, could we influence and put yellow lines around everywhere, and there was a whole piece about traffic calming, to slow the traffic down so children wouldn't get knocked over.'

This example and the way they managed this issue shows the importance of communication and information sharing with stakeholders for managing their influence on the project, although the main players were external stakeholders.

Another participant, E, said that in their company the contractors might be allowed to influence the construction process If they can see a different or better or more efficient way to construct what's been designed then that would be proposed in meetings and will be either agreed or disagreed and it will all be ironed out in a meeting, and that's the way it always has been for them.

Also, interviewee D confirms that the clients have a major influence on their project by making changes in the requirement while other stakeholders like contractors or fabricators have a minimal effect especially in major projects:

'Sometimes it's driven by the client that they will give their own matrix at the bid stage to say, you know, we want you to participate in the following activities and that would be used as a baseline for us.'

7.4.1.9 Organizational Responses

In this section, the strategies used by the interviewee's companies to respond to the influencing strategies of stakeholders on the execution of projects are investigated.

Participant A states that they are primarily customer-focused and therefore they have a desire to adapt to the requests and interests of stakeholders. For adapt, they identify what the implications are to make sure everybody around the table is happy to trigger the change. Because there may be consequences that may have not been foreseen, like programs when making these changes may impact on the program and the project will not be delivered for extra weeks or months after. He also affirms that sometimes they compromise with stakeholders request but it needs the second investigation which is trying to understand what has triggered the change and whether it is valid. So they could work with the client to understand whether it is needed or not because there are some situations where a change is triggered but it may not be informed by the right information so they can help the client to understand whether it is needed or not.

In this regards participant B explains that it is very difficult to say which strategy is more effective or harmful because it all depends on how strong their case is for the project how strong their argument is against the points or issues raised by stakeholders so they can not satisfy everyone at the same time. So he mentions transparency, honesty and flexibility in what they are trying to achieve as important elements and declares that they are flexible to a point where they can meet some of the stakeholders' requirements but at the same time deliver the objectives and outcomes of their own scheme to meet hem halfway through. So it can be interpreted as using of compromise strategy for dealing with influencing strategies of stakeholders on the scope. He also points out the importance of stakeholder engagement at every level in responding to their influence.

Another strategy that is used by participant B's firm is influence strategy where they get some of those stakeholders who are supporting to Project to talk to some of the stakeholders who are not supporting the project. So basically they use the group of stakeholders who are with them to help and mitigate the concerns which stakeholders have who are not supporting the project. They do this through communication, resource building and using the right resource and pitching at the right level. Likewise, he emphasizes the importance of understanding stakeholders' concerns because a lot of time what people miss in a stakeholder engagement is trying to understand why that particular stakeholder is saying whatever he is saying. Therefore, by understanding that they can put in the right resources to achieve the outcome they want to achieve.

Likewise, it seems that participant D's company use a compromise strategy in dealing with the stakeholders' influence on the scope. Although his main focus is on the clients' requests and influencing strategies as the main source of influence on the scope of projects. So they analyse the influence of the client's request on the scope and particularly the initial scope which they agreed upon, they define what the changes are for themselves and then they sit down with the client and project manager to negotiate the updates prices and cost. So he affirms that what the client asks for may result in increasing or decreasing the cost of the project depending on its impact on the scope of the project and this is the main agenda for those negotiations.

7.4.1.10 Stakeholder Risk and Uncertainty

As it is mentioned before, participant A stated that they use a matrix for recording stakeholders information which again will be used for managing stakeholders related risks as well.

Also, the interviewee confirms that risk management is used in their firm as part of the stakeholder management process because they cannot stop a project from progressing just because someone is opposing it. He says that it is a very dynamic process. So as part of the risk management process, they take into consideration the identified uncertainty, impacts and probability of that uncertain event to happen then they develop a risk allowance which is then part of their project cost.

Regarding main sources of uncertainty, he states that it all goes back to the key drivers for scope creep which is the needs for doing that project. So if someone changes the need of doing the scheme then that changes the scope. He then points out the role of external stakeholders who may have certain views of the scheme or want to achieve certain things for themselves from the project so they could come in and try to change or influence the scope.

In terms of sources of uncertainty Participant C express, that end-users and government are two groups of stakeholders that may cause uncertainty in a project. He says that end users may impose changes on the scope and affect his job and if the project is funded by the government they may change the funding rules or even stop funding project at certain points which again can result in uncertain events.

Participant D believes that internal stakeholders can be a source of uncertainty in terms of how the project is resourced by each stakeholder and their working pace during different stages of the project lifecycle:

'For example, the architects normally have to lead the pace and set certain requirements, set the layout, for example, before they haven't set the layout, you can't really do meaningful structural design because you don't know where your columns go…'

So he thinks the very key component of that is to make sure that each stakeholder is moving at the same pace towards the milestones and not putting all the effort in at the beginning and then doing nothing while everyone else catches up or sort of vice versa.

7.5 BIM, Collaborative Working and Integrated Project Delivery (IPD)

In this section, collected primary data are analysed according to the third research question in this study, "Q3. How effective is BIM in managing the scope of construction projects and preventing scope creep caused by stakeholder influence?" In addition, this analysis addresses the BIM, collaborative working and integrated project delivery themes of this research and their impact on stakeholder and scope management to validate the following stages of the Process Framework:

Primary stages

- PS1.Collaborative Working
- PS2.Setting up Integrated Project Delivery (IPD)
- PS3. Building Information Modelling (BIM)

Supporting elements

- Collaborative Working Engagement and Management
- IPD Implementation
- Common Data Environment (CDE)

7.5.1.1 BIM and Collaborative Working

It is declared by interviewee A that the key for them to work with internal stakeholders like clients is collaboration. So they do not work with individuals who are holding back information for their benefits because it tends to contradict the culture of the environment that they work in, therefore they would work with clients who look to establish project team as a collective rather than manipulative in certain situations.

Participant C claims that despite a lot of talking about collaborative working in the industry, it does not exist that much and nowadays working is more confrontational rather than collaborative. So he thinks people are still trying to maximise their profit in any way so they collaborate when they think it suits them and not when it does not. Although he believes that in future working approach will be changed but he says that at the moment the number of projects using the collaborative working approach is very low.

'BIM is great, and it's got to be the way to go because at the moment everything is so inefficient. Everyone's looking at everything from their own personal point of view, and that's about this collaborative piece, you know? Proper collaboration.'

It is mentioned by participant D that collaborative working has not changed that much in their company from what it used to be. Normally at certain times in the project, there are certain areas that they will focus on, so, for example, they would look at certain strategies, so what's the distribution strategy for the MEP, they would define key areas, key openings and things like that to make sure that the strategy and the envelope that the MEP engineers work in is clearly defined, which then informs managers and the architects for the space requirement that they need. So in principle, they would start with very broad strategies and space and area requirement and the architect would start with that information to find a space for these, and then they would go through various iterations to see how each discipline works around each other. In the researcher's opinion, it seems that they have developed their own way of collaborative working through creating strategies for each discipline and gathering information on requirements to improve collaboration through circles of iteration. Although sometimes it might be inefficient, it shows the importance of collaborative working among various disciplines of a project.

However, interviewee E admits the lack of collaborative working in projects as he says major conflicts arise when there are different internal departments working on the same project but independently of each other. In his opinion, the reason for that is when one of the internal stakeholders requires information from another, it is not forthcoming because they are just a kind of casualness about it so there's not the same level of formality as if it was external parties. So, it can be interpreted as a lack of established formal collaborative working processes in the projects.

'The main conflicts that I've seen are where there are different internal departments working on the same projects but independently of each other. Is where one requires information from another and it's not forthcoming because they're just a kind of casualness about it, "oh you work there and I work here", and so there's not the same level of formality as if it was external parties.'

Nevertheless, he admits that if as many participants as possible involved in the project during the early stages consequently the collaboration among them improve which results in optimizing design work quickly, optimizing construction methods quickly and handing over a far more efficient project in terms of physical and digital.

By saying the BIM success really depends on who is driving it and BIM intelligence of clients, interviewee D mentions one of their public sector projects to describe their process of collaboration. The collaboration primarily happens face to face around the table where they will have a two weekly design team meeting. Then they will have the model up on the screen and highlight clashes and issues and so the model will be very heavily used and basically becomes a record of design decisions made in a meeting which is reviewed post-meeting and then shared to the team and everyone goes and makes changes to their own information and then they share it two weeks later and then just keep on doing it like that. So that is a kind of an appropriate mixture of old fashioned meetings and using technology that suits everybody. Also, he thinks the simplest way to collaborate on a project is to look at the people that they have and the needs of the project and the size of the project as he declares in bigger projects collaboration would be too complicated due to the high number of involved stakeholders and required processes and hierarchies.

'It's when you start having hundreds of stakeholders and thousands of subcontractors and sub-subcontractors that doesn't work, and then you have the processes within processes and hierarchies under hierarchies and you basically then have a mega project with lots and lots of small

projects contained within it. I think the best way to use BIM to improve collaboration on a major project with a vast number of stakeholders is to keep it as simple as possible.'

7.5.1.2 BIM and Integrated Project Delivery

Regarding the integrated project delivery, participant D states that the very key component of this is to make sure that each stakeholder is moving at the same pace towards the milestones and not putting all the effort in at the beginning and then doing nothing while everyone else catches up or sort of vice versa.

'I think main uncertainties, the key ones that I experience over and over again is how the project is resourced by each stakeholder, let's say the architect, the MEP, and it's working through each project stage at the same pace, and whenever we find that, for example, the architects normally have to lead the pace and set certain requirements, set the layout, for example, before they haven't set the layout, you can't do meaningful structural design because you don't know where your columns go, for example.'

To reach this objective, he suggests that the project key milestones have to be broken down into smaller milestones to make sure that the projects, the stakeholders are moving at the same pace. So by considering small milestones from meeting to meeting they can sort out identified issues and certain things that need to be agreed upon. Hence, the researcher believes that by using work breakdown structure (WBS) this objective can be achieved to improve coordination among stakeholders and ensuring their move at the same pace and ultimately approaching integrated project delivery.

Accordingly participant E expresses that for integrated project delivery the stakeholders that should be appointed as soon as possible are the design team, QS (quantity surveyor) and the builder if one was going to go and construct the thing and also facilities manager even though he will have nothing to do for a long time. However, he mentions that facilities management is not undertaken in many projects because of its cost at the moment:

'…so they're, facilities managers, stage A+ and that's not happening fast enough on enough projects. I think there are projects where it does happen, but they're the big projects that kind of say we can afford it because they've got billions of pounds to spend.'

He continues commenting on integrated project delivery in terms of costs and stakeholders involved by saying there is a growing body of evidence that shows that whilst you may spend more money at the beginning of a project if you get as many people involved in the beginning as possible you will have a massive spending bump at the start of a project. But he believes because all those people involved will collaborate immediately the design and construction methods will be optimised and the project will be far more efficient digitally and physically and through this the spending curve goes down rapidly unlike the traditional methods where they used to spend a little at the beginning and the most at the end of the project. He also affirms that by using BIM and an integrated delivery approach companies can take a lot of learning to the next projects and consequently their costs will be decreased using these learned lessons.

7.5.1.3 BIM Impact on Stakeholder Management

By viewing the impact of BIM on the overall stakeholder management process, participant A believes that it can have tremendous positive effects on stakeholder management as it can facilitate consistent information sharing between stakeholders which can benefit the project and it can help the engagement of external stakeholders like utility companies. Plus he thinks that it has made the change in process of capturing stakeholders' needs and expectations and it can continue to do so if everybody within internal stakeholder teams has something to benefit from delivering that project. So BIM will have characteristics that benefit everybody within that team to a certain extent.

7.5.1.3.1 BIM Impact on Stakeholder Influence

Participant A states that BIM has a positive effect on stakeholders because every decision made is informed and all team members have access to more relevant information but probably for those stakeholders who are internal rather than external ones. Because the external stakeholders are outside that team and they don't share the same objectives so they have less to benefit from investing time and effort. He admits that BIM can greatly provide agile responses to the negative influence of stakeholders on the scope and preventing scope creep, however, he is not sure whether BIM can prevent scope creep itself.

In this regard interviewee, B affirms that BIM can't do it by itself, what they understand is that BIM is a tool that needs to be used effectively to get efficiencies and do things more efficiently to deliver more value and to do more effective communications. He also confirms that it has the potential to positively impact the stakeholder engagement process and again it is a fantastic communication tool so definitely enhances the level of communication and its quality.

He also believes that BIM can be effectively used to mitigate the influence of stakeholders and help in taking into consideration the stakeholders' view because as he says a lot of time stakeholders have concerns that are not genuine and the firm can use BIM to demonstrate back to them this not real concern. So through using visualisation and models of the end product they can look at different aspects of the scheme or different aspect of stakeholders' concern because it is much easier to get stakeholders to buy into what is proposed by visualisation. But again he emphasises that it is a tool and how effectively they use it is up to them.

Interviewee C points out that although if contractors or clients have not got the will to use BIM they will not use it neither but most of the time regardless of what the client says they will use it because they believe that it is a good thing and it will save them money.

However, participant C claims that BIM does not necessarily facilitate the flow of information between stakeholders due to problems like software compatibility. He continues by saying that for big contractor companies it can save money but it can result in technical issues and errors and cost money as well, besides the client-side of projects at the moment do not see the value in it for them. So he states that in the real world, clients have not realised the long term benefit of using BIM, especially asset management, and they only care about contractor keep the works on track:

'They just see it as the contractor making sure their work comes in on time, making sure there are no problems. They're not seeing the benefit of the 25 years of running my building and the heat cycles and the maintenance, and you need to change your window in ten years, the window you've got at the moment is this, this is the serial number, the glass, the glazing, the double glazing, it's all the components, so the asset management, which I see as a big part of BIM going forward, the construction, but that's not yet been recognised as the value.'

Interviewee D points out that the number of participants or stakeholders is increased in the BIM projects especially during the early stages for defining the scope because they have an extra deliverable,3D models, which is a little bit more complex than it used to be and that extra deliverable being the federated model where you used to do maybe only sketches or very simple 2D drawings.

Another impact of BIM on stakeholders mentioned by interviewee D is the clients' perception of cost, because with increasing BIM maturity in projects the amount of required works is shifting towards earlier stages so the old fee percentages and the old perception of the client as in what level of fee is needed for certain stages has changed to somewhat.

He also believes that using BIM in projects can help to engage stakeholders in the early stages of the project to get their feedback and develop the design:

'… as we develop a scheme for a library, the library users and the librarians were very closely involved in that, and various different libraries were analysed and, you know, certain scenarios were looked at…having the conversation and the feedback early on whether it would work or not.'

It is also mentioned by interviewee D that by taking each stakeholder along the journey and visualising each step of the project everybody will know what they are buying into at each stage and by receiving their comments they would be able to capture stakeholders' needs and expectations at an earlier stage rather than later on and stakeholders would have a better understanding of the project in comparison with traditional 2D drawings. So in our opinion, this can help in reducing the negative influence of stakeholders and positively using their comments.

However, participant E believes that BIM does not do anything itself and this is people being better at including other people by using BIM. He thinks that BIM is really a catch-all phrase for process and those processes always have existed but never been formally ratified and people are trying to embed these into the industry. He continues by saying that BIM has been recognised as a kind of becoming its own thing globally and it's got a projected value, but it really shouldn't be separated, it is a process primarily and in order to be able to deal with stakeholder conflicts and reduce their impacts on the project through BIM, stakeholders should be appointed as early as possible during the project lifecycle. He states that the main stakeholders that should be appointed as soon as possible would be the design team, QS and the builder together with facilities management despite the latest will not have that much to do for a long time but ultimately facilities managers are the ones who are going to manage the asset and he believes that they should be able to influence the design.

'I think the main stakeholders that should be appointed as soon as possible would be the design team, QS and the builder if one was going to go and construct the thing. So you have those who are going to design it, those who are going to say how much it's going to cost and those who are going to build it, and really the facilities management as well, even though they will have nothing to do for a very long time, ultimately the facilities management are those who are going to manage this asset, the digital and the physical. They should be able to influence the design.'

Despite the other participants, interviewee E believes that scoring and prioritising stakeholders in BIM project can create tension so they approach it warily because in their opinion everyone has influence over the project according to their role and responsibility from the design team to other stakeholders.

He declares that in order to deliver a successful BIM project two groups should be educated enough about BIM, clients and people who go and build it.

7.5.1.4 Common Data Environment (CDE) Impact on Stakeholder Management

Regarding Common Data Environment (CDE), interviewee E expresses that it is usually set up for those who need to use it and those who are appointed to the project. So he believes that the client should have access to everything that has been shared, published and archived following BS-1192 guidelines and processes. However, he affirms that the shared area generally exists for the design team but anyone who's been appointed to the project should have reasonable access to the CDE according to what they need access to.

In terms of confidentiality of information, Participant E explains that depending on the system that's used, areas of CDEs can be locked down, parts of the files can be password protected. Although security is an issue, as he says, and there are issues of confidentiality particularity if they are working for one of the government departments but usually if the project is of a sensitive nature the client will own the CDE and then they need to be granted access in and so that's where the security barrier is actually on the point of entry. Also about sharing information with external stakeholders, interviewee 'E' states that if they had a project that was of public interest and they wanted public consultation then the information will be created and shared in a way that the public can get to it easily, outside of the CDE like PDFs or PowerPoint which then would be put in a published folder with unrestricted accessibility.

It is mentioned by participant D that in a very short paragraph they set out the common data environment requirements because all they need to provide at the bid stage is to provide a clear understanding of the cost required so the person involved in the bid will be able to price with it.

7.5.1.5 BIM and Communication

Regarding the impact of BIM on communications and information sharing, participant A states that one of the fundamental BIM principles is the recognition that information is generated to benefit the wider project team rather than staying with the old group of people. So he affirms from a project management point of view that you should have access to information that without BIM you wouldn't have access to before, you can have a better understanding of what the implications are on various sequencing of the project, a more detailed understanding of the program and consequently better interaction between different parts of the project team. For achieving this objective he describes the following steps that should be undertaken:

'You should form the outset map out information flows and information transfer so that you consider how information is generated to make sure other members of the team will benefit from it.'

He also points out the reasons why information flow cannot flow as regularly as it can within an internal project:

'There are security reasons why information flow cannot flow as regularly as it can within an internal project and that is from both sides, no BIM information that our client does not want to us to share with stakeholders and no BIM information within stakeholder organization that they don't necessarily want to share with or they are not able to share with the parties.'

So it can be concluded that due to security issues stakeholders decide who to share information with and who should not share information with.

Also, participant B admits that the presentation is obviously one of the key tools for sharing information. He admits that towards the end of the particular scheme they use BIM models as an effective way of presentation in order to help stakeholders like clients visualise what they are trying to achieve and deliver a better understanding of the product. So the stakeholders' concerns will be eliminated by visualising the product and seeing that their interests are not threatened.

Likewise, participant B states that the information security and assurance aspect are very important. So there are certain parts of information that they can share with all stakeholders and there are bits that they cannot. But he believes that BIM can tremendously help in sharing the vision and in sharing the data which can be publicly shared with stakeholders and showing them the final outcome. Plus, he affirms that having a single source of truth can build trust and reliability in terms of communication and engagement.

In this regard, participant C confirms the positive impact of BIM on the information management of projects and particularly mapping and recording information on proposed changes during the project lifecycle.

Also, participant D admits that BIM can be useful in communication and sharing information with stakeholders. Particularly, he alludes to its ability to share information about clash detections and what each participant has discovered:

'For example, the architect goes through the model and find a major clash between structure and MEP and architecture so there's a multidisciplinary clash and you would then have a link back to your model to see which area that actually is, so you see the clash description in a picture but rather than having to find it in terms of gridline references and stuff, you would be able to click on it and it would send you straight into your model in the right place and so the confusion about where is this area that is clashing, or where is this area that needs to be resolved is actually a lot easier…'

So he believes that it will result in better clash definition and clearer communication because everyone is visually seeing the clash and then getting guided into their data environment to find the exact location where this problem is happening.

Participant E, emphasises the importance of simplifying communication and information, particularly for people who are working on site. Therefore they try to convert the big complicated language to something simple for them to understand. However, it will cost the client money and because of that, he thinks that some companies end up with quite complex media messes following British standards and BIM documents. Besides, he mentions the importance of information security and confidentiality by saying that depending on the system that is used areas of CDE can be locked and parts of the files can be password protected. He says that if it is a project of sensitive nature the client will own the CDE and participants will need to grant access, so the security barrier is actually on the point of entry. However for public projects where public consultation is needed he quoted:

'If you had a project that was of public interest and you wanted public consultation then the information will be created and shared in a way that the public can get to it easily, outside of the CDE. It's in that instance the CDE exists for the project and it could be that some PDFs or a PowerPoint are put in a published folder and the CDE and that published folder has got unrestricted access.'

7.5.1.6 BIM Impact on Scope Management

Regarding the impact of BIM on scope, it is stated by participant B that the BIM is not additional or extra scope because documents like EIR defines the brief for information, although he affirms that in transition there might be certain overlaps but in long run, he believes that it is not extra. He affirms that there may be the need to take initial investment but it is not duplicating or increasing the scope and it will result in doing things more efficiently and reducing the scope in long run.

It is stated by participant D that with the BIM process the conflict solving and level of design is shifting so with the maturity of BIM increasing, the amount of work that is put into the project is actually shifting towards the earlier stages, as in resolving clashes and defining a project. He also alludes to the change in the required amount of works at each stage:

'…So for example, if we deliver a stage one and two design for RIBA stages, we didn't use to have to produce a 3D model at that stage. Nowadays on projects of a certain size that is happening, so where in these stages we normally would just deliver key plans…'

He also declares that the amount of people that are needed at the early stages to define the scope is increased because they have an extra deliverable which is a little bit more complex than it used to be and that extra deliverable being the federated model where they used to do maybe only sketches or very simple 2D drawings.

By giving an example, participant D describes if the scope record of information or site information according to which the models are developed is not right then it can cause a clash in contractors work, consequently, they have to update their model and send it back for revision, particularly in refurbishment projects. In the researcher's opinion, it shows that although visualisation can help tremendously in understanding the scope of project and clash detection, if it is not defined properly at the outset it still can result in issues:

'So on one of our projects, for example, the steel manufacturer would use the model that we have passed on and develop their steel details from it, so they would do a detailed setting out survey onsite and especially in refurbishment situations, they might find some situations where the design information that we may have used at the beginning of the project from record information is not what's actually there on site, so for example, a concrete column might be 100mm away from the position where it should have been on drawing records so once they've Figured this out, they will then update their model and show that clash and that new environment for us to find a solution, so they would develop the model further.'

He adds on by saying that they use BIM and certain tools to visualise various features and functionalities, or milestones, of the scope to see how these can help the scheme and in order to inform clients about the appropriateness of their design and getting clients comments and feedback early on the project. They engage the key stakeholders in the early stages for defining the scope and they even do an analysis of similar projects for identifying features and functionalities. Through this, they will have a more clear vision of the scope and clients' requirements. He explains this process in detail by using an example of one of their project:

'…as we develop a scheme for a library, the library users and the librarians were very closely involved in that, and various different libraries were analysed and, you know, certain scenarios were looked at where we said, you know, in this library that works particularly well and in this

one it doesn't, and then having the BIM environment to create or to use certain tools for walkthroughs and getting an impression how this could work helped to inform the scheme, which in retrospect would inform the client very early on about the usefulness of the library that he gets back, so we would define, okay, you need a book return area and this return area is interfacing with certain other areas of the library, and hence it has to have a key position within the library. So you can work around those key items and position them very early on in the design.'

Participant D mentions that one of the tricky issues regarding scope is the dimension of time in terms of how long does it take to build certain things because in this regard the expectation of clients is sometimes far from reality and using 4D BIM to show the dimension of time can address this issue. So some companies use the 4D approach to show the timeframe of activities in terms of what is next and how long it will take. He mentions Birmingham New Street project as an example in which they used the 4D approach where they showed at this stage the following item will be demolished in this area and the following item will be built so everyone knew exactly where the main activities would happen. In order to be able to do that they had to look at a big task and then breaking it down into little tasks to make it manageable and visualising those tasks helped to see the other interfaces that might be impacted. So, the 4D model in that case will inform each process and will highlight to each stakeholder what processes are involved and what opportunities there are to optimise.

Also, participant E affirms that the correct format 3D model and project program can be shared and linked together by adding parameters like time and cost. He continues by saying that most of the time when that happens it sits on local servers in the Work In Progress (WIP) area to serve the people who've created it, but they can be shared and put onto the CDE. Accordingly, he explains they have built a Revit model, that will be exported to be an IFC file and then the project managers build their program and then he will import the IFC file, then project manager links objects and tasks together because he knows the project better.

Participant E explains that the Task Information Delivery Plan (TIDP) by the leader of that task which could be an entire discipline or a volume or a zone within a project. Therefore, BEP needs to define what these tasks are in order to map out exactly what they are going to produce within the remit of that task so everybody understands what they are going to get from them at what level of maturity, at what project stage. Then the MIDP is obviously bringing all of those task plans together and that needs to be driven by the project management side of a project.

7.5.1.7 BIM and Scope Creep

Participant A confirms that BIM can help in the reduction of scope change requests and better assessment of what the impatience is because they have access to the right information. This interviewee explains that the real opportunity is to deal with information to inform decisions. So when they experience scope change the fact that they have access to the right information allows them to better assess what the implications are and what the consequences are. He also affirms that it can help in terms of clash detection, program management and impact on other disciplines or other aspects of the project. He also admits the usefulness of BIM in managing stakeholders influence on the scope:

'BIM can greatly provide agile responses to the negative influence of stakeholders on the scope and preventing scope creep.'

Likewise, participant B confirms that BIM can reduce scope change because a lot of time what happens is that people are unable to visualise completely what they are trying to achieve or people are not able to adequately define their needs so if the things are presented to them early on and if they know how the final product will look like these issues would be addressed. Accordingly, it is mentioned that if the person who defines the needs can see the visualised product and if there is a difference between what he thought and what is visualised then he can come back quickly to them and ask for revision. So he believes that dealing with changes early on the project and before completing the scope baseline is much more efficient. Also, he points out the importance of information in preventing scope creep through identifying issues, clashes and gaps in the information:

'Again lot of time scope creep happens because we are unable to see the issues and clashes but if you have the information presented to you in a form where can actually identify those clashes and the gaps in the information it can potentially reduce your scope creep.'

Although participant C confess that because of his high position in the projects as project director he may not see BIM impacts very closely, but he affirms that clash detection is one of BIM benefits for managing the scope of projects. He adds that information management for all sorts of things and particularly scope change is beneficial and BIM helps to map out these changes and project managers updated on changes. He concludes that BIM is a good tool and it is not just an IT platform, it is a way of working. So on big projects if it is set up from day one and if it is fully integrated into an electronic project management system when a change is requested it will be hooked up to the BIM so they would be able to see the impact of fundamental changes by tracking asset and component tags and forecast the cost so everybody will buy into it. He declares that at the moment many things in the projects are inefficient and people look at aspects of the project from their point of view so BIM can bring forth efficiency and proper collaboration.

Participant D states that to some extent BIM can help to prevent scope creep through better defining the scope and deliverables, but he thinks in terms of managing and defining the level of details there are still problems in the projects. He mentions that some companies may use RIBA stages level of detail for defining the BIM level of complexity and the level of information provided at each stage.

As mentioned before for each project they look at similar previous projects and develop certain scenarios in order to define the specifications and then use the BIM environment to visualise the defined scope and understand which aspect of it works and which does not so they can get clients' impression on those aspects and define the key scope milestones early on during design stage. However, he believes that there is a difference between design development and scope change because the latter means changes in the specifications of the project.

'I think the key client changes because there is a difference between design development and scope change. The scope change is, the scope is we need a library that accommodates X thousand students, and we need that many books in the library, and that much storage.'

It is mentioned by participant E that BIM does not do anything by itself because BIM is a catch-up phrase for processes that existed before but never been formally ratified, so this is people who can benefit from it by including more people so he believes the way in which BIM can help to resolve the conflicts and reduce their impact on the project is to include and engage as many stakeholders as possible during early stages.

'…in terms of managing scope and scope creep really, it's more to do with people talking with each other and using tools as best as they possibly can. I don't think you can create more process to manage an issue that is originated with people.'

He continues by saying that if all the participants do their job properly in the BIM project then scope creep cannot and should not happen but it can happen if processes that already exist are not properly laid out and rolled out at the beginning of a project. So, then the risk reduction and safety targets of BIM would be approachable when the processes are being followed correctly from the beginning. Then he alludes to the meaning of doing the job properly as having a BIM manager on the project management side, producing EIR by the client, producing pre-contract and post-contract BEP and setting up a proper common data environment (CDE).

'I think what people would then seem to get is the maximum risk reduction and safety comes when the processes are being followed correctly from the very beginning. If there is a project management side of a project has a BIM manager, if the client produces an EIR and ideally an AIR and an OIR as well, that is given to the relevant people a BIM execution plan is created correct, a pre-contract and then a post-contract, the CDE is set up.'

So he concludes that for the project to be successful in terms of scope management and preventing scope creep, everyone should fully understand everything that is expected of them and they deliver on time and then you realise the reductions. This can be interpreted that even in BIM projects the expectations of stakeholders like clients and delivering required works on time is crucial. In addition, he points out the importance of training and educating various participants in the BIM project particularly clients and BIM team members.

'…two main groups I think that need the most education about BIM are the clients and the people who go and build it. If you can hit those two groups I really in terms of hierarchy, those are the top and those are the bottom. If they can completely understand their part to play then the whole thing will be totally transformed.'

7.5.1.8 BIM Maturity Levels

Despite the mandatory use of BIM by the UK government, participant A states that BIM maturity is various from project to project. The maturity to which BIM is applied to the project depends on the appetite of the client and they cannot control that.

Also, participant B declares that they are trying to reach BIM Level 2 according to government requirement in the public domain. He also affirms that there are a lot of organisations that are investing a lot in developing systems and focus primarily is on the technological side of things like building and accommodating BIM environment, engaging with supply chain, train them to use accommodating environment so there is one or single source of truth. Although they are still working toward level 2, he thinks in the long run BIM is working towards level 3 and beyond because he believes that BIM should be part of the decision-making process and stakeholder engagement through all the lifecycle of the asset.

'So it is just not the capital projects which we are building so it is not about creating the BIM or implementing the BIM principles for capital projects but also taking the principles beyond the project close to the asset management side of things and then bring it back to the end of the asset lifecycle. So that is a long term expression but I think currently what I do want is trying to achieve level 2 maturity.'

Participant D explains that in smaller projects, less than 10 million, defining the level of detail and preparing BIM document like pre and post BIM Execution Plan (BEP) is problematic because of the cost they have to spend during tendering stage and accordingly majority of private sector projects of this size are not complying with BIM level 2. So, he points out the importance of finding a lean way to understand the level of detail and prepare BIM documents.

'So the problem is that there should be a lean way of having an understanding of the level of detail, and most of those projects aren't actually BIM level two, but, you know, they might be public projects of that value that have to be level two, and they have to be properly done.'

In addition, he mentions that they have been using 3D modelling in their company for the last 6 years and then they reached BIM level one for the majority of their projects until the last two ones in which they delivered BIM level 2.

Also, participant E confirms that their company involved BIM for many years and they were certified with the BRE BIM level 2 certificate which basically says that they have the processes in place to deliver a project to BIM level 2 and they received that three years ago.

7.5.1.9 BIM Crucial Documents for Stakeholder Management

Regarding the crucial BIM documents, interviewee A believes that BIM Execution Plan (BEP) is the key to the successful delivery of the project because BEP is the thing that ties all together and should include stuff like information flow and the full interaction with internal and external stakeholders. So, it is mapping out the process and establishing the process from the outset. However, he thinks that there is still a lot of talk about what BIM is and whether it is the application of particular software packages or it is so much more than that. He declares that BIM is a project-specific proposition so the owner of that project, the client, will write the EIR which is an information brief and then the team will respond to that EIR and produce a collective BIM execution plan.

In contrast, participant B thinks that EIR is the key document to capture all the requirements because it identifies all the deliverables which in a way is a direct reflection of scope. He also points out the importance of RACI which is an acronym for responsible, accounTable, consulted and informed that can be effectively used to communicate with stakeholders in terms of what is expected from different individuals. Plus, it is mentioned by him that certain parts of BEP can give a lot more insight on how the scope will be delivered and if someone does the BEP properly they could potentially identify gaps in information which definitely adds value in terms of creating efficiencies and how things are done.

In terms of preparing and using BIM documents, participant D states that it all works well if everyone knows the general standards because at the beginning they just say these standards are applied and everyone knows what they are talking about and then they only have to actually mention in that document what they want over and above that standard.

Interviewee E explains that if the BIM manager sits as part of the project management team then they will provide all of the BIM documents. So, they will give the EIR and then the BIM execution plan and then ultimately they will give to the project team the task information delivery plan. The BIM protocol and all of that documentation should come from them, but they should all have input from the designer team, so everyone should have filled out a BIM competency questionnaire and then the project management side or information managers should have gone through all of the BIM needs like what software are you going to use, how're you going to do the BIM here so we can collate into one project.

7.5.1.10 BIM Crucial Documents for Scope Management

About the crucial BIM documents for scope management participant B claims that employers information requirements, EIR, is nothing but scope document so what they have been traditionally doing is preparing a project brief, now what is the same is that in doing project brief they create a document which defines the brief for the information. So he believes that EIR is the key document or the scope since it captures all the requirements and deliverables and therefore it is a direct reflection of scope.

'I think definitely EIR is the key document to capture all the requirements because ... differently identifies all the deliverables so what needs to be delivered which in a way is a direct reflection of scope…'

Another document which he states as important for the scope is BEP as he says certain sections of BEP can give a lot more insight on how the scope will be delivered and if it is properly done, the BEP, can potentially identify gaps in the information which can add value and improve efficiency in how things are done.

'…certain sections of the BEP can give a lot more insight on how the scope will be delivered and if someone does the BEP properly they could potentially identify information gaps which adds value in terms of creating efficiencies and how things are done. I think EIR and BEP are the key documents.'

Participant D pints out an issue in BIM projects' documentation which is if the project is not done properly the level of detail might not be defined 100 percent at the tender stage and consequently Pre-BEP, Project BEP and contract BEP will not be defined as they should be. He expresses that although on major projects it is fairly done, but on projects less than 10 million it is going to be a problem because in smaller projects the smaller things are not set up well like standard documentations. He affirms that their company has just got those documentations in place and they just have a Pre-Contract BEP and contract BEP that they use and they have a template in case the client or project manager hasn't got it because they have found out that if they do not steer it then it will be missed. He mentions that bigger projects need to be more defined as there will be bigger documentation on what is required however in smaller projects, sort of ten million and under, nobody can read big documents for defining the scope so they spend less effort and time for defining the scope of required information in Pre-BEP document during the bidding stage and they try to keep it lean and short. Interviewee D explains that the Pre-BEP document should only highlight the level of design, BIM maturity level and the level of details and deliverables at each stage. Consequently, by using general standards particularly BEP document the project managers can clarify what is required in terms of common data environment (CDE) requirements providing project server, tasks, costs, etc. for the bidding process.

7.5.1.11 BIM Positive Impacts and Challenges

In this section, we will investigate the positive and negative impacts of BIM on the management of projects according to the answers presented by participants.

Participant A mentions access to the right information at the right time as a positive impact of BIM which helps inform decisions made during the lifecycle of the project. Better coordination, risk reduction and a greater level of details through using software earlier on the project are other positive effects mentioned by this interviewee.

However, in terms of negative effects, he is worried that using software to produce a greater level of detail early on projects may circumnavigate important stages in the design process.

Also, participant B believes that BIM can bring forth benefits like greater efficiency, reduced waste and pushing the firms towards more joint decision making. He also mentions that it promotes more open and transparent communications and it can drive the right behaviours which result in greater efficiencies.

In terms of challenges, he points out the cost, technology and changes as some of its issues. So the industry has to make that initial investment into this and most importantly it is a people change programme in his view because at the end of the day if people are not trained to use BIM technologies and processes or people don't change the way they work using the system processes it is not going to deliver benefits.

Accordingly, interviewee C affirms that clash detection and improved facilities management are advantages of BIM in this industry. However, he declares that despite the government mandate some people in construction companies do not adopt it and even government departments clients do not actually recognize it or use it in their projects.

About the negative impacts of BIM, he alludes to some of his experience in working with governmental clients where the compatibility of IT systems caused trouble. He also mentions that although contractors benefit from using BIM in a various way but the clients don't yet see the value in it for them because they just see it as the contractor making sure their work comes in on time and they do not recognise the value of facility management for future of their project. He explains this is because of BIM costs which will be on clients' shoulders and they still see it as an additional cost.

Participant D confirms that BIM can partially be advantageous for projects in better definition of scope and preventing scope creep in terms of deliverables. But he states that there are still problems in many projects in terms of defining and managing the BIM level of details. He also mentions that it is not a negative or positive, it's all about the perception of the client because with the maturity of BIM increasing the amount of work that is put into the project is actually shifting towards the earlier stages of the project so in contrast with traditional methods clients need to spend more during early stages rather than stages at the end of the project and therefore it needs a change in perception of clients for using BIM. He also argued that the increased amount of needed participants during the early stages of projects for the production of a federated model while before in traditional approach they only had to produce sketches and 2D drawings. Besides, he thinks one thing that at the moment cannot be very well visualized and which is a tricky one is the dimension of time as in how long does it take to build certain things, sequencing and breaking down various milestones.

It is mentioned by participant E that advantages are when the contractor is the client to the rest of the design team so they are able to push the BIM, particularly if they are involved from the very beginning, and so there is immediate consistency. So a BIM execution plan exists before all stakeholders are involved and then is issued to them and they add their part and then it is updated by the contractor client owned the common data environment and invites everybody else in. Therefore, consistency in all the collective platforms, file naming conventions and all that stuff is in place and because they are directly under the client they have immediate access to all the information the client wants and needs and how they want it and then that can spread that out quite quickly.

Optimization of design, construction methods and delivering more efficient physical and digital product caused by immediate collaboration are other benefits of BIM in projects. He affirms that although the client may have to spend more money at the beginning of the project but as the project progresses the amount of costs decrease so the client will spend less at later stages and save money.

In terms of BIM challenges, interviewee E expresses that in a non-designer build contract where the architect is a design lead and then they have a design team and the contractor comes along later, it can take longer to reach that common ground. Because then they have got an architect driving usually civil or structural engineering, an MNE consultant initially, needs to come in with all their BIM baggage and then it takes longer to thrash it out and reach some kind of middle ground that suits the project rather than one designer. He affirms that it is more related to the culture in business as when it is driven by the contractor in a DMB they set the tone immediately. And it’s already there, it exists.

Another BIM challenge he mentions is producing a complicated communication system in the project by following BIM documents and standards and the need for simplifying BIM language in projects and particularly for site workers who may not know about BIM at all. However, he believes that this challenge happens because simplifying BIM language for people on-site will cost money and that is why sometimes they end up with media messes following British standards.

7.6 Summary

This chapter introduced the way in which the collected primary data were analysed. The main aim of this analysis was to validate the components and elements which constitute the developed Process Framework. For doing this and to avoid bias, rather than providing the interviewees with the developed Process Framework and get their feedback, the interview questions were designed around the components and concepts involved in the Process Framework such as primary stages, main stages and supporting elements. Plus, a scheme of codes was developed based on the components of the designed Process Framework for analysing data collected during the interviews. In section 7.1 the developed scheme of code groups for data analysis was described which includes the following code groups:

- Scope management and scope creep

- Stakeholder management, influence, uncertainty and communication
- BIM, collaborative working and integrated project delivery

An evaluation of each of these groups and associated subprocesses was then presented in sections 7.3 to 7.5. In the next chapter, the findings from this analysis will be discussed in further details.

Chapter 8 Discussion of Primary Data Findings

8.1 Introduction

In this chapter, the findings from the primary data collection and analysis process (chapter 7) are first discussed in section 8.2. Then the Process Framework is updated with these findings and the finalised version of the Process Framework is presented in section 8.3. In section 8.4, a number of conclusions are drawn about key parts of the work undertaken and answers to the research questions are presented, and finally, section 8.5 contains a summary of this chapter.

8.2 Discussion

8.2.1Stakeholder Management Process

By investigating collected primary data it seems that there is a need for a consistent, rigidly defined and well-granulated process for stakeholder management as participants A, C, D mentioned the majority of companies manage stakeholders instinctively and by using experience and lessons learned due to variation in projects' size and budget. It is stated that while in smaller projects stakeholder management process may be neglected due to lack of time, in bigger projects the complexity and amount of people involved cause this issue. Although, they still use stakeholder management tool like stakeholders map to identify and categories them and stakeholder matrices to record stakeholders' information and responsibilities but the majority of them do not have a separate and formal stakeholder management process in their organisations.

It seems that there is a disagreement between participants C and D in terms of stakeholder management process in the project with different sizes. Participant C believes that smaller projects may begin from scratch while bigger projects may have most of the project processes, in place already; But the size and complexity of big projects and the diversity and expertise of stakeholders may result in stakeholder management being neglected. However, participant D stated that it is more worthy to undertake a stakeholder management process in bigger projects in which more stakeholders are involved. Table 41 captures the flaws in current stakeholder management as stated by participants.

Table 41 Flaws in the Current Stakeholder Management Practices.

Participant	Flaws in the current stakeholder management practices
A	Managing stakeholders through experience and lessons learned
D	Lack of a formal stakeholder management process due to variation in project size and budget and lack of time
C	Poor, ad hoc and unclear stakeholder management process due to project complexity

So all said above, justifies the need for designing and establishing a consistent, integrated and step by step stakeholder management process in construction projects.

8.2.2 Stakeholder Analysis

In terms of stakeholder analysis, participant A, B, C and D confirm its importance, particularly the identification of stakeholders. Participant A stated they take into consideration both external and internal stakeholders but the main focus of their internal stakeholder identification process is on 'stakeholder culture'. To fulfil this objective, they use a stakeholder tracker to record stakeholders' information in a matrix. Also, participant B stated that they undertake a stakeholder identification process to identify stakeholders influence, interest and power through the stakeholder mapping technique. Another part of their identification process is determining stakeholders attribute towards the project in terms of supportive or opposing and developing appropriate strategies for managing them. They also categorise stakeholders into internal and external as both of these groups are important for them. Also, participant C admits they perform the stakeholder identification process by running workshops through employing stakeholder communications specialists. They also use the stakeholder mapping tool to understand which stakeholders need more attention to be involved. Also, participant D stated they analyse their clients during the early stages of the project including their background history. If they have worked with the clients before, they would take into consideration their culture and previous relationship as well by investigating learned lessons. So, the main focus of their analysis is on internal stakeholders. Although he mentions in the majority of their projects they do stakeholder analysis to some extent during the start-up phase but in some projects, they may not go through this process due to fast turnaround in the project. Table 42 summarizes the processes of stakeholder analysis in each interviewee's organization.

Table 42 Summary of Stakeholder Analysis Processes.

Participant	Stakeholder Analysis Process
A	-Stakeholder identification -Categorise them into internal and external -Analyse internal stakeholder culture -Stakeholder tracker matrix
B	-Stakeholder identification -Identify stakeholders influence, interest and power -Stakeholder mapping technique -Identify stakeholders attribute -Categorise stakeholders (internal/external) -Develop a stakeholder management strategy
C	-Stakeholder identification -communication workshops -Employ communications specialist -Stakeholder mapping
D	-Client analysis -Background check and lessons learned -Analyse stakeholder culture

8.2.3 Stakeholder Needs And Expectations

In regard to managing stakeholders' needs and expectations, participant B emphasises the importance of information sharing and understating stakeholder group's requirements especially in multidisciplinary projects in which different internal stakeholders from various disciplines are involved. Likewise, participant C stated that they capture stakeholder needs and expectations by employing a communication specialist and running workshops with the participation of internal stakeholders. However, he believes that this process is not done properly in projects due to the pressure from investors to finish the job within a particular duration of time.

8.2.4 Stakeholder Communication and Engagement

Participant A mentions that they communicate with stakeholders through meetings and brainstorming to amend the scope of the project on an on-going basis. Although he confirms that they believe in open communication and sharing information, but it seems that they are more focused on the need to establish a process that aligns with the level of communication they receive from stakeholders. According to what participants B explains, interaction and communication with stakeholders are important in managing their influence and attitude towards the project. So, to make sure stakeholders are well managed there is a need for lots of communication and common steam in the forms of information sharing, continuous formal and informal discussions for understanding, influencing stakeholders and finding solutions for different issues. He also mentioned BIM models presentation as an effective tool for communicating with stakeholders to help them understand the product and what they are trying to do, so their concerns about their interests and benefits will be eliminated and the firm can turn opposing stakeholders into supportive ones. It is also stated that building a good relationship with stakeholders can facilitate communication, increase the level of trust and engagement. Stakeholder engagement strategy for them depends on where the stakeholder is in their analysis in terms of influence and power. It is emphasised that stakeholder engagement through communication is an important factor in understanding stakeholders' expectation because otherwise, they may keep on adding the scope. Also, communications can be done directly or indirectly through using different groups of stakeholders like employing supporting stakeholders to communicate with opposing ones.

Also, participant C described they undertake communication process through employing communications specialists, running workshops and employing press officer to capture stakeholders' needs and expectations, engage stakeholders and share information. Likewise, he admits that they use different engagement approaches and level of communication for each stakeholder, whether they just need to be informed or regular meetings and engagement, according to their importance for the firm. It is also mentioned that level of communication and engagement depends on project size and budget. Also, participant D confirms they mostly communicate with internal stakeholders through conducting meetings and determining participants from various disciplines by using a matrix of roles and responsibilities. Table 43 summarises the approaches and practices mentioned by participants for stakeholder communication and engagement.

Table 43 Communication Management Processes.

Participant	Communication Process
A	Firm: meetings and brainstorming Stakeholders: meetings, telephone conversation, emails
B	-Weekly face to face meetings -Public consultation -Sharing Plans and objectives -Formal and informal discussions -Communication committees and subcommittees -Presentation of BIM models
C	-Employ communications specialists -Run workshops -Employ press officer -Meetings -Sending flyers
D	-Meetings with internal stakeholders -Discipline-based communications -Matrix of roles and responsibilities

8.2.5 Stakeholder Influence

Participant B confirms that during initial stakeholder mapping they analyse stakeholders level of power and interest and demonstrate them in a four-box map to understand their position towards the project and reach the optimum outcome of the project. Accordingly, they develop proper strategies in their stakeholder management plan to influence a particular key stakeholder to take him from his current box, e.g. opposing, in the map to where they want that stakeholders to be, e.g. supportive. So they use communication and sharing information, plans and objectives as a mean for understanding and influencing stakeholders. He points out that the nature of stakeholder management is dynamic and it is important to have a very committed team in place to make sure that stakeholders are well managed and they are still behind the scheme.

Interviewee B confirms stakeholders can come together if they can share similar views, especially if they are opposing the scheme, and they can block the progression of the project by protesting, forming lobbies and applying political pressure. They use a proactive approach to manage stakeholders influence by public consultation to provide the opportunity for the public to express their views. But it seems that the majority of their focus and concern is about external stakeholders, particularly public communities, as the influence of internal parties is neglected.

Regarding the effectiveness of stakeholder influence strategies he mentioned it depends on how strong their case is for the project and how strong their argument is against the points or issues raised by stakeholders. He believes being transparent, trusTable and clear about what they are trying to achieve and being flexible to a point where they can meet some of the stakeholders' requirements and at the same time delivering the objectives and outcomes of their scheme, are important elements to reach mutual agreement on issues. However, participant C thinks that the effectiveness of stakeholders' strategies depends on the type of stakeholder so everyone has to be handled in its own right and there isn't a model answer. For instance, if the stakeholder is the budget holder or end-user they deal with it differently and the form of communication will be different in terms of regular meetings or just keeping them informed. Interestingly he declared that they use contractual ties as a tool for managing or mitigating the influence of stakeholders. As this interviewee explains the relationship between stakeholders and the position of the firm within the network of relationship is an important factor in the ability to influence the project. For example, because they work on the client-side the only one who can influence their work is the client and they have to comply with the client's requested changes on the scope. So, he confirms that the response that they give to those influencing their project is basically depending on the position of that particular stakeholder.

Participant C alluded to the role of team members or workmanship in influencing the scope of projects as the majority of reworks being done nowadays are caused by inexperienced labour, poor execution of work packages and lack of supervision. Although the workmanship has been off the map in stakeholder theory studies but they could be taken into account as internal stakeholders. So, managing and controlling these team members can have a remarkable influence on the scope of projects, although this issue can be viewed from the quality control perspective as well.

It is also stated by him that although decisions made to change the scope on a value engineering basis can benefit the project but it may also result in disasters like Grenfell Tower.

Interviewee C mentions the users and governments as two of the stakeholders who can influence their work and project the most. The users usually impose changes on the project while governments can influence the project by making changes in funding rules.

Again communication plays a crucial role in managing the influence of stakeholders. Participant C expressed that in bigger projects, billion-plus, they employ a dedicated team to use different methods of communication like a press release, flyers, web portal and onsite cameras to manage the influence of stakeholders. By giving an example of a school construction project he claimed that projects may result in confrontation between stakeholders but it can be resolved through information sharing, communication and adding extra work to the scope.

Also, participant E admitted that sometimes contractors may be allowed to influence the project if they see a more effective way to construct what has been designed and they consider proposed changes in a meeting and evaluate implications. However, interviewee D declared that the clients have a major influence on their project by making changes in the requirement while other stakeholders like contractors or fabricators have a minimal effect, especially in major projects. So again it shows that for stakeholders to be able to influence the projects their type, position, power and company's strategy towards managing stakeholders are important elements.

8.2.6 Organizational Responses

As mentioned in the literature review organization may employ different strategies in dealing with the influence of stakeholders. Hence participant A said that because they are customer-focused they use adapt and compromise strategy in their company. But, before triggering changes caused by stakeholders' influence they identify the implications and undertake a second investigation to understand causes of change, whether it is informed by the right information and their validity to ensure if they are needed. The strength of the firm's case for the project and the strength of their argument against points or issued raised by stakeholders are mentioned by participant B as the factors for determining the company's responding strategy. Likewise, he affirms they use compromise and influence strategies in confrontation with stakeholder influence strategies. They try to be flexible to a point where they can meet some of the stakeholders' requirements but at the same time deliver the objectives and outcomes of their own scheme to meet them halfway through. Also, they use supporting stakeholders groups to communicate with opposing ones in order to mitigate their concerns and influence and make them support the scheme. He emphasises the importance of stakeholder engagement and understanding their concerns and expectations so by understanding that they can put in the right resources to achieve the outcome they want to achieve. Similarly, participant D's company use the compromise strategy in dealing with the stakeholders' influence on the scope. Their responding strategy will be designed to respond to client's requests and influence on the scope. So they analyse the implications of stakeholder's request for change on the scope, define changes and negotiate the updates with the client in terms of time and cost.

8.2.7 Stakeholder Uncertainty

As participant A explained they use stakeholder matrix and risk management as part of their stakeholder management process, especially in confrontation with opposing stakeholders. They take into consideration the identified uncertainty, impacts and probability of that uncertain event to happen then they develop a risk allowance which is then part of their project cost. He confirms that stakeholders' needs and requirements, particularly external stakeholders, is the main source of uncertainty in the scope of projects. On the other hand, participant C mentioned end-users and government as two main sources of uncertainty in projects that may create uncertain events by changing scope and funding rules. Also, Participant D believes that internal stakeholders can be a source of uncertainty in terms of how the project is resourced by each stakeholder and their working pace during different stages of the project lifecycle. Also, he thinks that the key factor is to make sure that each stakeholder is moving at the same pace towards obtaining the project milestones.

8.2.8 Scope Management Process

For managing the scope of projects, it seems that the majority of participants use an on-going basis for this process to constantly amend the scope and make sure its ultimate delivery. According to participant A they do this through communication and meeting with stakeholders and using brainstorming technique. Participant B described they start their scope management process by identifying the need, outcomes and objectives and then they develop a work breakdown structure for delivering these and define the scope. By defining the scope they divide it into the core or hard scope and soft scope by using MoSCOW prioritization technique before the feasibility stage. However, participant C points out that the scope management process after definition is poorly managed and he mentioned incidents caused by builders and workers as evidence for lack of supervision and control during the process. Participant D describes their scope management process starting from the bid stage by defining key deliverables and outlining them in a list for each stage of the project. So they outline exactly what they understand their scope is in that phase in a few bullet points which allows them to define the scope. After identifying clients requirements and defining scope they design work packages and assign them to each party by using a matrix of roles and responsibilities in an Excel spreadsheet format.

8.2.9 Scope Definition and Requirements Collection

As participant B explained, they define the scope into hard and soft scope by using MoSCOW method or analysis. The core scope is the features and functionalities which are needed to make project a success and are non-negotiable while the soft scope is the extra works that can be added to increase the quality or fully address the needs and expectation of stakeholders. So it provides the firm with the opportunity to develop the scope as they engage with more stakeholders during the project lifecycle. It is quite similar to the scope reduction list approach introduced by other authors in scope management literature. This approach can help to increase the quality of scope on one side and on the other side to anticipate any surplus or required extra work in advance to prevent any unplanned changes to scope and prevent scope creep.

Participant B stated that they define the core scope by engaging key stakeholders and creating a scope register. So, the core scope is fixed and the secondary scope is used to keep adding on in case of financial constrain or stakeholder request for change.

Also, participant D demonstrated that they define the scope by providing a list of deliverables at each stage and for each discipline according to the client's needs and requirements, key strategic points and key design points during the project lifecycle in a few bullet points. So they define this initial scope using the outline scope in RIBA stages to understand the required level of detail and create harmony.

Likewise, interviewee E mentions they use RIBA work stages so the scope is already pretty defined in what is expected from whom in what stage in terms of managing the client early on in the project.

Although RIBA can be used as an effective approach for defining scope but RIBA plan of work is not included within this research to avoid complicating the process framework, word limits and because we studied these issues from more theoretical and conceptual perspectives, so PMBOKGUIDE could provide a better conceptual baseline for the purpose of this research and majority of details and terminologies used in this research does not exist in RIBA plan of work.

8.2.10 Scope Creep

According to participant A's explanation majority of changes they experience during a project are caused by changes in the environment, change in work sequence, change of end-user and requests by stakeholders, but because they are customer-focused they tend to adapt to changes. He believes that at time of experiencing scope change having access to the right information is crucial to understand what the implications and consequences are. Therefore, this admits the importance of information sharing and communication which is addressed in this Process Framework. Likewise, participant B confirms that they are flexible in managing and dealing with changes in the scope of projects. However, this flexibility is applied by them on the soft scope part of the project scope and they try to make minimum changes on the core scope. Although it can give them the ability to benefit from advantages brought forth by adding or reducing the scope, but it can be risky. Participant C declares that there may be someone along the line who can suggest a variation, so it will go through the structured change process. He believes that the contract is the key in managing the influence of stakeholders and particularly internal ones in managing changes to the scope. So they can set up in the contract that certain stakeholders can have a certain influence at certain points during the project lifecycle. Participant D pointed out that the number of changes and variations are higher in refurbishment projects in comparison with new build projects. He also affirms that the main cause of change in the scope is the clients changing their mind in terms of what they need to be delivered due to commercial objectives. He confirms that changes may result in an increase or decrease in the scope they have to make sure that they inform the client and project manager to update the price in any case and prevent any tension between stakeholders.

Hence the change processes established and used in participant's companies are captured in the following Table 44. Although changes to the scope baseline can be managed through the 'Control and Monitor' stage of our process framework, but the aforementioned processes can be used to update this stage of the developed process framework and improve its efficiency. By considering these processes it seems that the following steps are mutual among them:

- Identify change
- Purpose and owner of the change
- Impact on scope
- Impact on time and cost
- Stakeholders' feedback
- Approve and authorize

Table 44 Summary of Change Management and Control Processes.

Participants	Change Process
A	-Investigate the purpose of change -Identify additional work -Resource requirement and availability -Impact on scope and delivery -Impact on time and finances -Client's feedback
B	-Change control process

	-Change identification and review -Time and cost evaluation -Approval and authorization
C	-Formal change request document -Identify change owner -Constructor's feedback on time and cost -Team feedback -Cost estimation -Client feedback and authorisation
D	-Define proposed change -Analyze impacts on the scope -Impacts on time and cost -Update Scope

Lack of information and improper understanding of scope at the outset are mentioned by participant A as the reasons for scope creep in projects. Likewise, participant B confirms that scope creep can appear even after scope definition decisions made, inadequate data and quality of data based on which the scope is defined. This again shows the importance of information sharing in the projects and admits the role of stakeholders in this issue. He emphasizes the importance of stakeholder engagement because if you don't know what are the expectations of stakeholder they can keep on adding to scope. Therefore, according to what he says the expectations of stakeholders can have a crucial effect on the scope of projects and causing scope creep. It is also stated that even with the scope defined and stakeholders engaged properly they may change their mind and request for a change in requirements, so this is the point where the control and monitor stage of the framework can be useful. Participant B also admitted that fundamental sequencing of the works and fundamental planning and allowing for the right level of resources is crucial to prevent scope creep. So it verifies the importance of stakeholder management plan and work breakdown structure (WBS) stages of process framework. Interviewee C believes that workmanship can be another reason for extra work and consequently, scope creep in the projects because of lack of proper control and supervision of work packages on site which are again addressed in 'Control and Monitor' and 'Create WBS 'stages of process framework. He confirms that there is always a chance of scope creep so they force the stakeholders like the contractor to perform according to the contract otherwise it will be at their own cost and to prevent scope creep they mandate the scope and put governance in place. Table 45 captures the main causes of scope creep in projects in participants' opinion which are addressed in the aforementioned stages of the process framework.

Table 45 Causes of Scope Creep.

Participant	Causes of Scope Creep
A	-Lack of information -Improper understanding of scope
B	-Decisions made -Inadequate information -Quality of data - Inadequate stakeholder engagement and expectations -Poor scope definition -Change in requirements -Inadequate on-site supervision and workmanship -Heritage and historical stuff
C	-Lack of workmanship supervision -Lack of control on work packages -Lack of contractual compliance

8.2.11 BIM and Collaborative Working

It is confirmed by participant A that collaboration is the key for working with internal stakeholders and they do not work with individuals who hold back information for their own benefit because it contradicts the culture of the environment they work in. However, interviewee C pointed out the absence of collaborative working in industry and working is more confrontational rather than collaborative. Also, participant D stated that collaborative working has not changed that much in their company. Although, they have developed their own way of collaborative working through creating strategies for each discipline and gathering information on requirements to improve collaboration through circles of iteration. In this regard, interviewee E admits the lack of collaborative working in projects as he says major conflicts arise when different internal departments are working on the same project but independently of each other. He alluded to the lack of information sharing and formality between different departments as the reasons for this issue. He confirms that collaboration improves by involving as many stakeholders as possible during the early stages and this result in optimizing design work quickly, optimizing construction methods quickly and handing over a far more efficient project in terms of physical and digital. Nevertheless, participant D described that collaboration primarily happens face to face around the table when they have a two weekly design team meeting where they review design models, highlight issues and clashes and share information on decisions made. So that is a kind of an appropriate mixture of old-fashioned meetings and using technology that suits everybody.

So, the data collected from interviews show the absence of a proper collaborative working approach in nowadays companies and industry. This issue is addressed in 'PS1. Collaborative Working' primary stage and 'Collaborative Working Engagement and Management' supporting element of the Process Framework which provides a Coherent and compact foundation for undertaking collaborative working.

8.2.12 BIM and Integrated Project Delivery

Interviewee D confirms that integrated project delivery is important particularly in terms of ensuring that all the stakeholders are moving at the same pace towards the milestones during the whole project lifecycle. In order to reach this objective, he suggests that the project key milestones have to be broken down into smaller milestones to make sure that the stakeholders are moving at the same pace. This objective is addressed within the 'WBS' stage of scope management and 'Define and Measuring Project Outcomes' stage of Integrated Project Delivery in the developed Process Framework as shown in Table 46.

Table 46 Defining and Measuring Project Outcomes.

Stage	Activity
Defining and Measuring Project Outcomes	Clearly spell out project goals and the consequences of success or failure.
	Includes project metric values like overall scope performance and measurements.
	Define reporting intervals to monitor the progress of the project.
	Define project goals and standards to judge the project's success.
	Establishment of performance criteria for major building systems.

Accordingly, participant E expresses that for integrated project delivery the stakeholders like the design team and facilities manager should be appointed as soon as possible. This statement verifies the 'IPD Team Building and Functioning' part of the Integrated Project Delivery stage in the Process Framework as presented in Table 47.

Table 47 IPD Team Building and Functioning.

Stage	Activity
IPD Team Building and Functioning	For the project team early in the project in two categories of primary and key supporting.
	Consider capability, team dynamics, compatibility, communication, trust-building and commitment to an integrated process.
	Define decision making methods and processes that each team member accepts.
	Decisions are made unanimously by defined decisions making body instead of a single body.
	Facilitate sharing information between team members.
	Development and use of an overarching communication protocol.
	Consider using BIM as a tool.
	Careful participant selection and contract drafting for using confidential information.
	Use methods of compensation that tie participants success to the overall success of the project.
	Make effort to maintain the continuity of the team.
	Resolve disputed internally and with the help of the project's decision-making body.

It is also admitted by him that by involving as many participants as possible in the beginning and moving project works upstream to the early stages, the project cost during these stages may increase but because all those people involved will collaborate immediately the design and construction methods will be optimised and the project will be far more efficient digitally and physically so spending curve goes down rapidly unlike the traditional methods. He also affirms that by using BIM and the Integrated Project Delivery approach companies can take a lot of learning to the next projects and consequently their costs will be decreased using these learned lessons.

8.2.13 BIM Impact on Stakeholder Management

As explained by interviewee A, BIM can have huge positive effects on the stakeholder management process in terms of consistent information sharing, improved stakeholder engagement and capturing stakeholders' needs and expectations.

Therefore, all this is in compliance with the purpose of using BIM in our developed Process Framework.

8.2.14 BIM Impact on Stakeholder Influence

Participant A confirmed the positive effect of BIM on stakeholders, particularly the internal ones, in terms of informed decisions and access to relevant information. However, he believes it has a minimum benefit for external stakeholders. He also admits that BIM can greatly provide agile responses to the negative influence of stakeholders on the scope and preventing scope creep, however, he is not sure whether BIM can prevent scope creep itself. Likewise, participant B and D stated although BIM does not do anything by itself, they confirmed that BIM has a positive impact on stakeholder management in terms of improving stakeholder engagement and level and quality of communications. This is in compliance with findings from the literature review on the impacts of BIM (Succar, 2009; Chen and Luo, 2014; Tomek and Matějka, 2014). It is also admitted by interviewees B and D that BIM can mitigate the negative influence of stakeholders by taking stakeholders' views, needs and expectations into consideration at earlier stages of the project and addressing their concerns through visualization of the end product. However, participant C claims that BIM does not necessarily facilitate the flow of information between stakeholders due to problems like software compatibility. He also mentioned clients have not realised the long-term benefit of using BIM, especially asset management, and they only care about contractor keep the works on track. So, this shows that there is a need to use the BIM process more effectively during the project lifecycle for the realization of its benefits as it is one of our process framework objectives. Participant D declared that by using BIM in projects the number of involved stakeholders during the early stages is increased because there is an extra deliverable which is federated models. He also alluded to the impact of BIM on clients' perception of cost as with increasing BIM maturity in projects the amount of required works is shifting towards earlier stages so the old fee percentages and the client's old perception as in what level of fee is needed for certain stages has changed to somewhat. Although participant E believes that BIM does not do anything itself, but admitted that BIM formally ratifies the processes that already exist in a compact form so other people can be involved more efficiently in projects. He also claimed that to be able to deal with stakeholder conflicts and reduce their impacts on the project through BIM, stakeholders should be appointed as early as possible during the project lifecycle.

So, all information provided above verifies the use of BIM in our developed process framework during primary and main stages in order to manage and mitigate the influence of stakeholders on the scope and addressing the need for undertaking the BIM process in coordination with other project management processes.

8.2.15 Common Data Environment (CDE)

CDE embedded in our process Framework as one of the supporting elements. It is expressed by participant E that CDE is set up mostly for use of internal stakeholders and the client should have access to everything including shared, published and archived data. Also, he admitted that confidentiality of information on CDE can be provided by locking down certain areas and creating passwords for files protection depending on the systems being used. This addresses the issues raised by various authors regarding the security and confidentiality of information on CDE (Won et al., 2013). Therefore, CDE can be used for other purposes like stakeholder, scope and uncertainty management as proposed in our Process Framework by maintaining confidentiality through the aforementioned approaches. Also, it is admitted that CDE can be used for sharing information with external stakeholders (e.g. public consultation) by extracting information and sharing them outside of CDE in the forms of PDFs or PowerPoint and putting them in a published folder with unrestricted accessibility.

8.2.16 BIM and Communication

Regarding the relationship between BIM and communication management, participants A, B, C, D and E admitted that BIM can be useful in communication and sharing information with stakeholders. According to what participant A said, one of BIM principles is that generated information should benefit the wider project team rather than staying with the group of originators. So he confirms that by using BIM following advantages can be delivered for communications management:

- Access to the information.

- A better understanding of implications on the sequencing of project works.
- More detailed understanding of the programme.
- Better interactions between different parts of the project team.

He points out to obtain these benefits, the information flow and transfer should be mapped out from the outset. This objective is addressed through the 'Plan communication' main stage of our process framework.

Also, interviewees A and B admitted that BIM models presentation is an effective tool to visualize the end product and what the firm is trying to achieve for stakeholders and eliminate their concerns. Furthermore, Participant B affirmed that having a single source of truth can build trust and reliability in terms of communication and engagement.

Also, participant C confirmed that BIM has a positive effect on information management in terms of mapping and recording information on proposed changes during the project lifecycle. So, it verifies employing BIM in our Process Framework to manage changes on the scope.

In addition, interviewee D declared that it will result in better clash definition and clearer communication because everyone is visually seeing the clash and then getting guided into their own data environment to find the exact location where this problem is happening. Therefore, this can help in preventing scope creep caused by uncertain events in the projects.

8.2.17 BIM Impact on Scope Management

Regarding the impact of BIM on scope, it is stated by participant B that the BIM is not additional or extra scope. He affirms that there may be the need to take initial investment but it is not duplicating or increasing the scope and it will result in doing things more efficiently and reducing the scope in long run. This complies with authors finings that BIM can bring efficiency to scope management by reducing rework and improving design (Merschbrock and Munkvold, 2012; Chen and Luo, 2014; Talebi, 2014). Also, interviewee D confirmed that with BIM maturity increasing, the majority of project works are being moved upstream into the earlier stages which consequently results in early resolution of conflicts and improved scope definition. However, it is understood form participant D statement that although visualisation can help tremendously in understanding the scope of project and clash detection but if it is not defined properly at the outset it still can result in issues. And this verifies the importance of 'MS7. Define Scope' stage of developed Process Framework as it is presented in Table 48.

Table 48 Define Scope Stage of the Process Framework.

Stage	Activity
Define Scope	• Develop a detailed description of the project product.
	• Describe major deliverables, assumptions and constraints.
	• Describe the works required to create deliverables.
	• Define which of the collected requirements will be included and excluded.
	• Define acceptance criteria.

It is also admitted by interviewee D that BIM models visualisation can help in better definition of the scope by demonstrating its features and functionalities and their appropriateness for the scheme and by helping clients to understand the scope and receiving their feedback earlier in the project.

Besides, Participant D mentioned that one of the tricky issues regarding scope is the dimension of time in terms of how long does it take to build certain things because in this regard the expectation of clients is sometimes far from reality and using of 4D BIM to show the dimension of time can address this issue. Likewise, participant E affirms that the correct format of the 3D model and project programme can be shared and linked together by adding parameters like time and cost. He continues by saying that most of the time when that happens, it sits on local servers in the WIP area to serve the people who've created it, but they can be shared and put onto the CDE. Hence, it validates the advantages of using BIM dimensions in the process framework for improved management of scope.

8.2.18 BIM and Scope Creep

Also, I investigated the impact of BIM on the appearance and management of scope creep in projects through analysis of primary data to understand how BIM application in our Process Framework can help to resolve this issue.

Participant A, B and C confirmed that BIM can help in the reduction of scope change requests by providing better access to the right information which results in clash detection and better assessment of implications on the programme and other aspects of the project. So the poor change control as one of the main causes of scope creep as mentioned by various authors will be resolved and prevented (Kuprenas and Nasr, 2003; Sharma, A. and Lutchman, 2006; Alp and Stack, 2012; Nahod, 2012).

Likewise, participant B and D confirmed that BIM can definitely reduce scope change by visualising project objectives and the end product so the stakeholders would be able to adequately define their needs and expectations. Consequently, the difference between the actual output of the project and the stakeholders' imagination will be identified and addressed through revisions in the early stages of the project. So, they believe that dealing with changes early on the project and before completing the scope baseline is much more efficient.

Also, participant D stated that in terms of managing and defining the level of details there are still problems in the projects. He mentioned that some companies may use RIBA stages level of detail for defining the BIM level of complexity and the level of information provided at each stage. This validates the 'BIM Implementation' stage of our developed Process Framework as we used the RIBA BIM Overlay document to develop data drop boxes.

In this regard, participant E admitted that the way in which BIM can help to resolve the conflicts and reduce their impact on the project is to include and engage as many stakeholders as possible during the early stages. So, by undertaking BIM processes properly through having a BIM manager on the project management side, producing EIR by the client, producing pre-contract and post-contract BEP and setting up a proper common data environment (CDE) scope creep can be prevented in projects.

8.2.19 BIM Crucial Documents for Stakeholder Management

We investigated the crucial BIM documents for stakeholder management in order to validate the use of BIM documents in our Process Framework. The summary of findings from this investigation is presented in Table 49.

Table 49 BIM Crucial Documents for Stakeholder Management.

Participant	Crucial Document	Reason
A	BIM Execution Plan (BEP)	-Information flow -Full interaction with internal and external stakeholders
B	-EIR -BEP (Partially)	- Identifies all the deliverables - Captures all the requirements - Potentially identify gaps in information - Creating efficiencies
D	All documents	-Nesseccary for successful BIM delivery
E	-EIR -BEP -TIDP	- Nesseccary for successful BIM delivery

Interestingly, participant B points out the importance of RACI which is an acronym for Responsible, AccounTable, Consulted and Informed that can be effectively used to communicate with stakeholders in terms of what is expected from different individuals. This will be discussed in the following sections.

8.2.20 BIM Crucial Documents for Scope Management

Also, by analysing collected primary data the crucial documents for efficient scope management are investigated and captured in following Table 50 to validate BIM documents used in our Process Framework:

Table 50 Crucial Documents for Scope Management.

Participant	Crucial Document	Reason
B	-EIR	-Form of scope document -Brief for the information

	- BEP	-Captures all the info requirements and deliverables -Direct reflection of scope. -Insight on how the scope will be delivered -Improves efficiency in how things are done
D	-Pre-BEP, Project BEP and contract BEP	-Define the level of detail - Highlight the level of design -Define BIM maturity level -Define deliverables at each stage - Clarify what is required

8.3Final Process Framework

By analysing primary data collected through conducting interviews with participants from the construction and infrastructure industry we investigated the validity of different themes, concepts and elements of our 'Process Framework'. The investigations showed a tangible correlation between themes of 'Process Framework' and no refusal or rejection of its elements and concepts is detected. However, to improve the efficiency of 'Process Framework' some minor modifications and revisions can be made in order to embed tools, methods and approaches proposed by participants during interviews. So the final 'Process Framework' is developed as follows in Figure 43. The developed Process Framework encompasses three phases including primary stages, main stages and supporting stages or elements. The primary stage of the framework provides the foundation for the successful delivery of BIM project by taking into consideration processes like collaborative working and integrated project delivery, preparation and production of essential BIM documents and evaluation of capability and competence of organization /project for deploying BIM. As it is mentioned in BIM Overlay to the RIBA Outline Plan of Work (Sinclair, 2012) the increasing BIM maturity in projects requires collaborative working, integrated methods and teamwork with closer ties between different team members like designers. Hence, For the determination of these stages the processes, phases, components, outcomes, tasks and responsibilities presented in BIM related British Standards are analyzed, interpreted, irrelevant ones are filtered and concentration is made on the most relevant ones in accordance with four main project management themes and topic of current research. Also by doing this, checklists of tasks and activities to be undertaken for collaborative working and IPD within this framework are developed. The second phase of utilizing BIM in this framework includes its relevant tasks and activities to be performed during project implementation gathered, analyzed and extracted from BIM Overlay to the RIBA Outline Plan of Work published by Royal Institute of British Architects (Sinclair, 2012).

The main stages of the Process Framework contain essential processes for stakeholder, scope, communication and risk management in order to mitigate the negative influence of stakeholders on the scope of projects and preventing scope creep. Hence, the scope creep is assumed as an uncertain event caused by the influence of stakeholders and other factors, wich may or may not result in risks. Accordingly, the Process Framework helps to resolve this issue by providing the essential steps for effective stakeholder engagement through efficient communication, detailed scope management and risk management to analyse the impacts of scope deviations and choose the most appropriate response. The information for developing the main stages of the framework are gathered by literature review and meta-analysis of PMBOK GUIDE (PMI, 2017) which provides a conceptual guideline for managing project management processes. The sequence of these main stages is determined precisely by tracking and analyzing processes, inputs and outputs of chosen main themes of project management as described previously.

Also, the primary developed Process Framework includes some supporting elements which facilitate implementation of main stages and help to take maximum advantage of utilizing this Process Framework. These elements include Control and Monitor, collaborative working engagement and management, change control process, IPD implementation and Common Data Environment (CDE).

In this regard the definition of the main stages of developed 'Process Framework' is as following:

- MS1.Identify Stakeholders: Identify People, groups and organizations and their relevant information.
- MS2.Plan Communication Management: Develop an appropriate approach and plan for communications based on stakeholder needs and requirements.
- MS3.Plan Stakeholder Management: Develop appropriate strategies to effectively engage stakeholders according to their needs, interest and potential impact.
- MS4.Plan Scope Management: Create a plan that documents how the project scope will be defined, validated and controlled.
- MS5.Plan Risk Management: Define how to conduct risk management activities regarding stakeholders and scope.

- MS6.Collect Requirements: Determine, Document and manage stakeholder needs and requirements to meet project objectives.
- MS7.Define Scope: Develop a detailed description of the project and product.
- MS8.Create WBS: Subdivide project deliverables and project work into smaller more manageable components.
- MS9.Identify Risks: Determine which risks may affect the scope and document their characteristics.
- MS10.Qualitative and Quantitative Risk Analysis: Prioritize risks for further analysis or action by assessing and combining their probability of occurrence and impact. Numerically analyze the effect of identified risks on the overall scope.
- MS11.Plan Risk Responses: Develop options and actions to enhance opportunities and reduce threats
- MS12.Manage Stakeholder Engagement: Communicate and work with stakeholders to meet their needs/expectations regarding scope, address issues as they occur and foster appropriate stakeholder engagement
- MS13.Manage Communications: Create, collect, distribute, store and retrieve project information in accordance with the scope and communication management plan
- MS14.Validate Scope: Formalise acceptance of completed project deliverables by stakeholders.

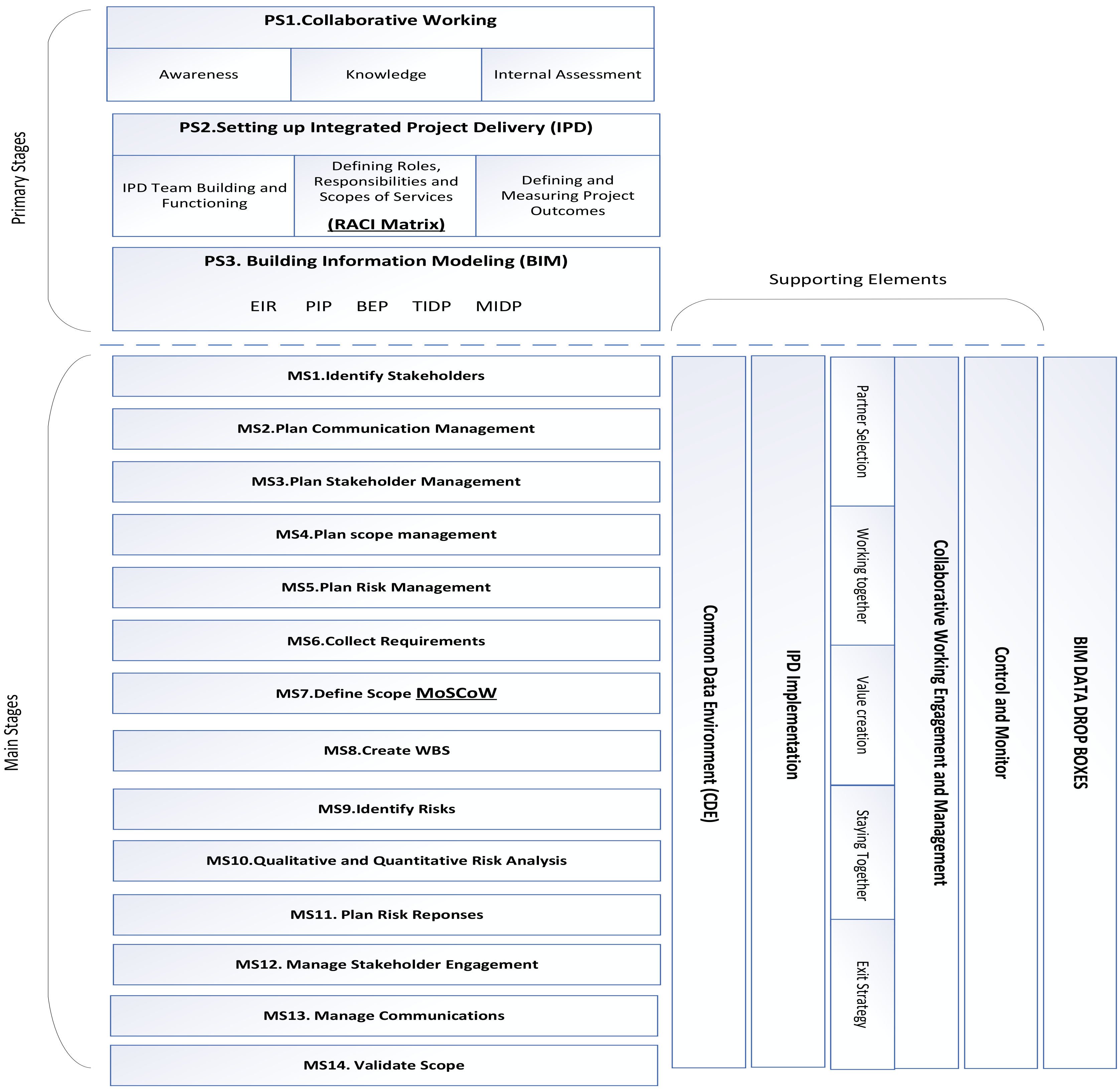

Figure 42 Final Process Framework.

As the first step of modifying the framework main stages of MS10.Qualitative Risk Analysis and MS11.Quantitative Risk Analysis is merged into each other due to the similarity in their nature. So the number of main stages is decreased from 15 to 14 stages.

Also, one of the participants pointed out the importance of RACI tool which is the acronym for Responsible, AccounTable, Consulted And Informed that can be effectively used to communicate with stakeholders in terms of what is expected from different individuals. So, this tool is embedded in the 'Defining Roles, Responsibilities and Scopes of Services' part of 'PS2. Setting up Integrated Project Delivery (IPD)' primary stage. The RACI matrix provides the opportunity for the identification of stakeholders' roles and responsibilities in order to facilitate their engagement and communication, particularly for delivering an integrated project. The RACI matrix can be employed to have a proper impression of different members involved in the project and their responsibilities in complex projects. Description of different participants and their roles in the completion of tasks or projects can be provided by this matrix in an orderly manner. The RACI matrix is consisting of activities, tasks, responsibilities and deliverables demonstrated on the vertical axis and demonstration of roles on the horizontal axis in a fixed layout. It should be mentioned that the role and individual should be distinguished (Morgan, 2008).

An example of RACI matrix is presented in Figure 44. RACI acronym is conducted according to the crucial characteristics within a project (Kofman *et al.*, 2009):

1. Responsible: the participant who possess the responsibility of completing the task and doing the work. The 'accounTable' person is the recipient of the task performer's report.

2. AccounTable: the ultimate responsibility of precise project tasks completion is assigned to this person. They will receive the reports and sign of the task. There might be one accounTable for each task.

3. Consulted: the responsibility of this person is giving advice. Two-way communication shall be made with this person and he/she is also responsible for providing direction and helping in task implementation.

4. Informed: they will be informed of any updates on results and progress and communication with this person will be in a one –way direction.

Tasks \ Roles	Expert witness	Case manager	Consultant
Provide testimony	R	A	A
Prepare document	I	A	R
Manage projects	I	R	C

Figure 43 RACI Matrix (Kofman et al., 2009).

Also, it was stated by one of the participants that they define the scope of the project in two categories of core scope and soft scope by using MoSCoW method which results in preventing scope creep in projects on one side and on the other side enables the firms to benefit from opportunities provided by improvements in the scope of projects. So this method is embedded in 'MS7. Define the Scope' stage of the 'Process Framework' as well.

In order to accomplish a common understanding of important stakeholders' requirements, a prioritization technique called MoSCoW method is used in project management and business analysis. The MoSCoW is an acronym for four prioritization categories of Must have, Should have, Could have, and Won't have. (Clegg and Barker, 1994) developed this prioritization method and it was used comprehensively for the first time in the project delivery framework Dynamic Systems Development Method (DSDM) (Bittner and Spence, 2003). This method is usually used with timeboxing in which a time limit is set to focus on the most important requirements. Although all requirements are important, but to deliver maximum and instant business benefits, they are prioritized. Must have, Should have and Could have requirements have priority over the rest of them but if the delivery timeline is threatened, the Should and Could requirements will be removed first. These prioritization categories can help project participants in better understanding of setting up priority in comparison with other prioritization categories like low, medium and high. Prioritization categories are defined as follows (IIBA, 2009):

1. Must have: these are the critical requirements for the delivery of the current timebox to be successful. The project delivery can be jeopardised even if one of the Must-have requirements is not included. The Must-have requirements can be lowered in rank but only by all relevant stakeholders' agreement.

2. Should have: the requirements which are important but not vital for the delivery of the current timebox are labelled as 'Should have' requirements. Their importance can be equal to Must-have requirements, there might be another way to satisfy those requirements since they are not time-critical. So, they may be postponed until the next delivery timebox.

3. Could have: these types of requirements are desirable but not essential and can improve customer satisfaction and improve the user experience for a tiny increase in cost. Could have requirements will be involved resources and time allow.

4. Won't have: the requirements labelled by this title are the ones which are agreed by stakeholders as low importance or least critical requirements at that time. So, these are not embedded into plans and schedule for delivery. Consequently, they are either reconsidered to be delivered in the next timebox or simply dropped.

The majority of participants emphasised the importance of controlling changes on the scope during the project lifecycle in order to prevent scope creep. Hence, the change control procedures used by interviewees are gathered and a comparison was made between these procedures and the Process Framework stages. The processes mentioned by participants can be summarised as:

- Identify change
- Purpose and owner of change
- Impact on scope
- Impact on time and cost
- Stakeholders' feedback

- Approve and authorize

However, it seems that the current elements of the Process Framework suffice for addressing the aforementioned change control steps. For instance, the ‘Identify Change’ and ‘Purpose and Owner of Change’ parts can be addressed by the ‘Identify Risk’ stage of the framework while the change ‘Impacts on Time, Cost and Scope’ can be evaluated via ‘Risk Analysis’ stage.

Also, the ‘BIM Data Drop Boxes’ element is assigned to the main stages to be implemented during project execution. It is mentioned that participants’ companies use RIBA stages level of detail for defining the BIM level of complexity and the level of information provided at each stage. Therefore, relevant BIM tasks and activities to be performed during project implementation gathered analysed and extracted from BIM Overlay to the RIBA Outline Plan of Work published by the Royal Institute of British Architects (Sinclair, 2012). These activities are shown in a checklist for BIM drop boxes for each project stage in Table 51.

Table 51 BIM Data Drop Boxes(Sinclair, 2012).

RIBA Stage	BIM DATA
BIM Drop Box 0 & 1	-Define purpose, benefits, implications and dimension of BIM -Advise client on Integrated Team scope of service in totality and for each designer including requirements for specialists and appointment of a BIM Model Manager. -Define long-term responsibilities, including ownership of model. -Define BIM Inputs and Outputs and scope of post-occupancy evaluation (Soft Landings). -Identify scope of and commission BIM surveys and investigation reports.
BIM Drop Box 2	-BIM pre-start meeting. -Initial model sharing with Design Team for strategic analysis and options appraisal. -BIM data used for environmental performance and area analysis. -Identify key model elements and create concept level parametric objects for all major elements. -Enable design team access to BIM data. -Agree extent of performance specified work.
BIM Drop Box 3	-Data sharing and integration for design co-ordination and detailed analysis including data links between models. -Integration/development of generic/bespoke design components. -BIM data used for environmental performance and area analysis. -Data sharing for design co-ordination, technical analysis and addition of specification data. -Export data for Planning Application. -4D and/or 5D assessment
BIM Drop Box 4	-Export data for Building Control Analysis. -Data sharing for conclusion of design co-ordination and detailed analysis with subcontractors. -Create production level parametric objects for all major elements. -Embed specifications to model. -Final review and sign off of model. Enable access to BIM model to contractor(s). -Integration of subcontractor performance specified work model information into BIM model data. -Review construction sequencing (4D) with contractor.
BIM Drop Box 5	-Agree timing and scope of 'Soft Landings'. -Co-ordinate and release of 'End of Construction' BIM record model data. -Use of 4D/5D BIM data for contract administration purposes.
BIM Drop Box 6	-FM BIM model data issued as asset changes are made. -Study of parametric object information contained within BIM model data.

In addition to the aforementioned stages and methods, the checklists of activities provided in the 'Primary Process Framework' (section 6.2.4) are still valid and provide guidelines on how each stage of 'Process Framework' should be performed and delivered. So, these activity checklists should be undertaken in parallel with the designed stages of the 'Process Framework' to deliver maximum benefit.

8.4 Summary

This chapter discussed the findings from the analysis of collected primary data in accordance with the project management themes of this research, namely scope management, stakeholder management, and BIM, to validate different themes and elements involved in the development of the process framework. Then, the process framework was updated by implementing the required changes from this stage, and the final version of the process framework was developed and explained.

Chapter 9 Conclusion

9.1 Introduction

In the concluding chapter, the study's findings are integrated and presented, taking into account the research's objectives and aiming to establish reliability and validity. This chapter also discusses the research's contribution to knowledge, the applicability and impact of the Process Framework, and recommendations. Furthermore, the study's limitations and potential future research directions are presented to aid future related research.

9.2 Review of The Research Questions And Objectives

In conclusion, this study investigated the influence of stakeholders on managing the scope of construction projects and the way in which Building Information Modelling (BIM) can help in the resolution of this issue by studying its impacts on different project management processes involved in this research. Hence, both secondary and primary data collection and analysis were recruited to develop a Process Framework for managing the influence of stakeholders on scope and preventing scope creep. This was done by bringing together, analysis and application of BIM processes, risk management processes, communication management processes and lessons learned from six case study projects. The elements of this Process Framework were verified by analysis of findings form primary data collected during interviews and answers were provided to the designed research questions. The research questions and their identified answers from the qualitative data analysis are as following:

Q 1: What are the main causes of scope creep in major construction projects and what are the best solutions for its management in order to prevent its negative impact on project success?

Hence by performing an extensive literature review it is discovered that stakeholders are one major source of uncertainty in projects as they request for change in the scope of the project which originates from their needs, expectations and interests. These requested changes can result in uncertain events like scope creep and even termination of projects. In this regard, it is reported by other authors that stakeholders employ various strategies such as Direct usage or withholding, Indirect usage or withholding, Resource building, Coalition building, Conflict escalation, Communication and credibility building to impose their influence on the scope of projects (Aaltonen, Jaakko and Tuomas, 2008). However, organizations can use various kinds of strategies like Compromise, adaptation, dismissal, influence and avoidance in responding to stakeholder influence strategies as well (Aaltonen and Sivonen, 2009). Also, several potential Benefits of BIM to Project Management were identified by investigating the impact of BIM on different processes of project management.

Q2: What is the role of stakeholder influence in the occurrence and management of scope creep in construction projects?

The majority of participants confirmed the importance of stakeholder identification and analysis in terms of their needs and expectations, power and interest and consequently stakeholders' influence. They also consider both internal and external stakeholders, but clients and local communities are at the centre of their analysis. Hence, the role of information sharing and communication is emphasised in capturing stakeholders' needs and expectation. Also, stakeholder engagement and communication is mentioned as an important element in managing and understanding the influence of stakeholders on the scope and finding solutions for issues like amending scope on an on-going basis. In this regard, they use various methods and approaches for communication and information sharing with stakeholders. However, it seems that they are more focused on the need to establish a process that aligns with the level of communication they receive from stakeholders rather than planning their own communications. Also, it is confirmed that communication with particular stakeholders depends on their level of power to influence the project. It is also admitted that information sharing and communication approaches like public consultation can help in managing the influence of stakeholder and through these opposing stakeholders can be turned into supporting ones.

It is confirmed by participants that opposing stakeholders can influence the project and block its progression by employing strategies like coalition building, protesting, forming lobbies and applying political pressure. In participants opinion, the effectiveness of stakeholder influence strategies is dependent on the strength of the project scheme and the firm's reasoning against issues raised by stakeholders on one side and position and power of those stakeholders (E.G. Budget holders and end-users) in the project on the other side.

Also being trustable, transparent and flexible are mentioned as important elements for the firms in dealing with and mitigating stakeholders influence. Accordingly, adapt, compromise and influence strategies are mentioned as the most frequent strategies in responding to the influence of stakeholders on the scope. In terms of dealing with internal stakeholders influence, it is realised that contractual ties and conditions are used as an effective approach for eliminating and mitigating their influence. Therefore, the relationship between stakeholders and the position of the firm within the network of relationship is an important factor in the ability to influence the project. Also, it is found that workmanship and quality and experience of labour is a vital element which can influence the scope of projects. In this regard, their influence on the scope can be managed through close supervision and monitoring.

Hence it is confirmed by the participants that although imposed changes on the scope may result in scope creep but sometimes these changes can result in efficiency and bring forth new opportunities. In this regard, local communities, government, clients, end-users and labour are mentioned as the main stakeholders who may influence the scope of projects.

Q3: How effective is BIM in managing the scope of construction projects and preventing scope creep caused by stakeholder influence?

Regarding the impact of BIM on scope, it is stated by participants that BIM is not additional or extra scope and it will result in doing things more efficiently and reducing the scope in long run. Also, it is concluded that with BIM maturity increasing, the majority of project works are being moved upstream into the earlier stages which consequently results in the early resolution of conflicts and improved scope definition. In addition, by visualising the specifications, the scope of the project is better defined by demonstrating its features and functionalities and their appropriateness for the scheme and clash detection is understood and performed more effectively. However, it should not undermine the importance of scope definition at the outset. Also, using 4D BIM to show the dimension of time can address the issue of how long it takes to build certain things because in this regard the expectation of clients is sometimes far from reality.

Regarding scope creep, participants confirmed that BIM can help in the reduction of scope change requests by providing better access to the right information which results in clash detection and better assessment of implications on the program and other aspects of the project. So, the poor change control as one of the main causes of scope creep as mentioned by various authors will be resolved and prevented. Besides, BIM can reduce scope change by visualising project objectives and the end product so the stakeholders would be able to adequately define their needs and expectations. Consequently, the difference between the actual output of the project and stakeholders' thought will be identified and addressed through revisions in the early stages of the project.

Also, it is admitted that how BIM can help to resolve the conflicts and reduce their impact on the project is to involve and engage as many stakeholders as possible during the early stages.

It is admitted by interviewees that BIM can have huge positive effects on the stakeholder management process in terms of consistent information sharing, improved stakeholder engagement and capturing stakeholders' needs and expectations. Although the benefits of BIM for external stakeholder are still vague, internal stakeholders can benefit from BIM in terms of informed decisions and access to information. Also, it is confirmed that BIM has a positive impact on stakeholder management in terms of improving stakeholder engagement, level and quality of communications. Furthermore, BIM can provide agile responses to the negative influence of stakeholders by taking stakeholders' views, needs and expectations into consideration at earlier stages of the project and addressing their concerns through visualization of the end product. Plus, by using BIM in projects the number of involved stakeholders during the early stages is increased because there is an extra deliverable which is federated models. Hence, to be able to deal with stakeholder conflicts and reduce their impacts on the project through BIM, stakeholders should be appointed as early as possible during the project lifecycle. Although it should be mentioned that BIM does not do anything itself and the delivery of all those advantages depends on how well BIM processes and guidelines are undertaken by people. In this regard, it seems that there is a need to change the perception of stakeholders and particularly clients about BIM costs and processes to perform BIM procedures like asset management more effectively and seriously to realise its long term benefits.

In conclusion, it is verified that BIM can have a positive effect on managing the influence of stakeholders on the scope of projects and preventing scope creep. However, participants remarked that BIM does not do anything by itself and its success depends on the appropriate implementation of BIM processes by people involved. Accordingly, BIM can help in managing the influence of stakeholder by facilitating information sharing and communication to capture stakeholders' needs, expectations and feedback on various elements of the project like project scope in the early stages of the project lifecycle. In this regard, collaboration is the key in working with internal stakeholders and BIM provides the opportunity for collaborative production and distribution of information.

But maybe the most beneficial element of BIM is the visualization of federated project models. BIM visualization can impact managing stakeholder influence and scope of projects in two ways. Firstly, by visualizing the ultimate project output or end product the needs and expectations of stakeholders can be captured properly and their unrealistic concerns can be eliminated and that consequently mitigates the negative influence of stakeholders on the scope through communication and proper stakeholder engagement. Secondly, by visualizing the project scope and specifications the vital project and stakeholder requirements will be defined, the interfaces will be managed and the clash detection will be done more effectively.

Finally, a process framework is developed for managing the influence of stakeholders on the scope of projects by bringing together and analysis of the crucial project management processes, Building Information Modeling processes and findings from six case studies. To fulfil this objective, the interdependencies of key project management processes of stakeholder, scope, communication and risk or uncertainty management were analysed and interpreted. In this regard communication management processes chosen due to their crucial role in stakeholder engagement and their close relevance with BIM as a standard for information management and distribution. Also, risk and uncertainty management is taken into account, by determining scope changes caused by stakeholders as uncertain events which may result in risks like scope creep. So, the main meaning of risk here is those related to the scope and stakeholders' risk and uncertainty. Through this, the interdependencies between these processes within the project environment are identified to understand their points of interactions and the sequence of their activities. In the next step, the relationship between BIM and project management processes is analysed form two perspectives. Firstly, from the project management perspective by investigating and identifying the linkages between processes of scope, stakeholder, communication and risk management with BIM applications and models, through tracking their inputs and outputs. Secondly from BIM perspective by investigating the relationship between various contents of BIM documents and processes within project management processes through studying how each element of BIM can be linked to a specific process or document of project management and creating a flowchart. Doing all this provided a foundation for developing the process framework. Consequently, by employing a case study strategy, 6 construction and infrastructure projects were investigated with two objectives; Firstly to identify issues and challenges that appeared in 5 projects which confronted difficulties in their delivery due to poor stakeholder and scope management which should be addressed in the Process Framework. Secondly, to identify key success factors in the delivery of the London 2012 Olympic Games construction programme to be included in the Process Framework for improving its efficiency. Finally, various themes involved in the developed Process Framework were validated, particularly BIM processes including collaborative working and integrated project delivery and their impacts on project management processes, by analysing collected primary data through conducting semi-structured and in-depth interviews with participants from the construction and infrastructure industry.

9.3 Research Limitations

Despite the valuable insights gained through this research on managing the influence of stakeholders on the scope of major construction projects to prevent scope creep in the BIM era, there are certain limitations that should be acknowledged.

1. Interpretivist Stance: The interpretivist research philosophy adopted in this study focuses on subjective experiences and interpretations of individuals. This approach may lead to biases in the interpretation of data and the potential for overlooking objective aspects of project scope management.

2. Multi-Qualitative Methodology: The multi-qualitative methodology used in this research, although valuable for its interpretive nature, may lack the rigor and objectivity of a mixed-methods or quantitative approach. This limitation may affect the generalizability and transferability of the study's findings to other contexts.

3. Research Strategy: The case study and phenomenological research strategies employed in this study provide rich insights into the experiences of stakeholders in the construction projects examined. However, these strategies may limit the generalizability of the findings to other projects, industries, or contexts.

4. Cross-Sectional Time Horizon: The cross-sectional approach used in this research enabled the collection of data through case studies and interviews within a shorter time frame. However, this approach might not capture the dynamics of stakeholder influence and scope management over the entire lifecycle of a construction project.

5. Purposeful Sampling: The purposeful sampling approach used in selecting five interview participants and six case studies from a target population of 15 projects may introduce bias and limit the representativeness of the sample. This could affect the generalizability of the findings to other construction projects.

6. Data Collection: While both primary and secondary data collection methods were employed, the reliance on semi-structured interviews and documentary sources may have limited the range of perspectives and data sources available for analysis.

In light of these limitations, future research could benefit from adopting a mixed-methods approach, considering longitudinal studies, and expanding the scope of the study to include a more diverse range of construction projects and stakeholder perspectives.

9.4 Contribution to knowledge

This research offers several significant contributions to construction and project management.

First, it addresses the issue of stakeholder influence and scope creep in major construction projects by developing an integrated and comprehensive Process Framework. The framework is based on the application of BIM processes and takes into consideration the perspectives of both practitioners and policy. The outcomes of this study may raise awareness about the importance of managing stakeholders and uncertain events before they escalate into significant problems, such as delays, cost overruns, or termination. This is particularly important given the limited research on scope creep.

Second, the research creates consensus and integration among project management processes, including scope, stakeholder, communication, and risk management. This is accomplished through analysing the sub-processes, inputs, and outputs of these processes. The resulting coherent approach allows project managers to concentrate on specific issues during the project lifecycle, thereby improving project outcomes.

Third, the research connects BIM aspects and processes to project management processes and knowledge areas. The study analyses the relationships between BIM elements and project management processes by conducting a literature review, interviewing experts, and interpreting the interaction and relationship between BIM processes and documents with project management processes. This analysis provides a wider perspective on BIM's impacts on different concepts of project management beyond technological aspects. Furthermore, the study highlights the interactions and linkage between different BIM dimensions (3D, 4D, and 5D) and various outputs of project management processes. This provides a clearer vision for project managers on how BIM fits within project management processes throughout the project lifecycle.

In conclusion this research offers a novel and comprehensive approach to managing stakeholder influence and preventing scope creep in major construction projects through the application of BIM processes. It also provides valuable insights into the relationships and interactions across different parties. The research offers a clear vision for project managers on how BIM fits within project management processes throughout the project lifecycle. The research outcomes may help the industry practitioners and policymakers to understand the importance of managing stakeholders and uncertain events in construction projects, thereby minimizing the risk of scope creep, delays, cost overruns, or termination.’’

9.5 Recommendation on Research Findings

There are two main areas where further research can be conducted:

1. Testing the applicability, effectiveness, and efficiency of the developed Process Framework in construction projects or other types of projects.

It is important to validate the effectiveness and applicability of the developed Process Framework in different construction projects. This can be done by conducting case studies or real-life projects to test the framework's effectiveness and efficiency. This will help to identify any shortcomings or limitations of the framework in different contexts, and provide insights for improvement.

2. Identifying the benefits and impacts of BIM on external stakeholders and internal parties like workers and workmanship.

While there has been some research on the benefits and impacts of BIM on external stakeholders, the findings are still not comprehensive. Therefore, it is important to conduct further research to identify the specific benefits and impacts of BIM on external stakeholders such as clients, regulators, and the public, and on internal parties like workers and workmanship. This will provide a better understanding of the value of BIM and help to maximize its potential in construction projects.

In addition to the two areas mentioned above, it is also important to consider the stakeholder influence strategies. While most of the research has been focused on managing the influence of external stakeholders, internal stakeholders like workers and workmanship should not be neglected. Further research can be conducted to identify the specific influence strategies that can be used to manage the impact of these internal stakeholders. This will help to ensure that their needs and concerns are addressed, and the project is completed successfully.

To sum up, there is a need for further research in construction projects to test the applicability, effectiveness, and efficiency of the developed Process Framework. Also, the benefits and impacts of BIM on external and internal stakeholders need to be identified comprehensively. Lastly, stakeholder influence strategies should not neglect internal stakeholders, and further research can be conducted to identify the specific strategies that can be used to manage their impact.

9.6 Summary

This chapter presented the processes and findings of the thesis, which are evaluated in light of the aim and objectives outlined in chapter one. Additionally, the chapter encompasses the study's impact and its contribution to knowledge and practice. The research suggests that using Building Information Modelling (BIM) processes can be an effective way to manage stakeholder influence and prevent scope creep in large construction projects. It also provides insights into the interactions between different parties and the importance of managing stakeholders and uncertainties to minimise the risk of project delays, cost overruns or termination. The outcomes of the research offer a clear vision for project managers on how BIM can fit within project management processes throughout the project lifecycle. This research provides a comprehensive approach to managing stakeholder influence and preventing scope creep in large construction projects, and its findings may be beneficial for industry practitioners and policymakers.

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Appendices

Appendix 1 Interview Questions.

Category	Code	Questions
Scope Management	ScM	• Key 1: From your experience, what are the main causes of scope creep in projects? • Key 2: Can you describe your company's approach to effectively managing and preventing scope creep in order to ensure project success?
Stakeholder Management	SM	• Key 3: According to your experience, what is the role of stakeholders' influence in the occurrence and management of scope creep? • Key 4: What kinds of influencing strategies did stakeholders use to impose changes on scope? • Key 5: In your company, what kinds of responding strategies do you choose to counter the influencing strategies of stakeholders?
Stakeholder Uncertainty & Risk	SUR	• Key 6: What types of effects did the uncertainty in scope bring forth, in terms of positive or negative?
Stakeholder Communication	SC	• Key 7: From your experience, what is the role of communications in managing the project scope and influence of stakeholders? • Key 8: In your company, what kinds of methods and approaches do you adopt for stakeholder engagement and communication?
Building Information Modelling	BIM	• Key 9: From your perspective, what are the positive and negative effects of using BIM in the project management of construction projects? • Key 10: How can Building Information Modelling (BIM) be leveraged to mitigate the adverse impacts of scope creep in your organisation's projects?

- Key 11: What is the potential role of BIM in managing the influence of stakeholders on the scope of the project?

Appendix 2 Consent form for interviews.

Consent form for interviews

University of East London

School of architecture, computing and engineering

Title of research project: *The Role of Stakeholders in Appearance and Management of Scope Creep in Major Construction Projects: Developing a Practical Framework According To BIM*

Thank you for reading the information sheet about the interview. If you are happy to participate then please complete and sign the form below.

I have read and had explained to me by *Mohsen Jamshidi* the information sheet relating to the project and any questions have been answered to my satisfaction.

- I agree to the arrangements described in the information sheet insofar as they relate to my participation.
- I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason and without there being any negative consequences. In addition, should I not wish to answer any particular question or questions, I am free to decline.
- I understand that my responses will be kept strictly confidential. I understand that my name will not be linked with the research materials, and will not be identified or identifiable in the report or reports that result from the research.
- I agree to the interview being audio recorded. I understand that the audio recording made of this interview will be used only for analysis and that extracts from the interview, from which I would not be personally identified, may be used in

any conference presentation, report or journal article developed as a result of the research. I understand that no other use will be made of the recording without my written permission, and that no one outside the research team will be allowed access to the original recording.

- I agree that my anonymised data will be kept for future research purposes such as publications related to this study after the completion of the study.
- I have received a copy of this consent form and of the accompanying information sheet.

Name of participant:

Signed:

Date:

The contact details for the person to talk to are:

Name of researcher: Mohsen Jamshidi

Email Address: u1055338@uel.ac.uk

Director of study: Dr. Phebe Mann

Email Address: p.mann@uel.ac.uk

Tel: 02082233000-2368

If you have any concerns about the conduct of the investigator, researcher(s) or any other aspect of this research project, you should contact:

Catherine Fieulleteau

Research Integrity and Ethics Manager

Email Address: researchethics@uel.ac.uk

Tel: 0208 223 6683

The Graduate School

Docklands Campus, University of East London, London, E16 2RD

Appendix 3 Participant Information Sheet.

Participant Information Sheet

University of East London

School Of Architecture, Computing and Engineering

Title of research project: *The Role of Stakeholders in Appearance and Management of Scope Creep in Major Construction Projects: Developing a Practical Framework According To BIM*

My name is Mohsen Jamshidi. I am a researcher studying at the University of East London. We are working on a project looking at the role of stakeholder's influence on the scope of projects and the occurrence of scope creep and the impact of

Building Information Modelling (BIM) on the resolution of this issue. We are talking to a number of construction/project managers, people in charge of managing stakeholders and scope or BIM managers from five case studies.

What is the purpose of the study?

The main aim is to investigate the experiences of participants like you in confrontation with scope creep caused by stakeholders and their opinion regarding the impact of BIM on the resolution of this problem. Consequently, a process framework can be developed to help project managers from the construction sector in managing the negative influence of stakeholders on projects and preventing scope creep through the application of Building Information Modeling (BIM) standards and processes.

Why have I been invited?

The projects being investigated include Metronet London Underground Modernization, Scottish parliament house, Wembley stadium, The Paddington Health Campus scheme, BBC Broadcasting House and Olympic Stadium Project. So you are nominated for participating in this study due to the involvement of you or your company in one of these projects and/or your experience and expertise in the field of this research.

What will I have to do if I take part?

If you agree to take part, we will ask you to answer some questions. There aren't any right or wrong answers – we just want to hear about your opinions. The discussion should take about 60 to 90 minutes at the longest. Please note that some of the questions will relate to your experiences during the implementation of the specific construction and infrastructure project.

Do I have to take part?

No, taking part is voluntary. If you don't want to take part, you do not have to give a reason and no pressure will be out on you to try and change your mind. You can choose not

to answer any particular questions and you are free to withdraw from the study at any time during or after completion of the interview. Also, you can request for withdrawal of the information you provided during the interview by sending an email to the researcher using provided contact information at the end of this information sheet.

If I agree to take part what happens to what I say?

All the information you give us will be confidential and used for the purposes of this study only. The participants or interviewees will remain anonymous due to confidentiality of projects information for some organizations or companies. Nothing said by participants will be attributed to them without first seeking and obtaining permission. However, it should be mentioned that due to small sample size of this research complete confidentiality and anonymity might not be possible in all circumstances. Also data will be captured by recording the conversation using MP3 Voice Recorder device and note taking. The data will be kept securely and destroyed securely after the completion of the project/after 5 years.

A copy of the completed project and summary of findings will be available on request.

The project has been subject to ethical review in accordance with the procedures specified by University of East London research ethics committee.

What do I do now?

Think about the information on this sheet, and ask me if you are not sure about anything. If you agree to take part, please sign the consent form. The consent form will not be used to identify you. It will be filed separately from all other information. If, after the discussion, you want any more information about the study please do not hesitate to contact me.

The contact details for the person to talk to are:

Name of researcher: Mohsen Jamshidi

Email Address: u1055338@uel.ac.uk

Director of study: Dr. Phebe Mann

Email Address: p.mann@uel.ac.uk

Tel: 02082233000-2368

If you have any concerns about the conduct of the investigator, researcher(s) or any other aspect of this research project, you should contact:

Catherine Fieulleteau

Research Integrity and Ethics Manager

Email Address: researchethics@uel.ac.uk

Tel: 0208 223 6683

The Graduate School

, Docklands Campus, University of East London, London, E16 2RD

THANK YOU VERY MUCH FOR YOUR HELP!

Appendix 4 The coding scheme for data analysis.

Categories/Sub Categories	Codes
Stakeholder Management	SM
• **Stakeholder identification**	SM-SI
• **Stakeholder categorization**	SM-SC
• **Requirements, needs and expectations**	SM-RNE
• **Stakeholder influence and potential impact**	SM-SIPI

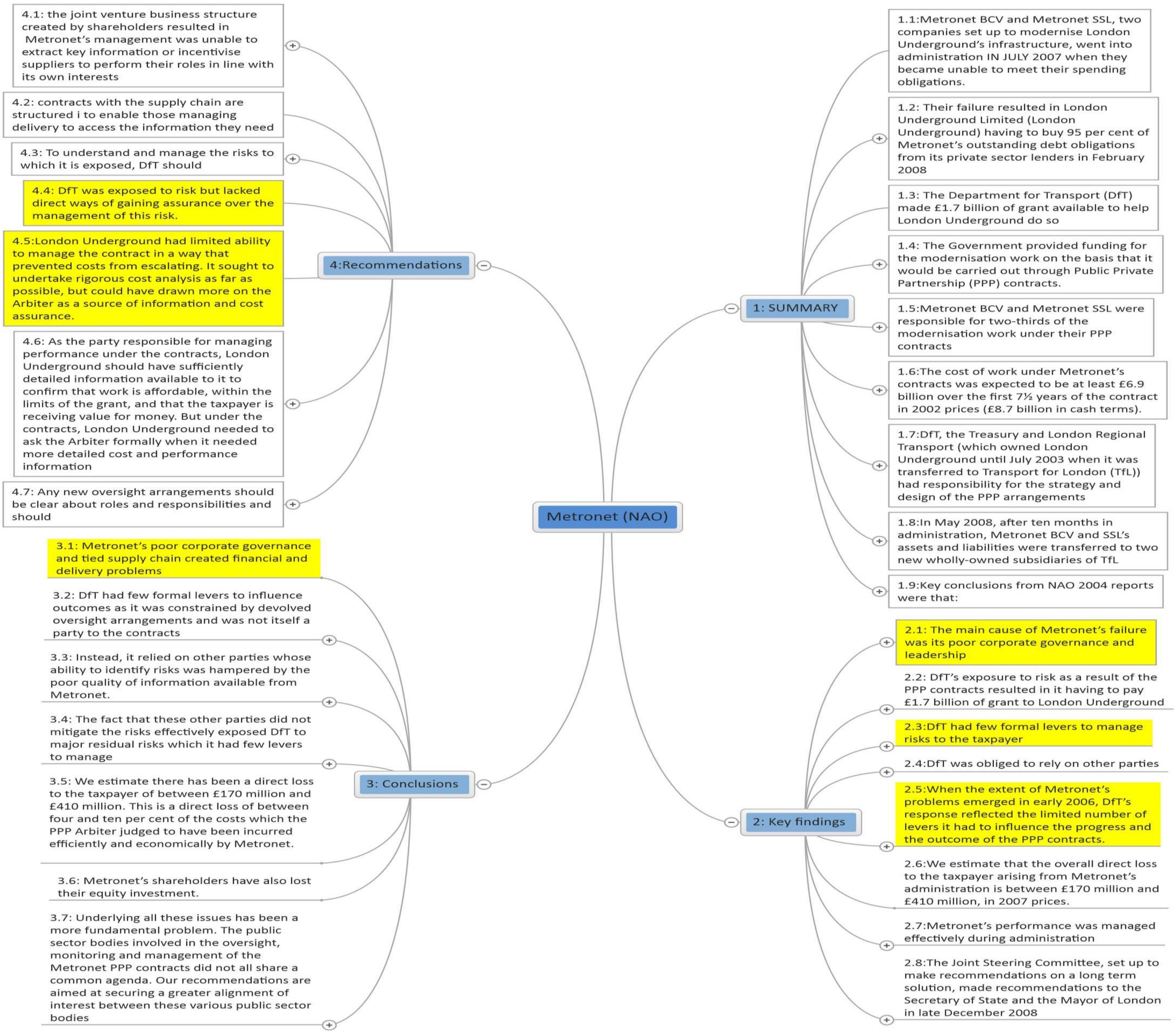
• **Stakeholder engagement strategy**	SM-SES
• **Engage through communication and negotiation**	SM-ECN
• **Engagement issues**	SM-EI
• **Monitor stakeholder relationships**	SM-MSR
Scope Management	ScM
• **Scope statement process**	ScM-SSP
• **WBS process**	ScM-WP
• **Create WBS**	ScM-CW
• **Deliverable information and schedule**	ScM-DIS
• **Deliverables acceptance**	ScM-DA
• **Requirements analysis process**	ScM-RAP
• **Prioritize and classify requirements**	ScM-PCR
• **Stakeholder involvement in collecting requirements**	ScM-SICR
• **Detailed description of project and product**	ScM-DDPP
• **Requirements inclusion and exclusion**	ScM-RIE
• **Scope deliverables, assumptions and constraints**	ScM-SDAC
• **Formalize deliverable acceptance**	ScM-FDA
• **Reviewing deliverables**	ScM-RD
• **Monitor status of scope**	ScM-MSS
• **Mange changes to scope**	ScM-MCS

• **Scope creep occurrence**	ScM-SCO
Stakeholders Uncertainty And Risk	SUR
• **Identify risks**	SUR-IR
• **Stakeholder involvement in risk identification**	SUR-SIRI
• **Provide list of risks and root causes**	SUR-PLRRC
• **List of Potential responses**	SUR-LPR
• **Assess probability of occurrence and impact**	SUR-APOI
• **Prioritize risk**	SUR-PR
• **Assess organizations risk tolerance**	SUR-AORT
• **Numerically analyse risks**	SUR-NAR
• **Develop options and actions**	SURDOA
• **Response mechanism to address risks**	SUR-RMAR
• **Assigning owner of risk**	SUR-AOR
• **Implement risk response plans**	SUR-IRRP
• **Track, monitor and evaluate risks**	SUR-TMER
Stakeholder Communication	SC
• **Developing communication approach and plan**	SC-DCAA
• **Identify stakeholder communication requirements**	SC-ISCR
• **Identify information to be communicated**	SC-IIC
• **Reason, time frame and frequency**	SC-RTFF

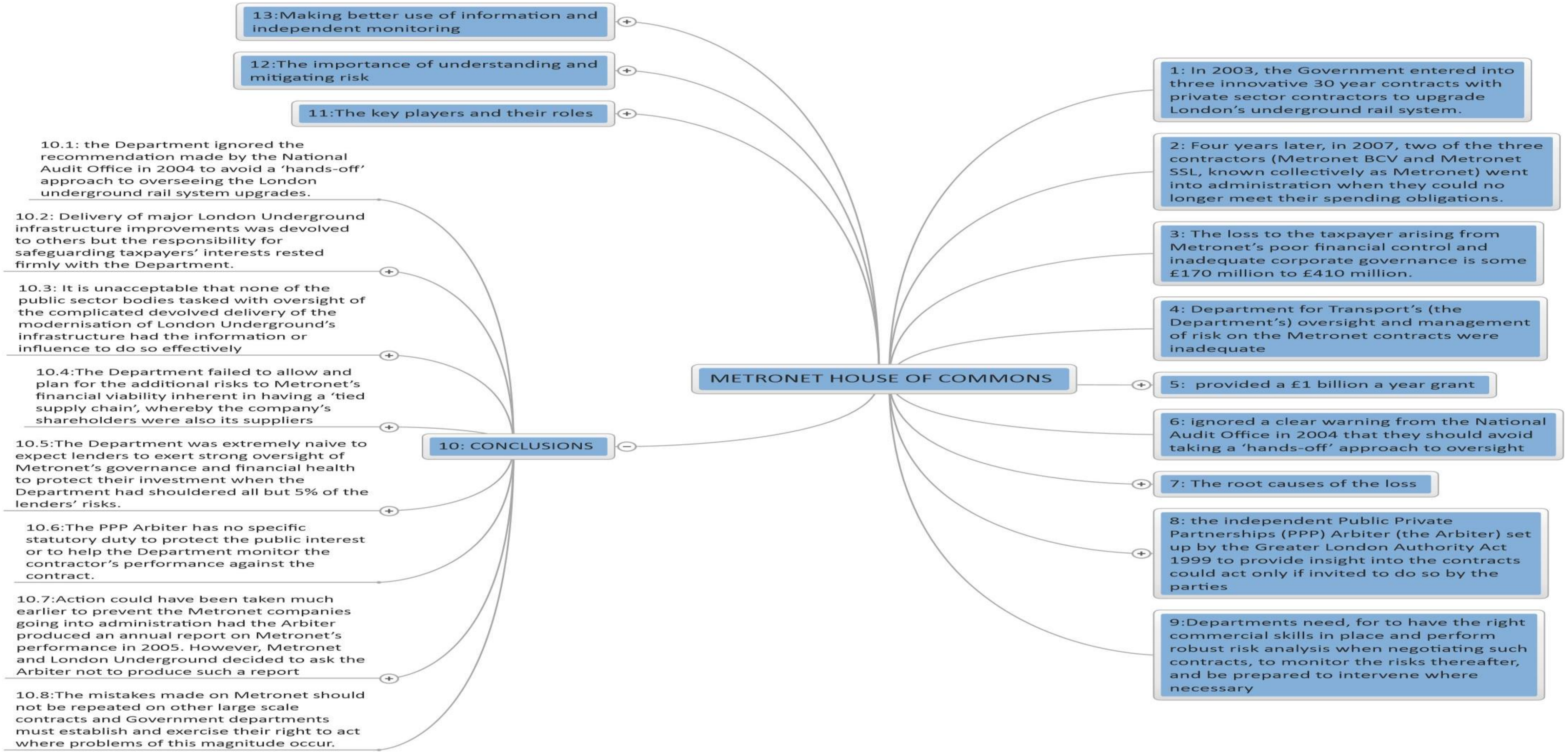
• **Define roles and responsibilities**	SC-DRR
• **Methods, models and technology to convey information**	SC-MMT
• **Communication constraints**	
• **Create, collect, distribute, store and retrieve information**	SC-CC
• **Ensure receiving and understanding of information**	SC-CCDSR
• **Determine communication details**	SC-ERU
• **Monitor and control communication**	SC-DCD
• **Ensure meeting stakeholders' information needs**	
• **Evaluate impact of communications**	SC-MCC
	SC-EMSIN
	SC-EIC
Building information modelling	BIM
• **Influence on stakeholder management**	BIM-ISM
• **Influence on uncertainty management**	BIM-IUM
• **Influence on the management of scope creep**	BIM-MSC
• **Policy for collaborative working**	BIM-PCW
• **Identify objectives and potential value**	BIM-IOPV
• **Resources, competencies and behaviours**	BIM-RCB
• **Relationship management plan**	BIM-RMP
• **Senior executive responsible**	BIM-SER

• **Procedure for knowledge management**	BIM-PKM
• **Relationship business case**	BIM-RBC
• **Structured assessment of capability and maturity**	BIM-SACM
• **Collaborative working value creation**	BIM-CWVC
• **IPD team building and functioning**	BIM-TBF
• **Roles and responsibilities**	BIM-RR
• **IPD defining and measuring outcomes**	BIM-FMO

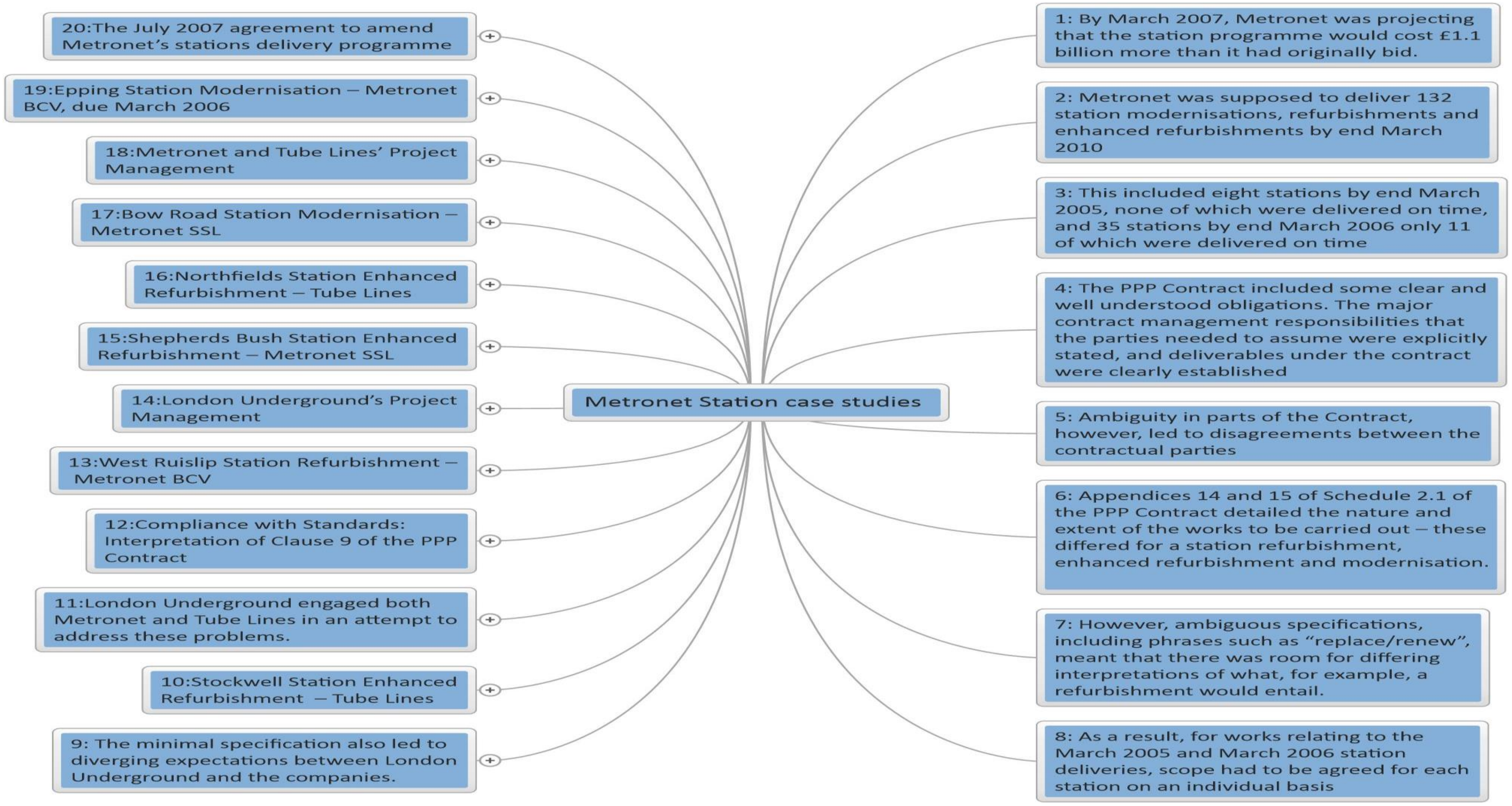
Appendix Figure 5 Collapsed view of Metronet project analysis (National Audit Office)



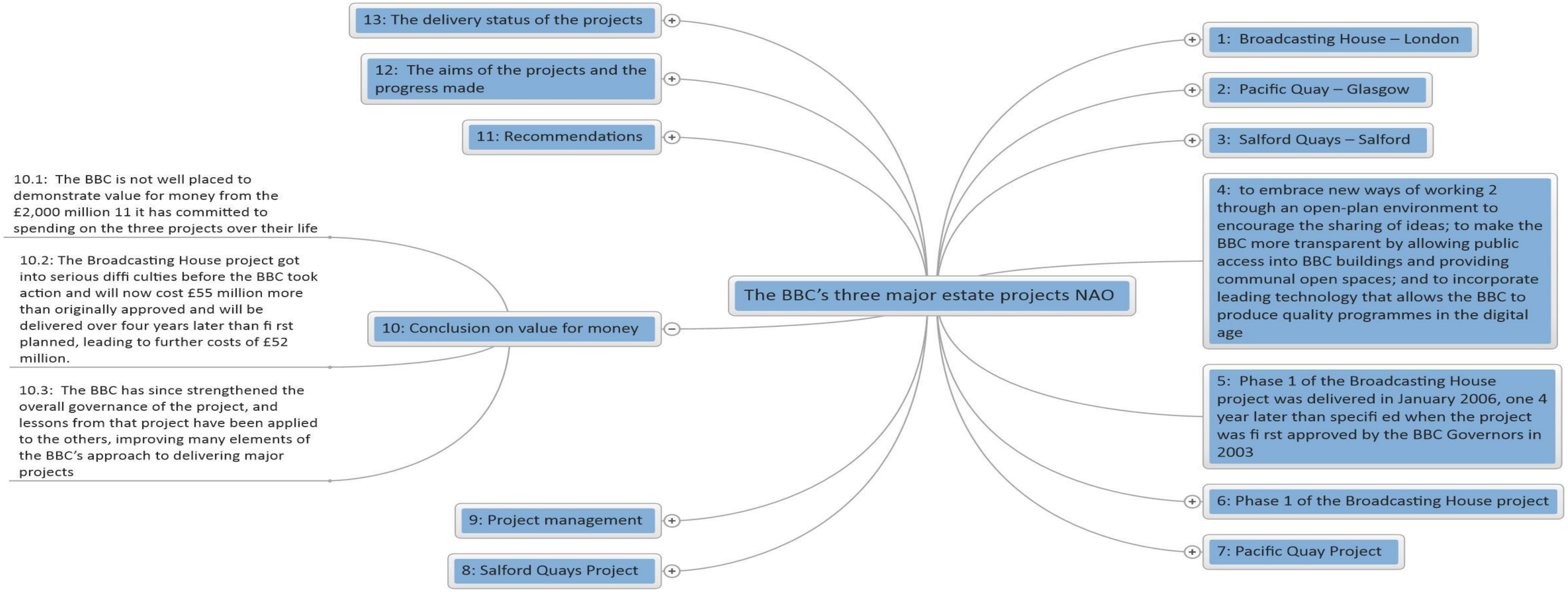
Appendix Figure 6 Collapsed view of the Metronet project analysis (House of Commons).



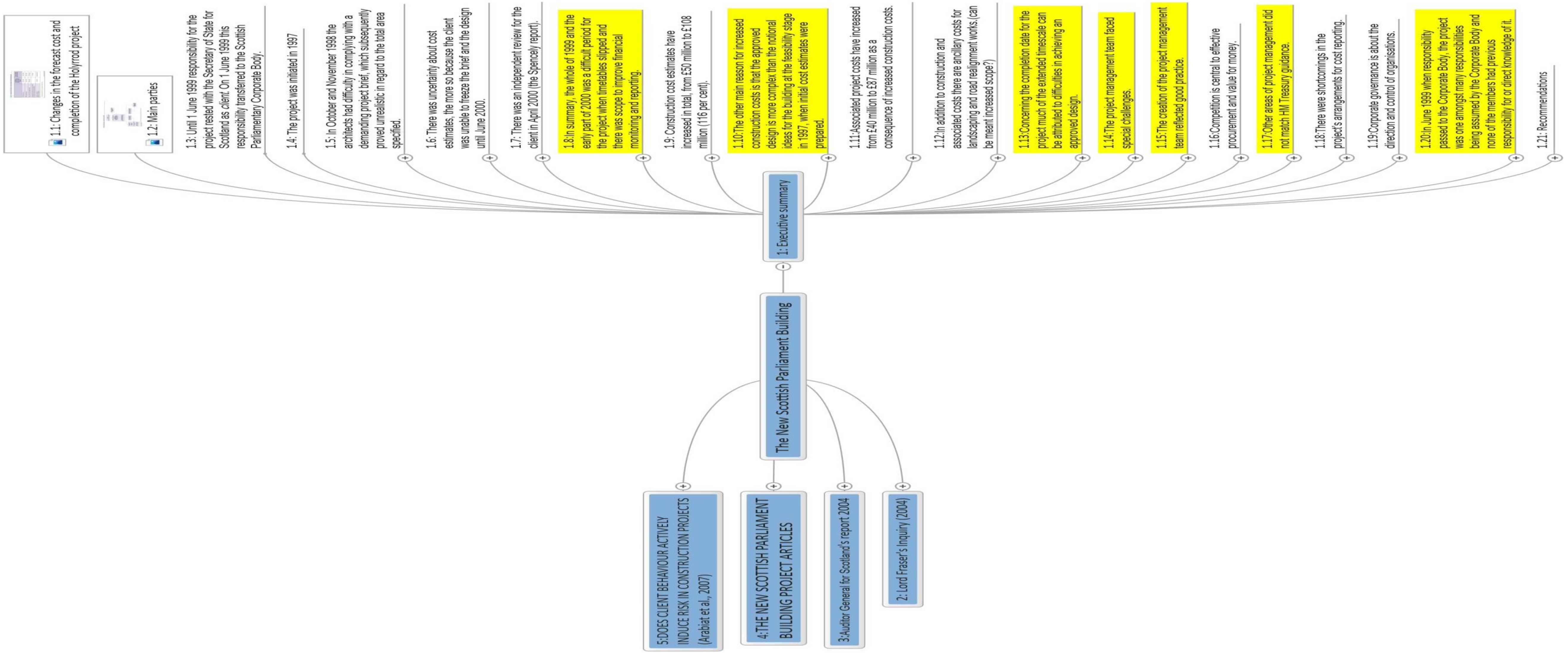
Appendix Figure 7 Collapsed view of the Metronet case studies (National Audit Office).



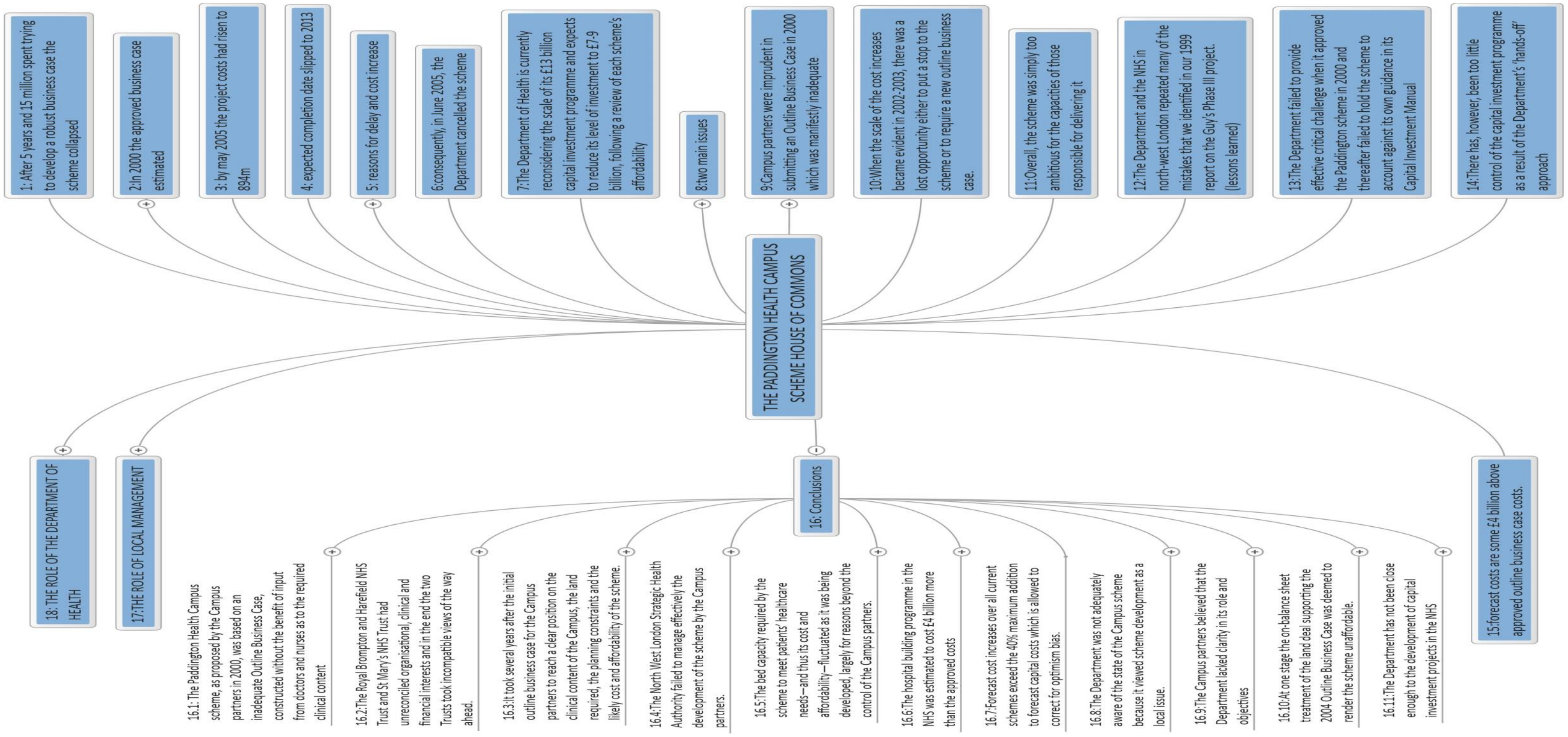
Appendix Figure 8 Collapsed view of the BBC's three major estate projects (NAO).



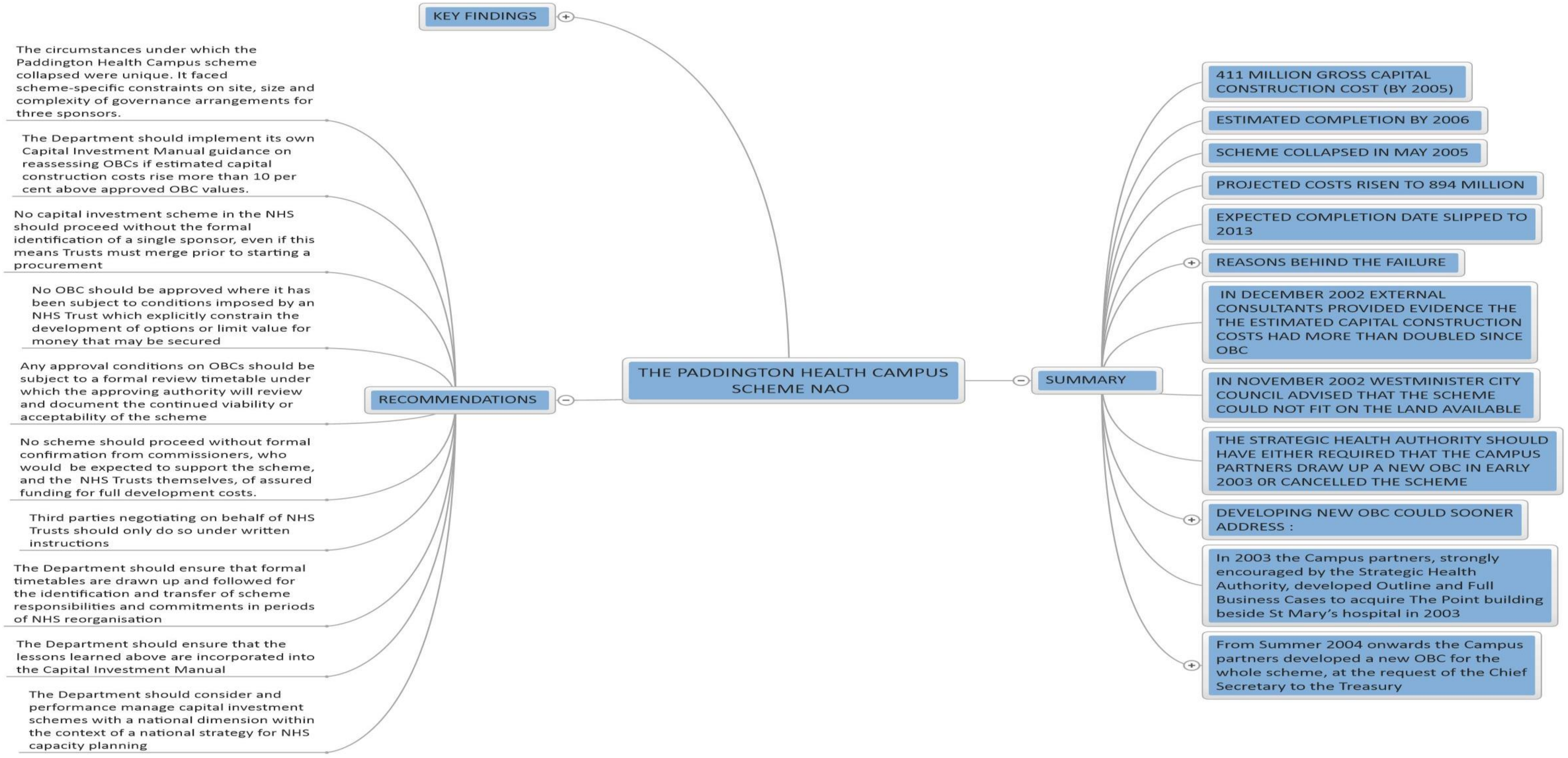
Appendix Figure 9 Collapsed view of the New Scottish Parliament Building Analysis (NAO).



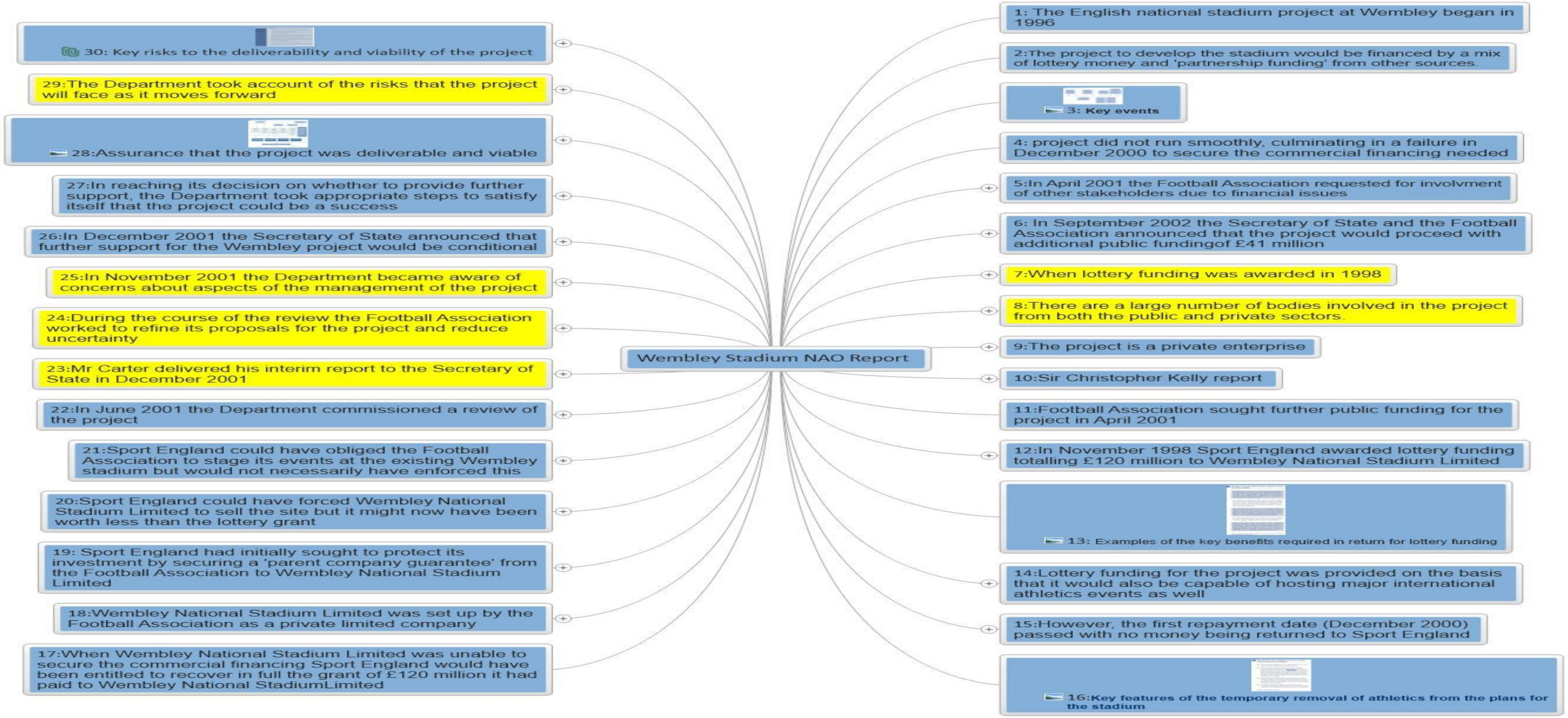
Appendix Figure 10 Collapsed view of the PADDINGTON HEALTH CAMPUS SCHEME (House of Commons).



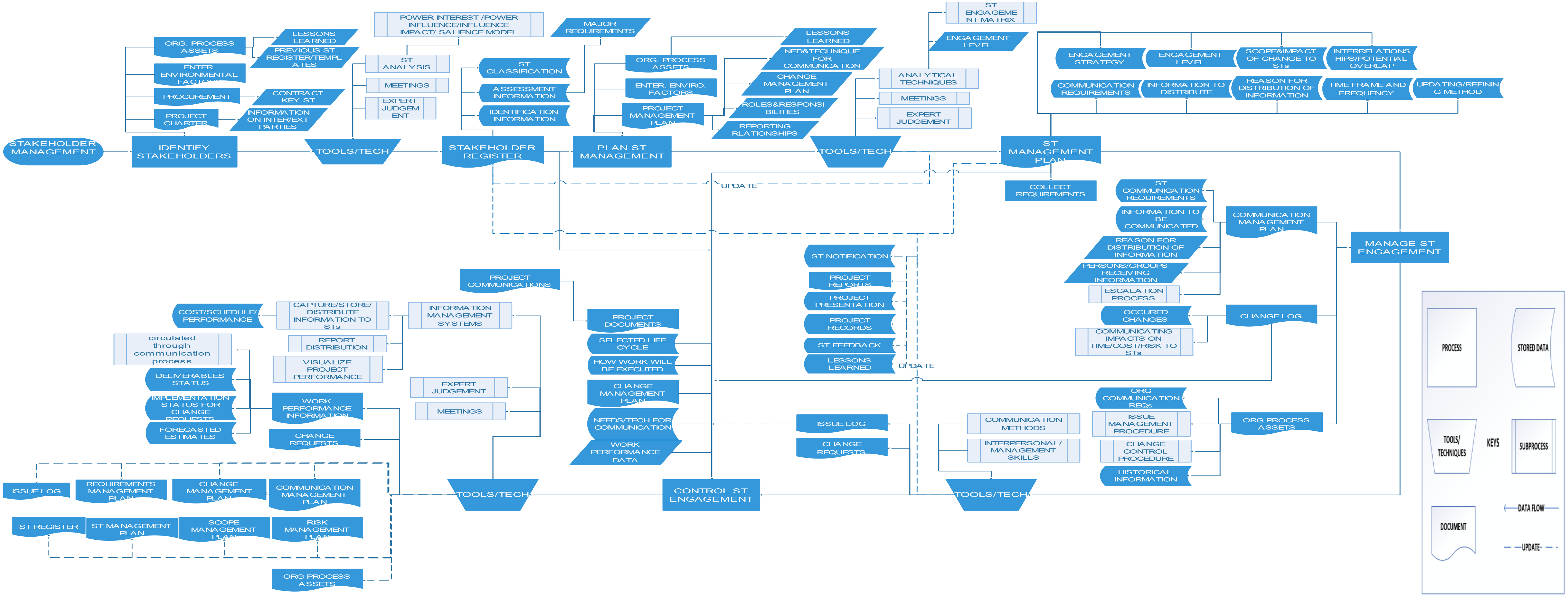
Appendix Figure 11 Collapsed view of the Paddington Health Campus Scheme (NAO).



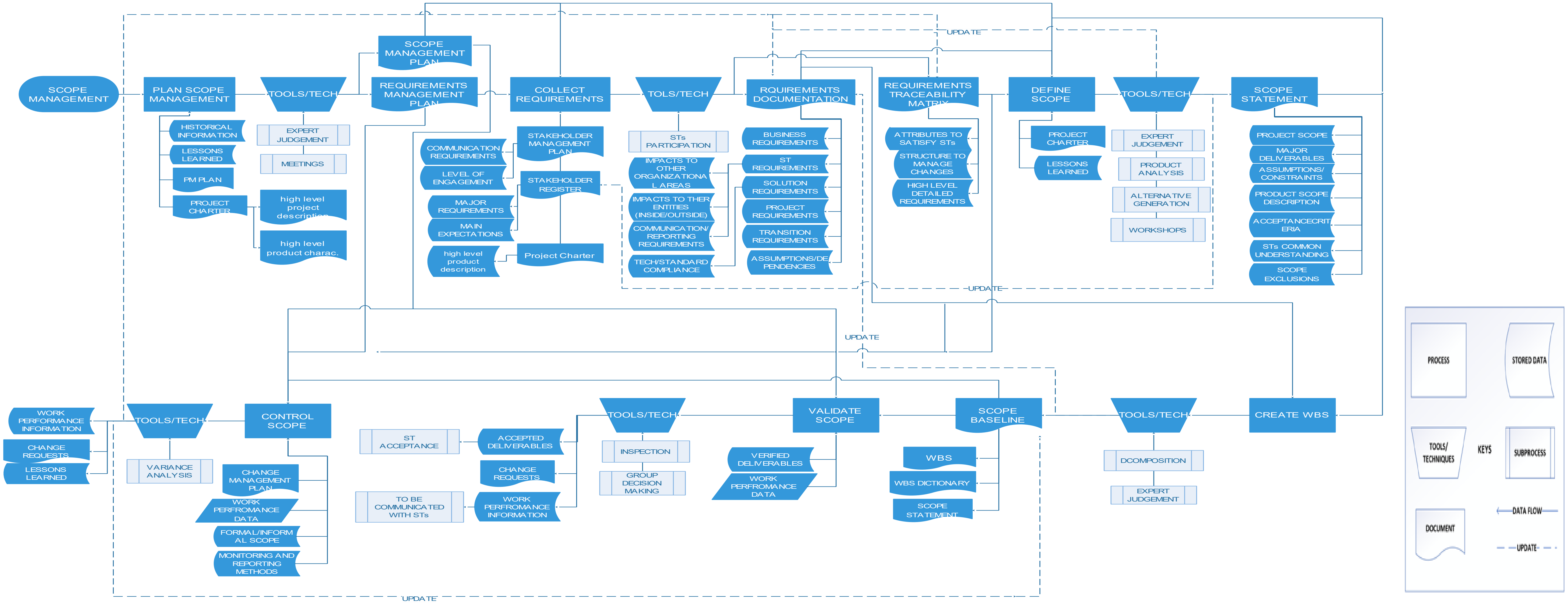
Appendix Figure 12 Collapsed view of the Wembley National Stadium Analysis (NAO).



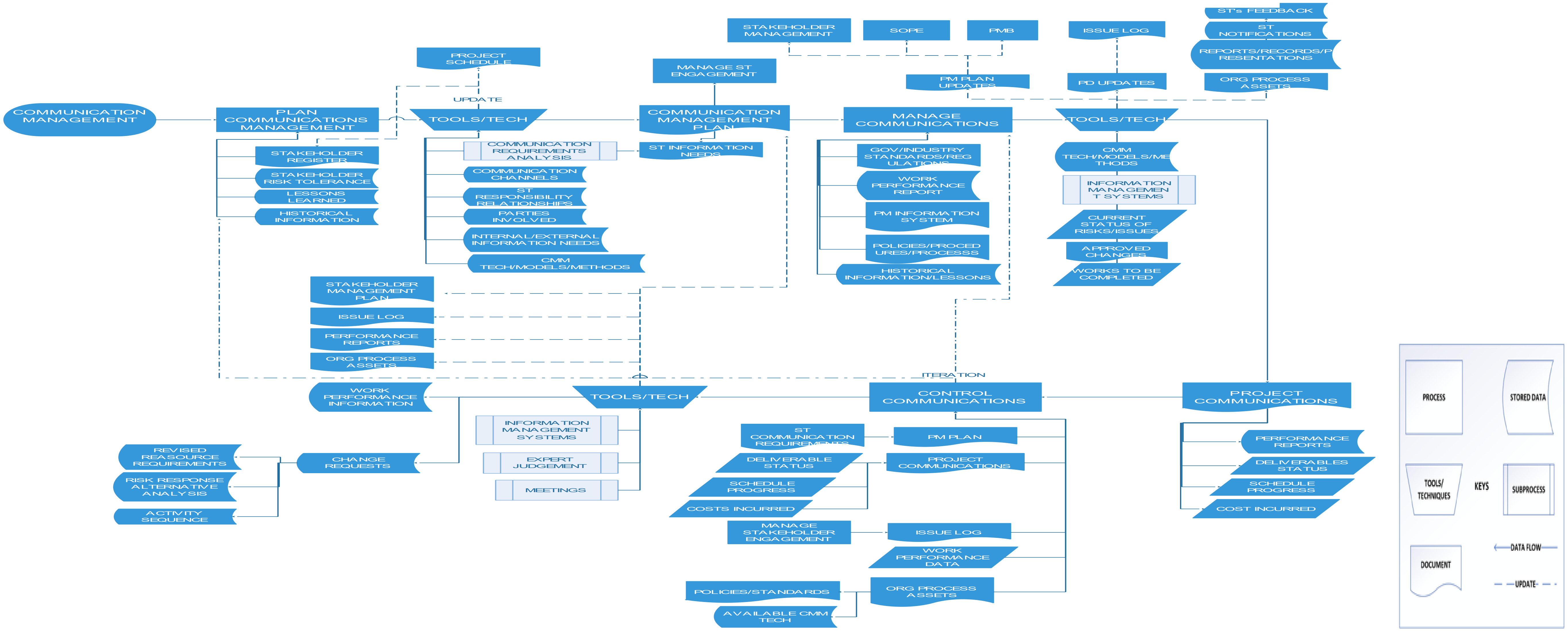
Appendix Figure 13 Stakeholder management process according to PMI (2017).



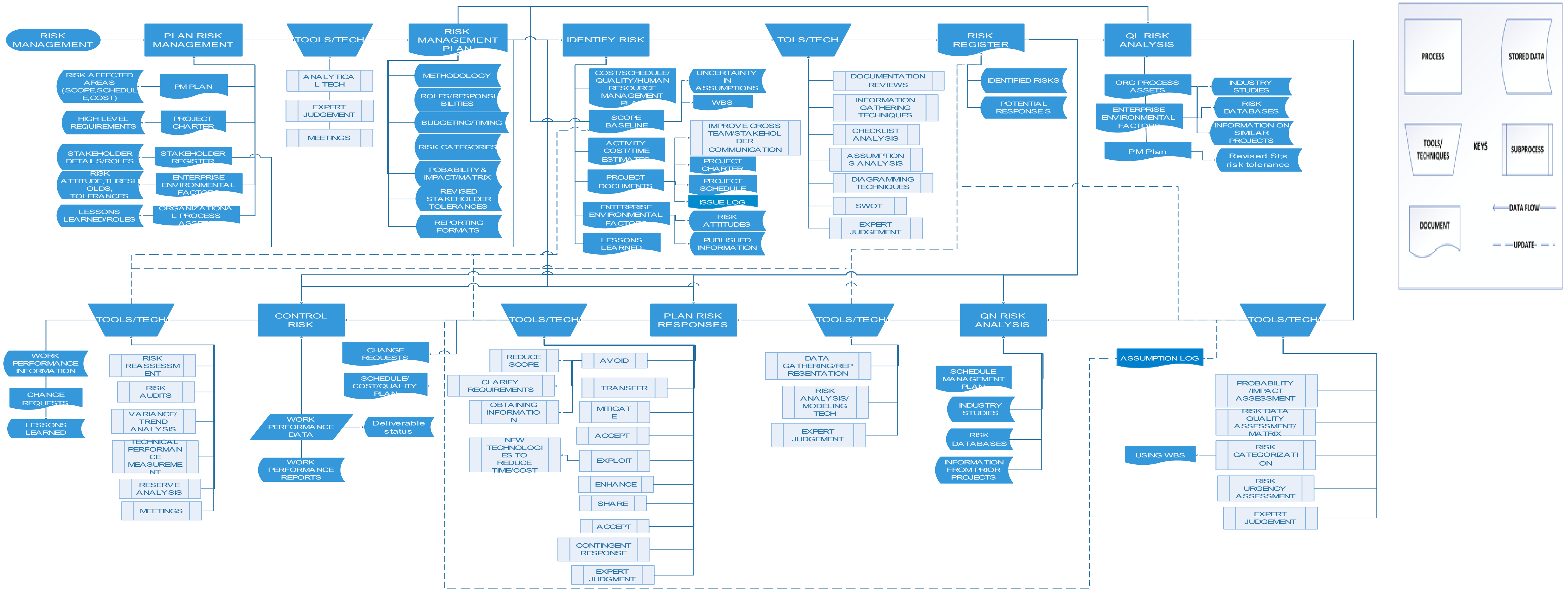
Appendix Figure 14 Scope management process analysis according to PMI (2017).



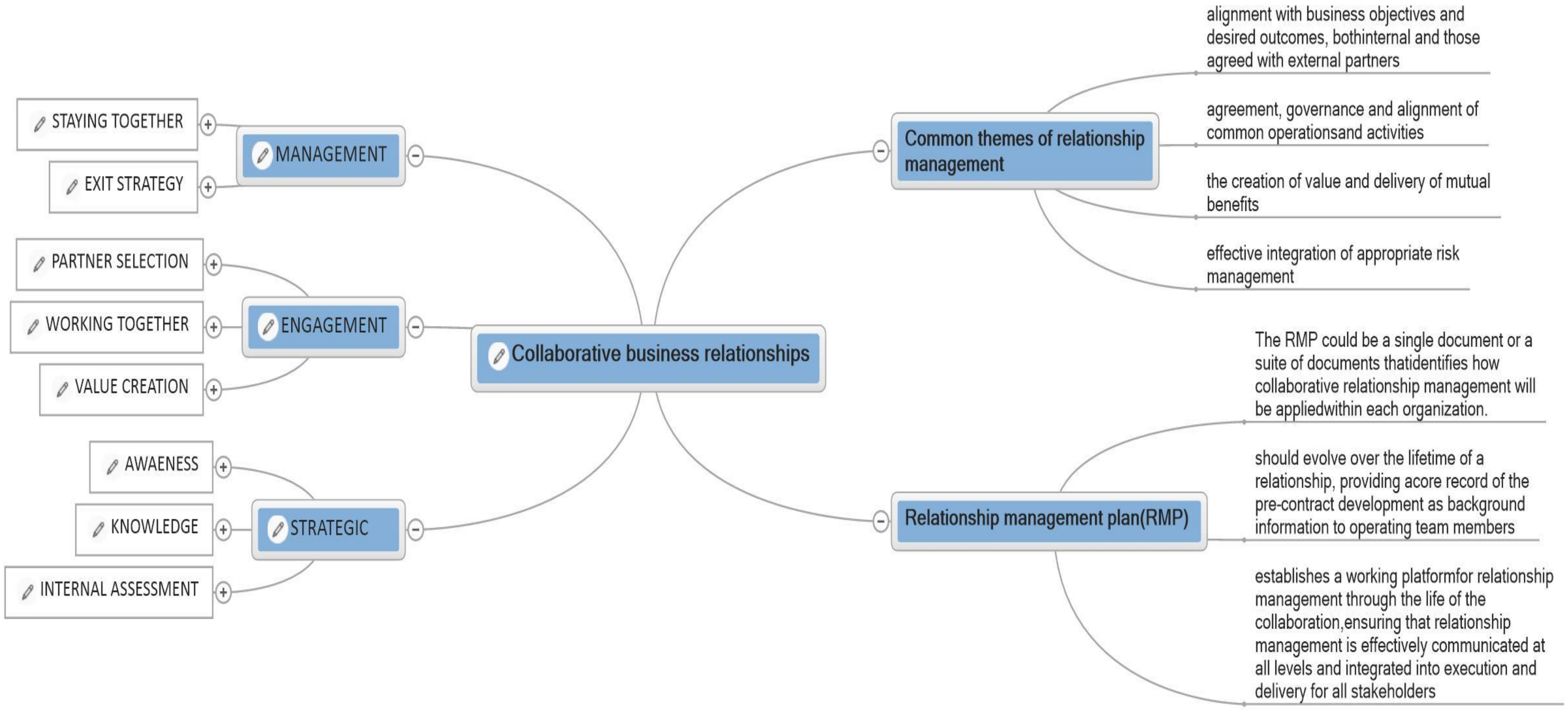
Appendix Figure 15 Communication management process analysis according to PMI (2017).



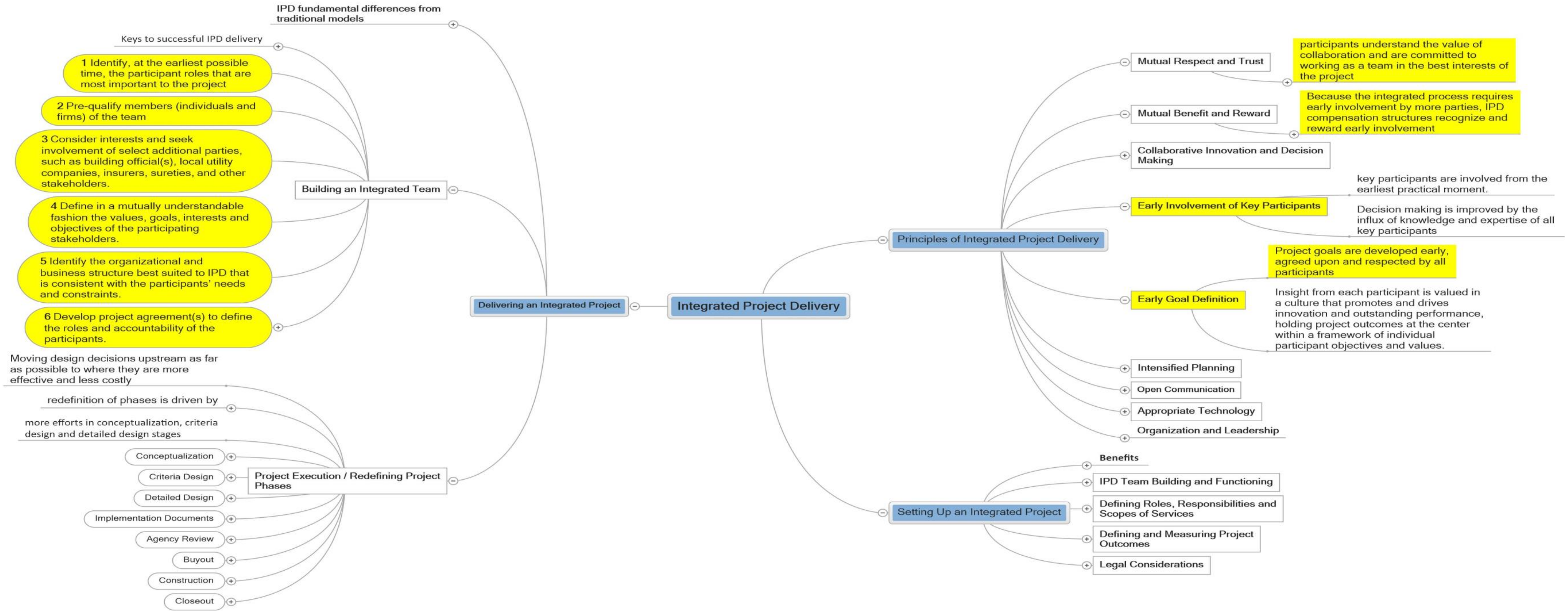
Appendix Figure 16 Risk management process analysis according to PMI (2017).



Appendix Figure 17 Collapsed view of the Collaborative Working standard analysis.



Appendix Figure 18 Collapsed view of the Integrated Project Delivery analysis.



Appendix Figure 19 Problematic issue occurred during the implementation of 5 case study projects

Project	Stakeholders	Scope	Communication	Risk
Metronet Project	-Poor corporate governance and leadership -Unanimous decision making by five shareholders acted as suppliers with different motivations -Frequent changing of executive management -5 Suppliers had power over some of the scope of work -DfT was not a party to the contracts and had no direct influence over performance(as the funder of grant) -Inadequate involvement of stakeholder due to lack of information and contractual lever(London underground)	-5 Suppliers expected to be paid for extra work undertaken -London Underground should have sufficiently detailed information available to it to confirm that work is affordable -London Underground did not have a breakdown of Metronet's high-level budget on station refurbishment work -Ambiguous specifications, including phrases such as "replace/renew", meant that there was room for differing interpretations of what, for example, a refurbishment would entail. -The minimal specification also led to diverging expectations between	-5 suppliers had better access to cost information than others -Poor quality of information available to management, particularly on the unit costs of the station and track programmes -All parties were hampered by a lack of good quality information -Metronet did not provide good quality performance and cost information -Lack of financial and performance data collection and analysis -Lack of information and poor information sharing -	-DfT had ultimate responsibility for protecting the interests of the taxpayer and was exposed to policy and financial risk due to PPP contract -Lack of proper risk management strategy by DFT due to devolution of power -Metronet's shareholders and lenders failed to identify and resolve performance problems -DfT had few formal levers to manage risks to the taxpayer -DfT's response to problems reflected the limited number of levers it had to influence the progress and the outcome of the PPP contracts. -The need for regular risk reports from contracted clients

	-DfT relied on the Arbiter to warn of potential cost overruns while he did not have a statutory duty -Metronet's shareholders did not tackle problems due to governance structures adopted, and their differing priorities and positions as beneficiaries of supply contracts -Dft decided not to become involved in disputes between contracting parties(2006) -Delays due to strike by RMT workers -Vague roles and responsibilities (Interpreted) -Public sector bodies involved in the oversight, monitoring and management of the Metronet PPP contracts did not all share a common agenda -Lack of alignment of interest between various public sector bodies	London Underground and the companies		-Poor parties understanding of key risks to the project -DfT was exposed to risk but lacked direct ways of gaining assurance over the management of this risk. -Dft relied on other parties to manage risks -Metronet's shareholders have also lost their equity investment -Direct loss to the taxpayers of 170 to 410 million

The BBC's three major estate projects	-Over 42 contract variations which contributed to significant delays and ultimately to a dispute with the developer -The changes were approved by the BBC Governors but indicate that the BBC had not clearly defined its needs at the outset of the projects -Recognising that weaknesses in the capability of the project team contributed to the difficulties with Broadcasting House phase 1 -Dispute between the developer and its sub-contractor	Broadcasting House: -Scope of the project was not sufficiently defined when the project was approved -The rebased contract simplified the specification of the building, extended the scope of the project and lengthened the timeTable for delivery Pacific Quay Project : -Both the size of the building and the technology requirements were increased as the project developed -None of the three projects were the intended benefits laid out at the outset with sufficient clarity to provide a basis for meaningful measurement of subsequent achievements -The BBC then increased the scope of the technology to include Digital Production and High Definition		Broadcasting House: -weak governance and poor change control processes contributed to severe delays and increased costs -The financial contingency set aside for the Broadcasting House project was insufficient for a project of that size and complexity and was not established based on an assessment of the project risks.

The New Scottish Parliament Building	-In other areas, more space was needed to meet increasing demands from the new Parliament Unforeseen changes requested by the client added to the workload of the design team. -There was a change of client after two years. -Project management had to respond to changes in the client specification	-Architects had difficulty in complying with a demanding project brief, which subsequently proved unrealistic in regard to the total area specified. -47 per cent increase in the total area of the building -The approved design was more complex than the notional ideas for the building at the feasibility stage in 1997 when initial cost estimates were prepared. -Extended timescale can be attributed to difficulties in achieving an approved design.	-Project management did not fully inform the client about their cost consultant's predictions on costs -There was not an arrangement that required project management to provide full cost information to accounTable officers or the client on a regular and systematic basis.	-Uncertainty about cost estimates, the more so because the client was unable to freeze the brief and the design -construction cost inflation risk and estimating uncertainty, and there were risks associated with coordinating and completing the large and complex programme of work -The type of contract leaves most of the risk with the client rather than the contractor -Project management did not identify and quantify a separate allowance for the major risks potentially affecting the project, as is good practice.
THE PADDINGTON HEALTH CAMPUS SCHEME	-Lack of a single sponsor -The way in which the campus partners organised and carried out the scheme -Change in the structure of the NHS BY government -The Royal Brompton and Harefield NHS Trust set out, as a	-Failure to secure adequate land for the scheme -Impact on design assumptions of new national policies for the NHS introduced while the scheme was being developed		-Sheer number and scale of risks -The scheme partners underestimated the risks to the scheme -risks due to its intrinsic complexity and the timescale over which it was being planed

	pre-condition, that a merger with St Mary's NHS Trust was not an option -Conflict between stakeholders in approving the revised business case -Disagreements about the content and affordability	-Mismatch between the size of the scheme and the land and funding available		-Inadequate mitigation or an effective risk management strategy
Wembley National Stadium	-Client organisations with limited experience of large-scale iconic stadiums projects and design-and-build procurement -Poor relations between the primary contractor and sub-contractors; leading to the dismissal of the steelwork subcontractor. -The management of the primary and secondary stakeholders for the Wembley project was vastly more complex and troublesome -The public body stakeholders associated with Wembley stadium had very diverse requirements	-Concerns about the platform solution led the -Department to request a review of the technical merits of the proposed design -Withdrawn athletics from the plans and returning them back again. -There were warnings to the main contractor Multiplex about rising costs and a delay on the steel job of almost a year due to design changes which Multiplex rejected -Many of the hold-ups have been blamed on the complicated nature of the design		-Minor delays installing seating were blamed on the recent insolvency of a supplier -The client was trying to counterbalance all RISK input to the contractor -Cost of changes made after the contract award is significant

	which were linked to the release of their funds -Dispute between Wembley National Stadium Ltd (WNSL) and Multiplex -Multiplex was involved strongly in the project with no exit strategy and their relationship with their supply chain was weak	-Multiplex has claimed that the 560 changes made to their brief by WNSL caused the delays

Appendix Figure 20 Summary of the problematic issues that occurred during the implementation of case study projects.

Processes	Stakeholder Management	Scope Management	Communication Management	Risk Management
Issues	- Different motivation and priorities and interests of stakeholders - Changes in stakeholders - Power and influence of stakeholders on the scope - Inadequate stakeholder involvement - Roles and responsibilities - Lack of addressing stakeholders' issues - Neglecting resolution of disputes - Contractual dispute between stakeholders	- Extra work costs - Affordability of work - Reworks and estimation - Lack of proper scope definition - Poor identification of specifications - Extended scope - Increased technology requirements	- Access to information - Poor information quality - Lack of data collection and analysis - Inadequate information sharing	- Lack of risk management strategy - Failure in identifying and responding to risks - Lack of proper levers for responding to risks - Poor understanding of key risks - Risk management roles and responsibilities - Insufficient financial contingency

	- Inadequate identification of stakeholders’ needs - The capability of participants and stakeholders - Poor stakeholders' relationships - Complex primary and secondary stakeholder management - No exit strategy	- Lack of value creation - Invalidity of deliverables - Complex and unrealistic project scope - Difficulties in approving the design - Changes in scope and design - Poor requirements collection		- Inadequate risk assessment - Risk allocation - Quantifying risks - Poor analysis of risk impacts

Appendix Figure 21 Ethics approval application form.

28th November 2017

Dear Mohsen,

Project Title:	**The Role of Stakeholders in Appearance and Management of Scope Creep in Major Construction Projects: Developing a Practical Framework According To BIM**
Principal Investigator:	**Dr Phebe Mann**
Researcher:	**Mohsen Jamshidi**
Reference Number:	**UREC 1718 05**

I am writing to confirm the outcome of your application to the University Research Ethics Committee (UREC), which was considered by UREC on **Wednesday 13 September 2017.**

The decision made by members of the Committee is **Approved**. The Committee's response is based on the protocol described in the application form and supporting documentation. Your study has received ethical approval from the date of this letter.

Should you wish to make any changes in connection with your research project, this must be reported immediately to UREC. A Notification of Amendment form should be submitted for approval, accompanied by any additional or amended documents: http://www.uel.ac.uk/wwwmedia/schools/graduate/documents/Notification-of-Amendment-to-Approved-Ethics-App-150115.doc

Any adverse events that occur in connection with this research project must be reported immediately to UREC.

Approved Research Site

I am pleased to confirm that the approval of the proposed research applies to the following research site.

Research Site	**Principal Investigator / Local Collaborator**
Participants' office	Dr Phebe Mann

Approved Documents

The final list of documents reviewed and approved by the Committee is as follows:

Document	*Version*	*Date*
UREC application form	2.0	19 November 2017
Interview Questions	1.0	15 August 2017
List of potential participants	1.0	15 August 2017
Consent form for interviews	1.0	15 August 2017
Participant Information sheet	2.0	19 November 2017

Approval is given on the understanding that the UEL Code of Practice in Research is adhered to.

The University will periodically audit a random sample of applications for ethical approval, to ensure that the research study is conducted in compliance with the consent given by the ethics Committee and to the highest standards of rigour and integrity.

Please note, it is your responsibility to retain this letter for your records.

With the Committee's best wishes for the success of this project.

Yours sincerely,

Fernanda Silva

Fernanda Silva
Administrative Officer for Research Governance
University Research Ethics Committee (UREC)
Email: researchethics@uel.ac.uk

Appendix Figure 22 The approval of the request for change in the project title.

University of East London

Change project title - Mr Mohsen Jamshidi

The ACE Research Degrees Sub-Committee on behalf of the Impact and Innovation Committee has considered your request. The decision is:

Approved

Your new thesis title is confirmed as follows:

Old thesis title: The role of stakeholders in occurrence and management of scope creep in major construction projects: developing a practical framework According to Building Information Modelling (BIM)

New thesis title: Managing the Influence of Stakeholders on the Scope of Major Construction Projects to Prevent Scope Creep in the BIM Era

Your registration period remains unchanged.

END