Delft University of Technology

MASTER'S THESIS REPORT

Overcoming Challenges in BIM Adoption in post-Soviet countries:

a Framework for Building Client Organizations

by Azamat Baktybaev

Student number: 5833973

Construction Management and Engineering, MSc

Graduation committee:

Chairman:	First supervisor:	Second supervisor:
Ir. Hans Ramler	Dr.ir. Sander van Nederveen	Dr.ir. Jelle Koolwijk
Civil Engineering and Geosciences	Civil Engineering and Geosciences	Architecture and the Built Environment

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Preface

The thesis “Overcoming Challenges in BIM Adoption in Post-Soviet Countries: A Framework for Building Client Organizations,” which is now in front of you, is the result of the past few months of research and two years of study in the MSc Construction Management and Engineering program at TU Delft, together with my experience in the AEC industry. My first meet with Building Information Modelling (BIM) was in the mid 2010s when I worked as an engineer for a client organization on a full-field development project in the Arctic region of Russia. During that time, I took my first steps into information management, organizing collaboration with contractors and digitizing document flow for project execution. I encountered both support for these changes and resistance from our contractors, who were unwilling to work within a shared data environment.

This thesis explores the key barriers to BIM adoption and strategies to overcome them, drawing from my personal experiences as well as academic research.

I would like to express my gratitude to all those who made this work possible. I am particularly thankful to the members of my graduation committee: Hans Ramler, the committee chair; Sander van Nederveen, my first supervisor and lecturer of the course Information Systems for the Construction Industry; and Jelle Koolwijk, supervisor, who provided valuable insights during the writing process.

I would also like to extend special thanks to Menno de Jonge, board member of buildingSMART Saudi Arabia, who gave the first insights into this research on BIM adoption.

Above all, my deepest gratitude goes to my family: my wife Elza, my children, my parents, and my in-laws. Their love and support, even from a distance, have been my greatest source of strength. Thanks to them, I was able to reach this milestone. I deeply regret that my mother passed away before I could complete this research. However, it was she who, from my earliest days, instilled in me a love for learning and encouraged me to seek knowledge and strive for excellence. For that, I am forever grateful.

Thank you all.

Azamat Baktybaev,
Delft, the Netherlands
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Abstract

Building Information Modelling (BIM) has emerged as a transformative technology in the Architecture, Engineering, and Construction (AEC) industry, offering significant potential for improving project efficiency, collaboration, and transparency. However, its adoption in post-Soviet countries, particularly within the Commonwealth of Independent States (CIS), remains limited due to a range of socio-technical, organizational, and regulatory challenges. This research investigates the primary barriers faced by Building Client Organizations (BCO) in the CIS region when adopting and implementing BIM. The study also examines the role of Design-Engineering Organizations (DEO) in supporting BCO during this digital transition.

The research follows a qualitative methodology, combining semi-structured interviews with professionals from a design-engineering company and document analysis of BIM Execution Plans (BEP) and Employer's Information Requirements (EIR). Four interviews were conducted with industry experts who were involved in BIM projects in the CIS region. This data was analyzed using selective coding to identify key challenges and strategies for overcoming these barriers. Additionally, the research employed document analysis to validate the insights from interviews and to provide context for the identified challenges.

The study proposes a comprehensive change framework to address the identified challenges in BIM adoption. The framework emphasizes the need for enhanced collaboration between BCO and DEO, with a focus on standardizing processes, improving client education, and aligning expectations. It integrates change management models, such as Kotter's 8-Step Change Model and the ADKAR model, to guide organizations through the digital transformation process. This framework aims to address technical barriers, such as interoperability and data standardization, while also fostering cultural and organizational shifts needed to overcome resistance to change and low client engagement.

Despite the limitation of a small sample size and validation from one organization, the research contributes valuable insights due to the expertise of the participants and the lack of existing studies focused on BIM adoption in the CIS region. The findings provide practical recommendations for advancing BIM implementation in this context, contributing to the broader body of knowledge on BIM adoption in transitioning economies.

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List of Abbreviations

AEC – Architecture, Engineering, Construction

BCO – Building Client Organization

BEP – BIM Execution Plan

BIM – Building Information Modelling

CDE – Common Data Environment

CEO – Chief Executive Officer

CIS – Commonwealth of Independent States

CPE – Chief Project Engineer

DEO – Design-Engineering Organization

EAEU – Eurasia Economic Union

EIR – Employer’s Information Requirements

IFC – Industry Foundation Classes

LOD – Level of Details

SNiP – Building norms and rules (Rus)

Chapter 1. Introduction

1.1 Background and Context

Building Information Modelling (BIM) has become a critical aspect of the digital transformation in the Architecture, Engineering, and Construction (AEC) industry globally. The implementation of BIM, alongside other technologies like digital twins and cloud computing, has been recognized as an important factor in enhancing productivity, collaboration, and efficiency across project lifecycles (Eastman et al., 2011; Oesterreich & Teuteberg, 2019). As a digital tool, BIM enables the integration of data and the creation of a collaborative environment where stakeholders, including architects, engineers, and construction managers, can work seamlessly on virtual models of a project. This transformation is not only leading to more accurate designs and reduced rework but is also fostering advancements in real-time project tracking and lifecycle management (Azhar, 2011).

Despite its benefits, the global adoption of BIM has been slower than expected, with numerous barriers hindering its widespread use. According to the *NBS 2020 BIM Report*, while the adoption rate of BIM in the UK has increased significantly from 13% in 2011 to 73% in 2020, many regions still lag in integrating this technology fully (NBS, 2020). Developing countries and Small and Medium Enterprises (SMEs) face particular challenges due to limited resources, lack of expertise, and high costs associated with BIM implementation (Saka & Chan, 2021). Moreover, many firms struggle with the complexity of transitioning from traditional methods to digital workflows, as well as issues surrounding interoperability between various software platforms. These factors contribute to a growing digital divide between larger firms and SMEs, and between developed and developing economies in terms of BIM maturity levels (Saka & Chan, 2021).

In post-Soviet countries, such as those in the Commonwealth of Independent States (CIS) and the Eurasian Economic Union (EAEU), BIM adoption presents unique challenges influenced by the region's socio-economic and cultural context. The construction industry in this region has traditionally been slow to embrace digital technologies due to outdated practices, regulatory barriers, and a general lack of government-led initiatives to promote BIM usage (Aitbayeva & Hossan, 2020). Moreover, the region faces additional hurdles, including a lack of local expertise, insufficient digital infrastructure, and high costs related to software procurement and training (Vilisova & Mironova, 2021). As a result, the CIS and EAEU countries, which are still transitioning from Soviet-era construction methods, require targeted studies to understand how BIM can be successfully implemented in such environments. This study aims to address the gap in research concerning BIM barriers in this region, with the goal of providing actionable strategies for overcoming these obstacles.

1.2 Importance of Studying Early BIM Adoption

The study of organizations that are in the early stages of adopting BIM offers critical insights into the initial barriers they encounter and the strategies they deploy to overcome these challenges. Early adopters provide a unique perspective on the challenges inherent in shifting from traditional workflows to a more integrated digital approach, especially in regions that have been slow to embrace digital transformation. These organizations' experiences can yield valuable lessons for policymakers and other stakeholders, helping to design better support structures and frameworks to facilitate BIM implementation on a broader scale (Eadie et al., 2013).

Such studies can highlight the need for governmental incentives, industry-wide training programs, and the development of localized standards that align with global BIM protocols. The role of early adopters is particularly important in regions where the regulatory environment and industry infrastructure are still evolving to accommodate digitalization.

Unique Opportunities and Challenges

Early adopters often become the benchmark for the rest of the industry, setting the standards that others will eventually follow (Rogers, 2003). These organizations may not only influence national BIM strategies but also contribute to the development of regional standards that shape future adoption. However, early adopters also face unique challenges – particularly in regions where support networks and digital infrastructure are still underdeveloped (Georgiadou, 2019).

Without the benefit of extensive regional expertise or peer support, these organizations often have to rely on international best practices and external guidance, which may not be fully adaptable to the local context. This makes early adoption more complex but also creates a fertile ground for innovation, as these organizations find ways to make BIM work in environments not yet fully equipped for it.

Impact on Digital Transformation

Successful early adoption of BIM can have a significant impact on the broader digital transformation of the AEC industry in CIS region. Early adopters act as catalysts for change by showcasing the benefits of digital workflows, such as improved project efficiency, better collaboration, and enhanced decision-making through data integration (Chowdhury et al., 2019).

These organizations not only accelerate their own technological growth but also play a critical role in shifting industry norms toward embracing digital solutions. Their success can encourage government agencies, regulatory bodies, and private-sector stakeholders to expedite the development of digital standards and training programs that support further BIM adoption across the region.

Moreover, early adopters can influence cultural change within the AEC industry, helping to shift the focus from manual, paper-based processes to more data-driven, automated systems. This transformation is key to enhancing competitiveness and ensuring that post-Soviet countries can modernize their infrastructure and construction practices to meet global standards.

1.3 Research Gap

Despite the increasing interest in BIM adoption globally, there is a noticeable lack of empirical studies focusing on the early stages of BIM implementation in post-Soviet countries. Much of the existing literature concentrates on regions that have already made significant progress in digital transformation, such as Western Europe, North America, and parts of Asia (Barbosa et al., 2017).

In contrast, studies on the CIS region are limited, particularly regarding the initial challenges that organizations face when transitioning to BIM. This presents a critical research gap, which this study aims to address by focusing on companies in the early stages of BIM adoption. By filling this gap, the research will provide actionable insights that can assist both practitioners and policymakers in these regions, helping them to navigate the complexities of digital transformation.

1.4 Scope of the Research

The scope of this research is focused on examining the challenges faced by Building Client Organizations (BCO) in adopting and implementing BIM during the digital transformation of the AEC industry and supporting role of Design Engineering Organizations (DEO). While the empirical data is drawn from interviews with industry professionals in the CIS region, this study aims to uncover common barriers and effective strategies that can be applied more broadly, to other countries transitioning from traditional construction practices to digital methods.

Although the focus is on the CIS region, many countries globally are in similar stages of digital transformation within the AEC sector. These regions often face analogous challenges, including organizational readiness, technical capability gaps, and stakeholder engagement issues. The research seeks to draw insights from the CIS context, recognizing that the challenges in early-stage BIM adoption are not confined to post-Soviet countries. Rather, the barriers to BIM adoption identified here can be relevant for many countries and organizations in the early stages of digital adoption.

The research specifically covers:

- Organizational and Technical Challenges: The study investigates internal factors that influence the successful adoption of BIM. These include project management practices, BIM literacy, software interoperability, and effective use of BIM tools.

- Client Engagement and Education: The research will examine how BCO understanding and involvement influence the success of BIM implementation, particularly how aligning expectations and improving BCO education can drive adoption.
- Strategies for Overcoming Challenges: The study will develop best practices and recommendations for BCO to effectively navigate the challenges of BIM adoption.
- Regulatory and Policy Considerations: The research investigates how national regulations, standards, and governmental initiatives support or hinder BIM implementation. This analysis is essential for understanding the external forces that shape BIM adoption and for proposing policy changes that could promote standardization and wider adoption across the region.

Despite the broad applicability of the findings, there are limitations in terms of generalizability. Cultural, economic, and regulatory differences may necessitate adaptations in different regions, and the primary data collected from the CIS region may reflect unique challenges specific to this geographical and historical context. However, the research's aim is to identify universal principles that can offer value to any organization in the early stages of BIM adoption.

1.5 Research Aim and Questions

Research Aim

The primary aim of this research is to identify and analyze the challenges that BCO face in adopting and implementing BIM during their digital transformation and to develop practical strategies to overcome these barriers, facilitating smoother BIM adoption and enhancing digitalization efforts globally.

Main Research Question

What are the main challenges that building client organizations (BCO) of post-Soviet countries face in adopting and implementing BIM during the digital transformation of the AEC industry, and how can these challenges be effectively addressed with the support of design-engineering organizations (DEO)?

Research Sub-Questions

1. **What challenges do companies encounter in BIM adoption and implementation?**

This sub-question focuses on identifying the organizational and technical barriers that companies face when trying to adopt and implement BIM.

2. **How does the level of client engagement and education affect the successful implementation of BIM in projects, and what approaches can enhance client understanding and alignment of expectations?**

This sub-question examines how client involvement and education impact the success of BIM projects. It explores the importance of client understanding of BIM's benefits and seeks to identify methods to align client expectations with project outcomes through improved engagement and education.

3. **What strategies and best practices can BCO adopt to overcome the identified challenges and effectively implement BIM? How can DEO contribute to the successful implementation of these strategies?**

This sub-question looks at the practical strategies that BCO can employ to address the challenges of BIM adoption, such as change management models, training programs, and collaborative workflows. It also highlights the role of DEO in supporting these strategies, providing technical expertise and project management solutions.

4. **How do regulatory and policy factors influence the adoption and implementation of BIM by BCO, and what initiatives can support standardization and effective implementation? How can DEO assist clients in adapting to evolving regulations?**

This sub-question investigates how regulations and policies affect BIM adoption in client organizations, considering the potential for mandates, standards, and incentives. It also explores how DEO can assist clients in navigating and complying with regulatory changes to ensure the successful implementation of BIM.

Table 1 Research Design

Research Question	Research Method	Outcome(s)	Chapter Addressed
SQ 1: What challenges do companies encounter in BIM adoption and implementation?	Interviews, Literature Review	Key challenges identified: technical (interoperability, data standardization), organizational (resistance to change, etc.).	2 and 4
SQ 2: How does the level of client engagement and education affect the successful implementation of BIM in projects, and what approaches can enhance client understanding and alignment of expectations?	Interviews, Literature Review	Lack of client demand and awareness are key barriers. Effective education and engagement strategies are required.	2, 4 and 6
SQ 3: What strategies and best practices can BCO adopt to overcome the identified challenges and effectively implement BIM? How can DEO contribute to the successful implementation of these strategies?	Interviews, Case Study Analysis, Literature Review	Identified best practices: standardization, change management models, and DEO's role in client support and training.	5, 6 and 7

SQ4: How do regulatory and policy factors influence the adoption and implementation of BIM by BCO, and what initiatives can support standardization and effective implementation? How can DEO assist clients in adapting to evolving regulations?	Document Analysis, Literature Review	Inconsistent regulations identified as a major barrier. The need for standardization and government-driven initiatives.	2, 5 and 6
Main Research Question: What are the primary challenges that building client organizations (BCO) in post-Soviet countries face in adopting and implementing BIM during the digital transformation of the AEC industry, and how can these challenges be effectively addressed with the support of design-engineering organizations (DEO)?		Identified key challenges, including interoperability issues, client engagement problems, and organizational barriers.	4, 6 and 7

By answering these research sub-questions, this study will provide an in-depth analysis of the challenges hindering BIM adoption in BCO. The findings will contribute to the existing literature by offering practical solutions and strategies that can help organizations overcome barriers and successfully implement BIM. This research will also provide valuable insights for policymakers aiming to facilitate the digital transformation of the AEC industry in the CIS region and beyond.

1.6 Thesis Structure

This thesis is organized into six chapters, each systematically contributing to the understanding of the challenges faced by building client organizations in adopting and implementing BIM during the digital transformation of the AEC industry. The structure is designed to address the research questions and objectives outlined in the introduction.

Chapter 1: Introduction

The first chapter sets the stage by presenting the background and context of BIM adoption globally and within the post-Soviet countries. It defines the scope of the study, articulates the research aim and questions, and introduces the thesis structure. The chapter frames the challenges of early-stage BIM adoption and the need for research in this domain.

Chapter 2: Literature Review

Chapter 2 offers a comprehensive review of existing literature on BIM adoption globally and within the CIS region. It critically examines the key challenges, including organizational and technical barriers, client engagement, strategies for successful implementation, and regulatory and policy factors. The chapter also identifies gaps in the literature, especially regarding early BIM adoption in post-Soviet countries, which provides a foundation for the research focus.

Chapter 3: Research Methodology

This chapter details the research design and methodology employed to address the research questions. It outlines the qualitative approach, including the use of semi-structured interviews with industry professionals. The chapter explains the rationale for focusing on BCO in the CIS region, the role of DEO, discusses the selection process, and describes the data collection and thematic analysis techniques used to derive findings. Ethical considerations are also addressed.

Chapter 4: Research Findings

Chapter 4 presents the empirical findings based on the interviews conducted. The data is analyzed according to key themes identified in the research, including organizational challenges, technical barriers, and Client engagement issues. This chapter provides evidence of the challenges that BCO face during the early stages of BIM adoption and offers insights into the strategies being employed to overcome these obstacles.

Chapter 5: Framework and Validation

This chapter represents framework structured on Literature review and Interview data analysis to guide BCO through each stage of BIM adoption.

Chapter 6: Discussion

The sixth chapter interprets the findings in relation to the literature reviewed in Chapter 2. It discusses the implications of the research for BIM adoption in the AEC industry, particularly in the context of CIS region. The chapter revisits the main research question and sub-questions, providing a clear explanation of how they have been addressed through the study.

Chapter 7: Conclusions and Recommendations

The final chapter summarizes the key conclusions of the research. The chapter offers practical recommendations for BCO seeking to adopt BIM and emphasizes strategies to overcome early-stage challenges. Additionally, it identifies areas for future research, particularly in the context of advancing digital transformation in the AEC industry.

Chapter 2. Literature Review

2.1 Introduction

This chapter presents a comprehensive review of the current literature on BIM adoption, with a focus on the AEC industry. The review addresses the primary research aim of identifying the challenges faced by building client organizations during the early stages of BIM adoption and the digital transformation of the AEC industry. The chapter is structured to examine BIM from a global perspective, explore organizational and technical challenges, Client engagement, and strategies for overcoming these barriers, and synthesize the literature to identify gaps relevant to the context of post-Soviet countries. The findings of this review will inform the research questions and guide the methodology used in the study.

2.2 Global Overview of BIM in the AEC Industry

2.2.1 History and Evolution of BIM

BIM has significantly evolved over the past few decades, transforming how projects are designed, constructed, and managed. Initially, construction relied heavily on 2D drafting methods, which were inefficient and prone to errors. BIM introduced 3D digital representations that included not only the physical aspects of a building but also detailed metadata for various components, significantly improving project management, visualization, and collaboration.

The early development of BIM started in the 1970s with the introduction of software tools such as Sketchpad and Building Description System (BDS), which laid the foundation for modern BIM technologies. As the demand for more integrated and collaborative project delivery grew, BIM platforms like Autodesk's Revit and Bentley's MicroStation revolutionized the industry, enabling project teams to work on shared models. By the 2000s, BIM became essential in countries like the United Kingdom and the United States, where government mandates drove its widespread adoption (Eastman et al., 2011).

2.2.2 Benefits and Drivers of BIM Adoption

BIM offers several benefits that have driven its global adoption. Its ability to improve collaboration between stakeholders is one of the most significant advantages. With a centralized model, architects, engineers, and contractors can simultaneously work on different aspects of a project, leading to better coordination and fewer errors (Barbosa et al., 2017).

Additionally, BIM enables more accurate project visualizations, allowing stakeholders to foresee potential design conflicts or construction issues before they arise. This leads to improved decision-making, reduces costly rework, and improves overall project quality. Studies have shown that BIM adoption reduces construction costs and project timelines, while also providing more efficient facilities management after construction is complete (Eadie et al., 2013; Succar, 2009).

BIM adoption is also driven by its alignment with global digital transformation trends. As the AEC industry moves towards Industry 4.0, BIM is seen as a cornerstone in integrating smart technologies, data analytics, and automation into the construction lifecycle (Boje et al., 2020). The integration of technologies such as augmented reality (AR) and virtual reality (VR) with BIM further enhances its utility in visualizing and planning complex projects.

2.2.3 Global BIM Adoption Trends

BIM adoption varies significantly across the globe, with certain countries setting the benchmark for its use, while others are still in the early stages of adoption. The United Kingdom is often cited as a global leader in BIM implementation, largely due to the government's 2016 mandate requiring Level 2 BIM for all public projects. This move set a precedent for other nations and positioned the UK as a model for structured BIM adoption (UK Government, 2015). Similarly, Singapore has embraced BIM as part of its Smart Nation initiative, promoting its use through government incentives and regulations (Wong et al., 2011).

The pace of adoption is also influenced by the presence of BIM standards and protocols, such as ISO 19650, which provide a framework for implementing BIM at various stages of the construction process. Countries that have adopted such standards tend to experience smoother transitions to BIM, as these protocols offer guidelines for data management, collaboration, and model sharing across projects (EUBIM Task Group, 2017).

2.3 Specificity of the CIS Region in AEC Industry and BIM Implementation

The Commonwealth of Independent States (CIS) region, composed of post-Soviet countries, has a unique set of challenges and opportunities for BIM implementation in the AEC industry. This section examines the particularities of the AEC industry in the CIS, focusing on historical, regulatory, economic, and technological aspects, with a detailed view of some countries, that are key players in the region.

2.3.1. Historical Context of AEC in the CIS

The construction sector in the CIS countries was heavily influenced by Soviet-era methods, characterized by centralized planning and prescriptive building codes. These legacy systems have shaped the pace of modernization in the AEC sector today (Ginzburg et al., 2016). Following the dissolution of the Soviet Union, economic instability slowed technological advancements in construction, leaving many companies reliant on traditional methods, such as manual drafting and 2D CAD, for years (Aitbayeva & Hossan, 2020).

2.3.2. Regulatory Framework and Government Initiatives

Government regulations and initiatives are essential drivers of BIM adoption in the CIS region. For example, the Ministry of Construction of the most influential country has promoted BIM by adopting a Decree, which outlines the phased implementation of BIM technologies across the construction industry (Ginzburg et al., 2016). This means that BIM is now mandatory for public sector projects, where its use is intended to improve transparency, reduce construction times, and optimize resources (Turkova et al., 2020).

Another example is Kazakhstan, they have taken a similar approach with its "Concept for the Implementation of Information Modeling Technologies in Industrial and Civil Construction" (2018-2022), aiming to standardize BIM usage in public projects. The government has set clear goals, including aligning with international BIM standards such as ISO 19650, improving project management efficiency, and achieving cost reductions (Aitbayeva & Hossan, 2020).

2.3.3. Barriers to BIM Implementation

Despite the positive regulatory environment, several challenges hinder the widespread adoption of BIM in the CIS region.

Legacy Systems and Resistance to Change

A major barrier is the presence of legacy systems from the Soviet era. Many companies continue to use outdated methods, making it difficult to transition to modern BIM systems. This resistance is partly due to the perception that traditional methods are more cost-effective, even though BIM offers long-term benefits (Ginzburg et al., 2016).

Lack of Skilled Workforce

Another significant challenge is the shortage of skilled workers trained in BIM technologies. The AEC workforce in the CIS is still dominated by professionals proficient in 2D CAD and manual drafting, while there are limited training opportunities for 3D modeling and BIM-related skills (Aitbayeva & Hossan, 2020). Although Russian universities have introduced BIM courses, the number of qualified professionals remains insufficient to meet the demand (Ginzburg et al., 2016).

Financial Constraints for Small Enterprises

The costs associated with BIM adoption also present a challenge, especially for small and medium-sized enterprises (SMEs). Larger corporations have the resources to invest in the necessary software, hardware, and training, but SMEs often lack the capital to justify such investments (Aitbayeva & Hossan, 2020). While governments have introduced some financial incentives, particularly in Kazakhstan, these have not been enough to drive widespread adoption in the private sector.

2.3.4 Opportunities for BIM in the CIS Region

Despite the challenges, there are significant opportunities for the widespread adoption of BIM in the CIS region, particularly in large-scale infrastructure projects. For example, BIM has been used successfully in high-profile projects such as the construction of sports stadiums for the 2018 FIFA World Cup, demonstrating its potential to improve project coordination, reduce errors, and optimize timelines (Ginzburg et al., 2016).

Kazakhstan's focus on integrating BIM with sustainable construction practices presents another opportunity. BIM can optimize energy performance, manage materials, and assess lifecycle costs, making it a key tool in achieving environmental goals and improving project efficiency (Aitbayeva & Hossan, 2020).

2.3.5. Expectations from BIM Implementation

The expectations for BIM implementation in the CIS region, particularly in the biggest country of the region, are substantial. According to its Ministry of Construction, the integration of BIM is expected to reduce project costs by up to 20%, shorten construction times, and lower administrative barriers. The ultimate goal is to create a more efficient, transparent construction process that aligns with modern digital economy practices (Turkova et al., 2020).

In addition, the use of BIM in the construction industry is seen as an essential step in the digital transformation of the sector. It is expected to enhance collaboration across project stakeholders, improve decision-making through data-driven insights, and reduce the risk of errors or delays. For instance, the development of 4D and 5D BIM (which integrates time and cost dimensions into the model) allows contractors to better visualize the impact of design changes and make more informed decisions, potentially revolutionizing project management (Turkova et al., 2020).

In Kazakhstan, the government expects BIM to streamline public sector projects by improving quality control, reducing waste, and ensuring that projects are delivered on time and within budget. The gradual adoption of BIM across various sectors, including infrastructure and energy, is expected to contribute to the country's long-term economic growth (Aitbayeva & Hossan, 2020).

Table 2Desired goals from BIM implementation by CIS governments

Goals
Reduce project costs and streamline project delivery
Shorten construction times
Lower administrative barriers
Create more efficient, transparent, and well-managed construction process
Enhance collaboration across stakeholders and improve decision-making
Reduce the risk of errors or delays
Allow better visualization of design changes (4D & 5D BIM)
Improve quality control and reduce waste
Contribute to long-term economic growth through better project outcomes

2.4 Challenges in BIM adoption

BIM offers significant opportunities for improving efficiency and collaboration in the industry. However, its widespread adoption faces numerous socio-technical challenges. These challenges stem from a complex interplay of technical, organizational, economic, and human factors that can slow or prevent the successful implementation of BIM across various sectors. Understanding these challenges is critical to devising effective strategies that enhance the adoption and utilization of BIM in construction projects.

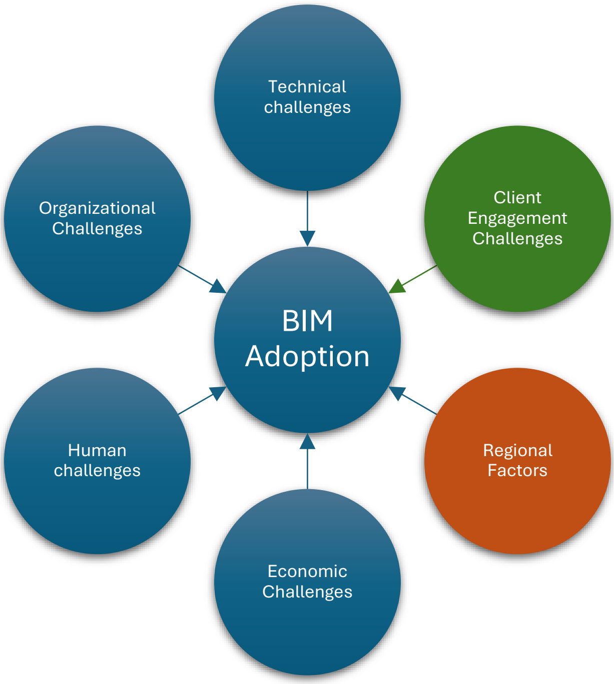

Figure 1 Challenges in BIM adoption

2.4.1 Technical Challenges

The technical challenges associated with BIM adoption are among the most frequently cited barriers in the literature. A key issue is the lack of interoperability between different BIM software platforms. Many organizations adopt BIM using varying software tools, which often lack seamless integration capabilities, leading to difficulties in data exchange and communication between project stakeholders. Saka and Chan (2023**)** highlight that this problem is exacerbated in projects involving multiple stakeholders from different organizations, each using different platforms, which leads to inconsistent data flows and potential errors in project execution. Similarly, Oesterreich and Teuteberg (2019) emphasize that these interoperability issues are critical technical obstacles, particularly for smaller organizations that cannot afford the high costs of advanced software tools designed to bridge these gaps.

Another significant technical challenge is the high cost of BIM technology, which includes both software and hardware infrastructure. Ahmed (2021) points out that small and medium-sized enterprises (SMEs) often find it financially prohibitive to invest in the latest BIM technologies, particularly as the software and hardware requirements evolve rapidly. Beyond costs, the complexity of BIM models and the integration of other technologies like 4D (time) and 5D (cost) BIM have introduced new technical hurdles. These advanced features require high levels of precision and expertise, which further complicates their widespread use and effective implementation.

2.4.2 Organizational Challenges

Organizational challenges refer to the internal hurdles within a company or between organizations that inhibit the successful adoption of BIM. A critical organizational challenge is the lack of standardized processes for BIM adoption within companies. As Siebelink et al. (2021) discuss, many organizations lack formalized BIM processes, leading to inconsistent usage of the technology across projects. The absence of internal BIM standards also creates difficulties in ensuring consistent quality and collaboration. This issue is further compounded by the fragmentation of the construction industry, where different firms, especially SMEs, struggle to align with larger firms' BIM practices, creating disconnects and delays in project workflows (Saka and Chan, 2023).

Another key organizational challenge is resistance to change. Many organizations are reluctant to move away from traditional construction practices and are slow to embrace the new digital workflows that BIM demands. Ahmed (2021) identifies habitual resistance to change as one of the most impactful barriers to BIM adoption. In many cases, the integration of BIM requires restructuring internal processes, reallocating roles, and investing in new skills and training. Without strong leadership to drive this change, organizations may find it difficult to fully embrace BIM.

2.4.3 Economic Challenges

Economic challenges present some of the most significant barriers to BIM adoption, particularly for smaller firms that operate with limited budgets. Cost-related barriers include not only the high upfront costs of purchasing BIM software and the necessary hardware but also the ongoing expenses of training employees and maintaining up-to-date systems. Ahmed (2021) identifies training expenses as a crucial economic barrier, particularly for SMEs that must bear the financial burden of retraining their workforce to be BIM-proficient. Similarly, Radzi et al. (2024) highlight that many organizations struggle to justify the high initial investment required for BIM, particularly when the return on investment (ROI) may not be immediately visible.

Additionally, the perceived high cost of transitioning from traditional to digital workflows has deterred many companies from adopting BIM. This is particularly prevalent in developing economies, where the infrastructure for digital transformation is underdeveloped, and organizations may not see the financial incentives for BIM adoption. Saka and Chan (2023) found that SMEs in both developed and developing countries often perceive the costs of BIM as outweighing the benefits, which further hinders its widespread adoption.

2.4.4 Human Challenges

Human-related challenges encompass the skills, knowledge, and behaviors of individuals working within BIM-enabled environments. A major issue is the lack of skilled personnel to operate BIM systems effectively. Ahmed (2021) highlights that the shortage of BIM experts and the unavailability of proper training programs is one of the top barriers to BIM adoption. Many organizations find it difficult to hire qualified professionals who have the technical expertise to use BIM effectively, especially in regions where digital education has not kept pace with the technological advancements in the construction industry.

The steep learning curve of BIM software also presents a significant human challenge. Employees are often required to undergo extensive training to use BIM tools proficiently, and the time and resources needed for this training can hinder the rapid adoption of BIM. Siebelink et al. (2021) emphasize that continuous training programs are essential to ensure that employees remain competent as BIM technology evolves. Without such programs, the workforce may struggle to keep up with the demands of BIM processes.

2.4.5 Client Engagement Challenges

Client engagement plays a crucial role in the successful adoption and implementation of BIM. Many of the barriers to BIM adoption originate not from the technical or organizational sides of the project but from client-related challenges. These challenges stem from a lack of client understanding and demand for BIM, reluctance to invest in BIM technologies, and difficulties in aligning BIM processes with the client's expectations.

Lack of Client Awareness and Understanding

One of the most significant challenges in BIM adoption is the lack of client awareness about the potential benefits of BIM. Oesterreich and Teuteberg (2019) highlight that clients, particularly in the private sector, often have limited understanding of how BIM can improve project outcomes, leading to a reluctance to demand its use. This lack of demand creates a bottleneck, as contractors and project teams are less likely to invest in BIM technologies and processes if they are not required or requested by their clients.

Moreover, the perceived complexity of BIM processes may deter clients from fully engaging with BIM. Radzi et al. (2024) found that many clients view BIM as a highly technical tool that does not align with their traditional methods of overseeing projects. This perception is particularly prevalent in smaller projects where clients may not see the immediate benefits of investing in BIM, preferring to rely on more familiar, low-tech project management approaches.

Reluctance to Invest in BIM

In addition to a lack of awareness, many clients are reluctant to invest in the use of BIM due to the perceived high costs. As Saka and Chan (2023) discuss, clients, especially in developing economies, often believe that traditional construction methods are more cost-effective than the use of advanced BIM technologies. Even in regions where BIM is more widely recognized, clients may be unwilling to bear the additional upfront costs associated with implementing BIM, such as purchasing software or hiring specialists. This reluctance creates a challenge for contractors and project managers who must balance the need to adopt BIM with the client's expectations of cost control.

Furthermore, clients may struggle to see the long-term benefits of BIM, such as improved facility management and lifecycle cost savings. Oesterreich and Teuteberg (2019) note that many clients focus on short-term project costs rather than long-term value, making it difficult to justify the initial investment in BIM tools and processes. This creates a mismatch between the technological advancements that BIM offers and the financial priorities of many clients.

Difficulty in Aligning BIM with Client Expectations

Even when clients are aware of BIM, aligning the expectations of clients with the capabilities of BIM can be a challenge. Siebelink et al. (2021) explain that BIM requires a significant shift in how projects are managed and delivered, and clients may not fully understand how BIM's collaborative and data-centric approach will affect traditional workflows. The cultural shift needed to move from paper-based, sequential processes to a digitally integrated BIM process can be difficult for clients to navigate.

Additionally, clients may struggle with the data requirements that BIM imposes. For BIM to be effective, clients must provide detailed project requirements early in the process and must be willing to participate in data-driven decision-making. However, Radzi et al. (2024) found that many clients are unprepared or unwilling to engage in this level of detail, leading to misaligned expectations and frustration during project execution. This lack of engagement can undermine the benefits of BIM, as the client's input is crucial for ensuring that the project is delivered to meet their specific needs and standards.

In summary, the client engagement challenges to BIM adoption are multifaceted. They include a lack of awareness and understanding of BIM's benefits, reluctance to invest in BIM due to perceived high costs, and difficulties in aligning BIM processes with the client's expectations. Addressing these challenges requires not only educating clients about the long-term value of BIM but also working closely with them to ensure that BIM is integrated into the project in a way that aligns with their goals and workflows.

2.5 Regional Factors in BIM Adoption

BIM adoption is influenced not only by technological, economic or other factors listed above but also by regional cultural and regulatory elements that shape how industries and governments approach digital transformation. In the CIS region, cultural challenges such as hierarchical organizational structures, and regulatory challenges related to outdated bureaucratic processes, have created unique barriers to BIM implementation. This section explores both cultural and regulatory challenges that impact BIM adoption in the CIS region.

2.5.1 Cultural Challenges

The CIS region is characterized by a top-down hierarchical management structure, where decision-making authority is often centralized at the senior leadership level (Bershadskaya et al., 2013). This approach creates barriers to BIM adoption because decisions regarding technological innovations like BIM are made by top-level executives, who may not be closely involved in day-to-day project operations. As a result, the practical benefits of BIM, such as improved collaboration, cost savings, and project efficiency, may not be fully understood or appreciated by senior management.

In such environments, middle management and operational staff – those who would directly interact with BIM technology – often have limited input in decision-making processes. Ahmed (2021) notes that in organizations with rigid hierarchical structures, change tends to be slow and faces resistance, especially when adopting technologies that require a more decentralized, collaborative approach. In the CIS region, this is further exacerbated by the cultural reluctance of employees at lower levels to advocate for change, particularly if it challenges established norms or contradicts the opinions of senior leaders.

As BIM is inherently a collaborative tool that requires information sharing and teamwork across different stakeholders (Tereshko et al, 2021), the top-down approach hampers its successful implementation. To address this, organizational changes that foster greater inclusivity in decision-making and empower lower-level staff to propose and implement innovative solutions are crucial.

2.5.2 National and Regional Policies

In addition to cultural factors, regulatory challenges in the CIS region have slowed the widespread adoption of BIM. Much of the construction regulation in the CIS countries is based on Soviet-era standards that prioritize prescriptive methods over innovative and flexible approaches (Strategy, 2022). Many of these regulations are outdated and do not align with the digital, data-driven workflows that BIM requires, creating significant regulatory hurdles for companies attempting to implement BIM.

For example, in Russia, the Strategy for the Development of the Construction Industry up to 2030 (2022) aims to reduce the number of outdated building codes and introduce modern regulatory frameworks that support digitalization, including BIM. However, progress has been slow, and the construction sector is still largely governed by SNiP (Construction Norms and Rules), which are not conducive to the collaborative, real-time data sharing that BIM enables. Azieva et al. (2023) argue that while there is growing governmental recognition of BIM’s potential, the regulatory environment remains complex and inconsistent across different regions of the CIS

Furthermore, Kazakhstan has made strides in promoting BIM adoption through its digital transformation strategies, aiming to align with global Industry 4.0 standards (Global BIM, n.d.). However, challenges such as limited technical infrastructure and inconsistent enforcement of policies continue to slow the adoption process, especially for smaller firms that lack the resources to invest in both the technology and the compliance processes required by new regulations

2.5.3 Impact of Regulations on BCO

Regulatory and policy factors have a direct impact on how BCO approaches BIM adoption. In countries with strong governmental mandates, such as the UK or Singapore, clients are often required to adopt BIM as part of their contractual obligations, leading to higher levels of adoption across the industry (Shafiq, 2021). In contrast, regions without such mandates, like parts of the post-Soviet area, face slower adoption rates as clients are not incentivized or obligated to invest in BIM technologies.

Additionally, the cost of compliance with BIM-related regulations can be prohibitive for smaller organizations. The need for specialized software, staff training, and new workflows may deter some building clients from fully adopting BIM, especially if they perceive traditional methods to be more cost-effective (Li et al., 2017).

2.5.4 Policy Initiatives and Standardization Efforts

Despite the challenges, several policy initiatives have been launched to support BIM adoption in the CIS region. For example, Russia's Digital Economy Program, launched in 2017, includes provisions for modernizing construction practices through BIM. The program outlines a roadmap for BIM implementation, particularly in public infrastructure projects, with the goal of creating a SMART format for regulatory compliance by 2030 (Strategy, 2022)

At a broader level, international frameworks such as the ISO 19650 standard are beginning to influence how CIS countries approach BIM. By aligning with global BIM standards, post-Soviet countries can benefit from international best practices, which facilitate better interoperability and data management across borders. Additionally, the EU BIM Task Group (2021) provides a valuable reference for harmonizing BIM standards across regions, offering guidelines that can be adapted to the CIS context to drive digital transformation

In summary, the success of BIM adoption in the CIS region will depend on both cultural changes within organizations and regulatory reforms that modernize construction standards to better align with digital workflows. By addressing these regional factors, the construction industry in the CIS can overcome existing barriers and fully realize the potential of BIM to improve project outcomes.

2.6 Strategies and Best Practices for Successful BIM Implementation

Successfully implementing BIM requires a comprehensive approach that addresses both organizational and technical challenges. This section outlines key strategies and best practices that BCO can adopt to overcome these challenges and ensure effective BIM implementation. These strategies include change management approaches, the development of internal BIM standards, and the adoption of technical solutions that facilitate collaboration and information exchange.

Organizational Strategies:

- Developing internal BIM standards and workflows.
- Investing in continuous training programs and leadership support.

Technical Solutions:

- Implementing Common Data Environments (CDEs) to improve data sharing.
- Standardizing software platforms to reduce interoperability challenges.

Case Stuies:

- Successful BIM adoption learning
- Critical success factors

Figure 2 Strategies for Successful BIM Implementation

2.6.1 Organizational Strategies

Change Management Approaches

The adoption of BIM requires organizations to undergo significant changes in terms of their processes, culture, and workflows. Effective change management strategies are essential for navigating this transition. Change management models, such as Kotter's 8-Step Change Model and ADKAR Change Management Model, provide frameworks that guide organizations through the stages of change, from building awareness to embedding new processes into the organizational culture (Whelan-Berry, Gordon & Hinings, 2003). These models emphasize the importance of leadership commitment, stakeholder involvement, and continuous communication in ensuring the success of BIM adoption (Kotter, 2018).

Developing Internal BIM Standards and Processes

Developing internal BIM standards is critical for ensuring consistency and efficiency in BIM implementation. These standards define the level of detail required at different project stages, establish protocols for data management, and outline the roles and responsibilities of all stakeholders involved in the project. Organizations that implement clear, well-defined BIM standards are better equipped to manage the complexities of BIM projects and achieve the desired outcomes (Succar, 2009). Additionally, establishing internal processes that align with industry standards, such as ISO 19650, enhances collaboration and facilitates compliance with regulatory requirements (Shafiq, 2021).

2.6.2 Technical Solutions

Software Selection and Integration

Selecting the right software tools is a critical step in successful BIM implementation. Organizations must choose software platforms that are compatible with industry standards and capable of facilitating collaboration among project (Li et al., 2017). Interoperability between different software systems is essential for avoiding data silos and ensuring that information flows seamlessly across all phases of the project (Hochscheid & Halin, 2018). By investing in interoperable software tools and integrating them into existing workflows, organizations can improve efficiency, reduce errors, and enhance project outcomes.

Use of Common Data Environments (CDE)

Common Data Environments (CDE) are collaborative platforms that provide a centralized location for storing, sharing, and managing project data. The use of CDEs enhances transparency, facilitates real-time collaboration, and ensures that all project stakeholders have access to the most up-to-date information (Siebelink, 2021). Implementing a CDE allows for better coordination between teams, reduces duplication of efforts, and improves decision-making processes. For building client organizations, adopting a CDE is a critical step toward achieving seamless BIM integration across the project lifecycle (Low, 2023).

2.6.3 Case Studies and Lessons Learned

Numerous case studies highlight the successful adoption of BIM in various contexts. For example, Eadie et al. (2013) identify critical success factors such as stakeholder collaboration, education, and technological readiness. These case studies provide valuable insights into how organizations can effectively adopt BIM. For example, projects in Singapore and the United Kingdom have shown that government mandates, strong leadership, and well-defined BIM standards play a significant role in driving BIM adoption (Shafiq, 2021). These case studies emphasize the importance of a top-down approach, where organizational leaders champion BIM adoption and ensure that all stakeholders are aligned with the project goals.

Another key lesson from these case studies is the need for continuous training and development. Organizations that invest in ongoing BIM training programs are better positioned to overcome the skills gap and ensure that their teams are equipped with the knowledge and expertise required for successful implementation (Vass & Gustavsson, 2017).

2.7 Theoretical Frameworks and Models

To understand the adoption of BIM in the AEC industry, it is essential to examine theoretical frameworks that provide insights into how new technologies are adopted and implemented within organizations.

Technology Acceptance Model

TAM can be relevant framework (Figure 3), focusing on how perceived usefulness and ease of use influence individuals' decisions to adopt new technologies. In the context of BIM, clients' perceptions of its benefits and the complexity of its implementation are key factors that determine whether they will invest in BIM technologies (Venkatesh & Davis, 2000).

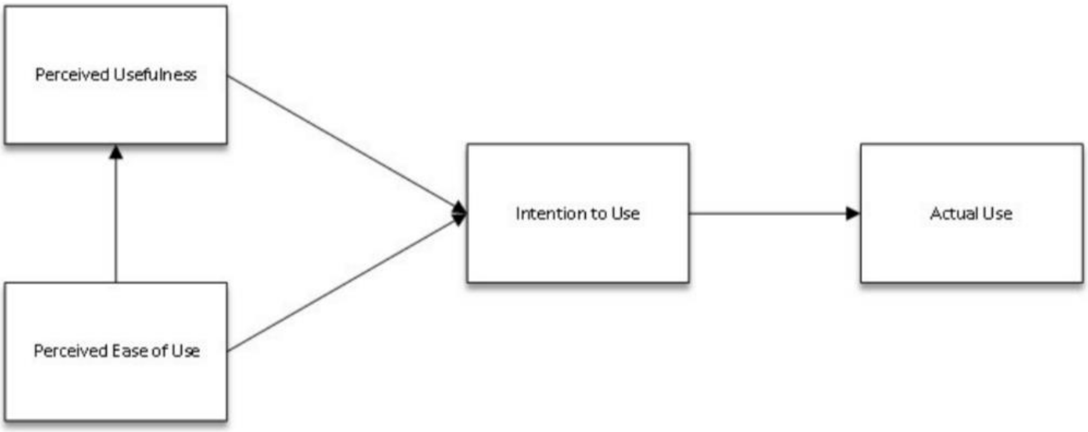

Figure 3 Technology Acceptance Model

Change Management Models

Implementing BIM requires significant organizational change, which can be guided by established change management models. The successful adoption of BIM within an organization is significantly influenced by several organizational factors, including readiness, training, and change management. Organizational readiness, which includes the availability of appropriate technology, skilled personnel, and supportive leadership, is often the foundation upon which BIM implementation is built (Siebelink et al., 2018). A lack of readiness can result in resistance to change, underutilization of BIM capabilities, and ultimately, failure to realize the full potential of BIM in improving project outcomes.

Training is another critical factor in BIM adoption. The introduction of BIM into an organization typically requires new skill sets and competencies that may not be present in the existing workforce. Therefore, comprehensive training programs are essential to equip staff with the necessary knowledge and skills to use BIM effectively. According to a study by Succar et al. (2013), successful BIM adoption requires not just technical training, but also education on the collaborative processes and workflows that BIM facilitates. Without adequate training, even the most advanced BIM systems can fail to deliver expected benefits due to improper use or misunderstanding of its functions.

Change management plays a crucial role in mitigating resistance and facilitating the smooth transition to BIM. Organizational change management strategies should address the cultural shifts required for BIM adoption, including breaking down silos between departments and encouraging a more collaborative working environment.

Kotter's 8-Step Change Model is one such framework (Figure 4) that provides a structured approach to managing change within organizations. This model emphasizes the importance of creating a sense of urgency, building a coalition of leaders, and embedding changes into the organizational culture (Kotter, 1996). Applying this model to BIM adoption can help organizations navigate the challenges of implementing new processes and technologies.

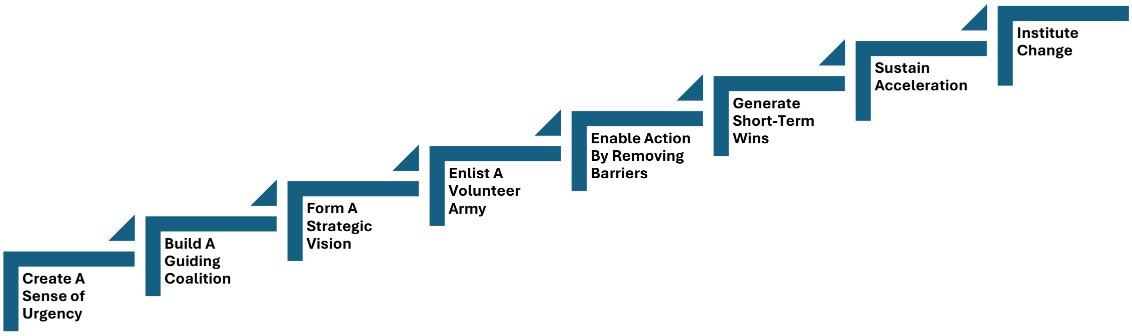

Figure 4 Kotter's 8-step Change model

The ADKAR model, which stands for Awareness, Desire, Knowledge, Ability, and Reinforcement, has been effectively used to guide organizations through the change process by focusing on the human aspects of change (Hiatt, 2006). Successful change management ensures that all stakeholders understand the benefits of BIM, are committed to its adoption, and are supported throughout the transition.

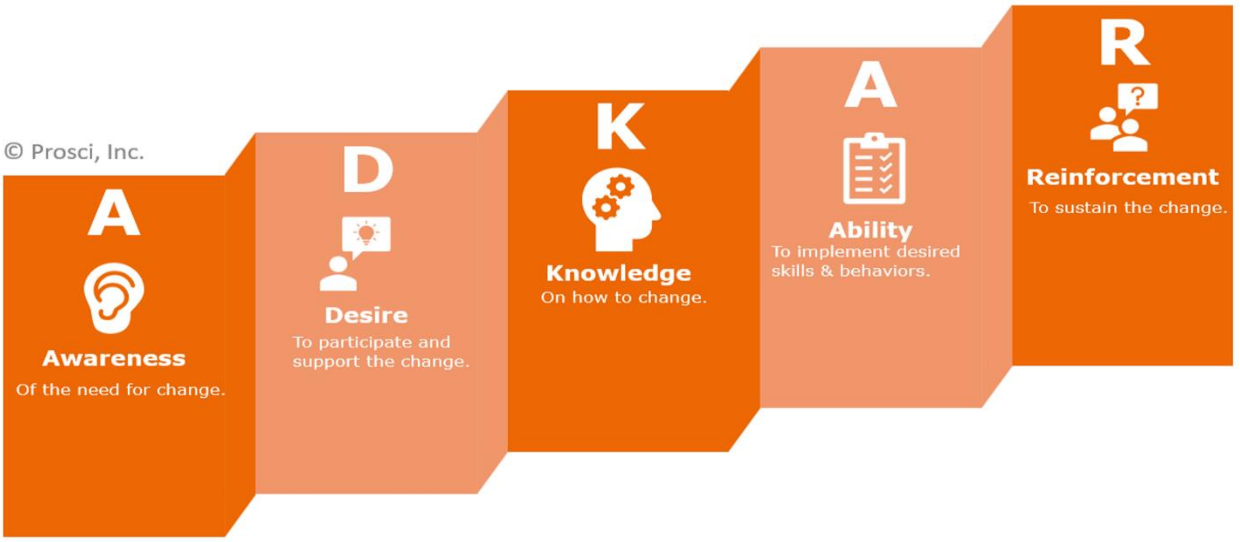

Figure 5 ADKAR Model

The adoption of BIM in an organization is not just a technical challenge, but a multifaceted process that requires careful consideration of organizational readiness, comprehensive training programs, and robust change management strategies. Addressing these factors is essential for overcoming the barriers to BIM adoption and for leveraging its full potential to enhance project outcomes.

2.8 Synthesis and Gaps in the Literature

A critical review of the literature reveals several key themes and gaps that need to be addressed to advance the understanding of BIM adoption in BCO. This section synthesizes the findings from the previous sections and identifies areas where further research is needed.

While there is extensive research on the technical and organizational challenges of BIM adoption, there is limited empirical research focusing on BCO, particularly in CIS countries. Most studies focus on contractors, architects, and engineers, neglecting the crucial role that clients play in driving BIM adoption (Vass & Gustavsson, 2017). Additionally, research on the regulatory and policy factors influencing BIM adoption is often region-specific, with a significant focus on countries like the UK and Singapore, leaving gaps in understanding how these factors play out in other contexts, such as the CIS region.

Existing studies tend to focus on the benefits of BIM without thoroughly addressing the challenges faced by organizations during the early stages of adoption. While many studies highlight the technical advantages of BIM, such as improved collaboration and efficiency, few provide practical insights into overcoming organizational resistance, lack of client engagement, or regulatory hurdles (Shafiq, 2021).

2.9 Summary

This chapter has provided a comprehensive review of the key literature surrounding BIM adoption in the AEC industry. The review has been structured around several critical themes that align with the main research questions: the global adoption of BIM, the organizational and technical challenges of BIM implementation, client engagement and education, strategies and best practices, regulatory and policy considerations, and theoretical frameworks that guide the understanding of BIM adoption.

Key Findings

1. **Global Adoption Trends**: BIM adoption has grown significantly in recent years, particularly in countries like the United Kingdom, Singapore, and the United States, where strong governmental mandates and standardized protocols have facilitated widespread implementation. However, in CIS countries, the rate of BIM adoption remains slower due to regulatory, organizational, and infrastructural challenges.

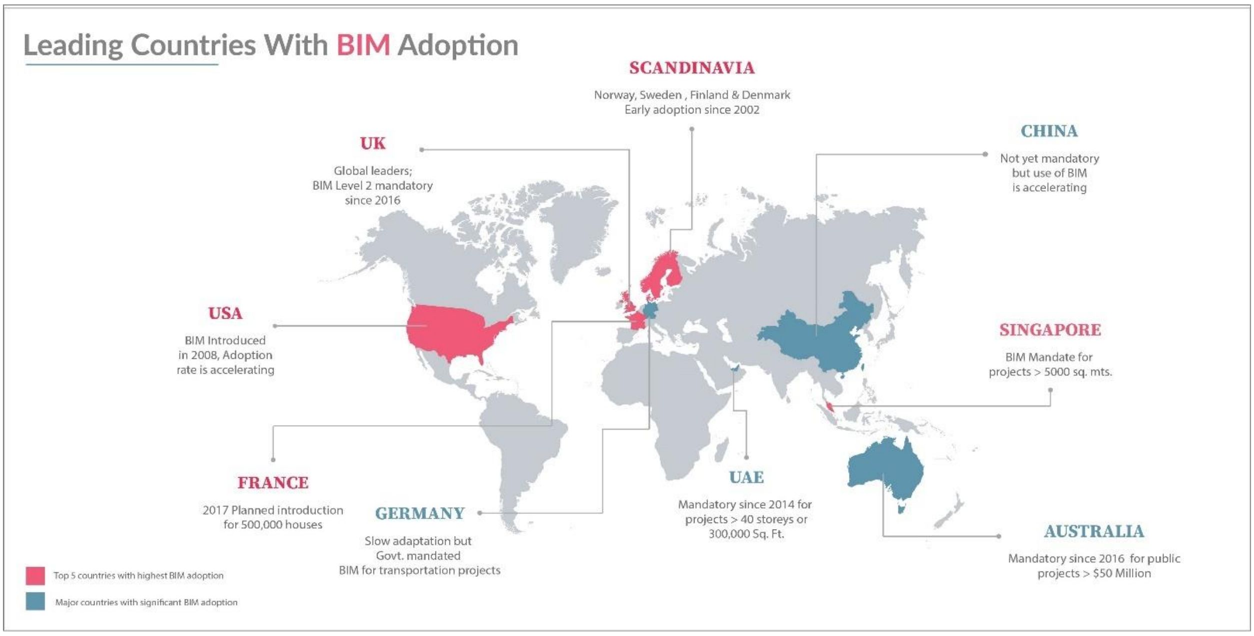

Figure 6 Leading countries with BIM adoption. Source: United-BIM.com (2020)

2. **Organizational and Technical Challenges**: The literature highlights several organizational and technical barriers to BIM adoption, including resistance to change, lack of expertise, and the need for significant investment in both technology and training. Technical issues, such as software interoperability and data management, further complicate the transition to BIM for many organizations.

3. **Client Engagement and Education**: Client involvement plays a critical role in the success of BIM projects. However, a lack of understanding and misalignment of expectations between clients and project teams often hinders successful BIM implementation. Strategies that focus on improving client education and communication are crucial to bridging this gap.

4. **Best Practices and Strategies**: Effective BIM adoption requires a combination of organizational strategies and technical solutions. Change management approaches, such as Kotter's 8-Step Change Model or ADKAR, and the establishment of clear internal BIM standards are key to overcoming organizational barriers. Technical solutions, such as selecting appropriate software and integrating Common Data Environments (CDE), also play an essential role.

5. **Regulatory and Policy Factors**: Regulatory and policy frameworks significantly influence the adoption of BIM. Countries with well-defined BIM mandates, such as the UK's Level 2 BIM, experience higher adoption rates due to standardized protocols and government support. In CIS countries, while national strategies for digital transformation are in place, inconsistent enforcement and infrastructural limitations continue to impede BIM adoption.

6. **Theoretical Frameworks**: The Technology Acceptance Model (TAM), provide valuable insights into the factors that influence BIM adoption. This model, combined with change management frameworks like Kotter's and ADKAR, offer a theoretical basis for understanding how organizations can effectively transition to BIM.

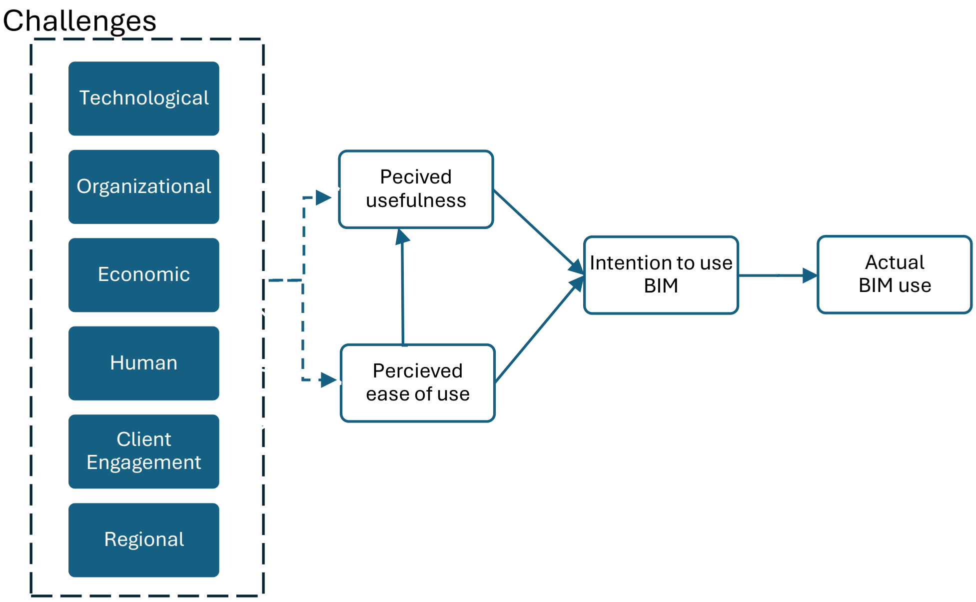

Figure 7 TAM model of BIM adoption

This chapter has set the stage for the research methodology discussed in the next chapter. The methodological approach will draw upon the themes and gaps identified in this literature review, using qualitative approach to explore the specific challenges faced by BCO during the early stages of BIM adoption.

Chapter 3. Research Methodology

3.1 Introduction

This chapter outlines the research methodology employed to investigate the challenges that building client organizations face in adopting and implementing BIM during the digital transformation of the AEC industry. The study also explores how DEO can support clients in overcoming these challenges by offering technical expertise, collaborative strategies, and assistance in navigating regulatory changes.

The research is based on qualitative methods, with data collected through semi-structured interviews with professionals from a DEO experienced in BIM implementation. Although the interviews were conducted with representatives from the design-engineering firm, the focus of the study remains on understanding the barriers that client organizations face during BIM adoption, as well as how DEO can assist in addressing these challenges. In addition, document analysis of BIM Execution Plans (BEPs) and Employer's Information Requirements (EIRs) was conducted to further validate the interview findings and provide context to the challenges and strategies discussed.

This chapter outlines the research design, sampling strategy, data collection methods, and analytical techniques used to achieve the study's objectives.

3.2 Research Design

The research employs a qualitative approach, which is well-suited for exploring the complex challenges faced by client organizations in adopting BIM. Qualitative methods allow for a deep exploration of organizational, technical, and regulatory barriers through interviews and document analysis. The data collected from interviews with both design-engineering professionals and client organization representatives provide a rich, contextual understanding of the obstacles to BIM adoption and the potential strategies for overcoming them.

This study uses deductive reasoning, as it builds on existing literature to confirm and elaborate on known challenges while also exploring new insights specific to the CIS region and post-Soviet countries. The findings from the research are expected to provide actionable strategies for both client organizations and design-engineering firms to enhance BIM adoption and comply with evolving regulations.

3.3 Data Collection

3.3.1 Data Sources

Two primary methods were used for data collection: semi-structured interviews and document analysis. These methods were chosen to gather a comprehensive range of data on the challenges of BIM adoption.

3.3.2 Semi-Structured Interviews and Case Study

The case studies for this research were selected using a diverse-case method to explore a wide range of outcomes associated with BIM adoption (Seawright, 2008). This approach allowed for the examination of both a challenging and unsuccessful case and a successful case, providing variation on key dimensions of BIM implementation. The cases were provided by a design engineering organization where interviews with BIM experts were conducted, allowing for a practical, real-world analysis of the factors contributing to success or failure in BIM adoption.

The first case study (an Ore Processing Plant) was selected due to its unsuccessful outcome despite the development of a comprehensive BIM adoption strategy. In this case, the client ultimately refused to utilize BIM as intended at the conclusion of the design phase, illustrating the potential disconnect between strategy formulation and client engagement in the execution of BIM in practice.

The second case study (Railcar Factory Paint Shop), by contrast, represented a successful BIM implementation. In this project, the design BIM model was completed, and the project received official permission. Importantly, several advanced BIM tools, such as 4D (time management), 5D (cost management), and laser scanning, were used for the first time by the company, highlighting the potential of BIM to enhance project efficiency when fully embraced by all stakeholders.

By selecting these two diverse cases, the research captures the range of challenges and opportunities associated with BIM adoption, offering valuable insights into the factors that influence success in this context.

Semi-structured interviews were conducted with professionals from DEO experienced in BIM implementation and participated in both case studies mentioned above. The focus of these interviews was to gather insights on the technical, organizational, and regulatory challenges that clients face when adopting BIM through case study discussion. The summaries of these Interviews are available in Appendix A. Additionally, the interviews explored how DEO support their clients in overcoming the challenges.

Four experts from a design-engineering firm were interviewed:

- CEO: Provided insights on strategic and organizational challenges related to BIM adoption.

- BIM Manager: Discussed technical barriers, including interoperability issues and data standardization.
- Chief Project Engineer (CPE): Focused on client engagement and collaboration challenges.
- Project Manager (PM): Provided detailed perspectives on project management and the integration of BIM into workflows.

Table 3 Interview Participants

Interviewee ID	Company type	Job title	Work experience (years)	BIM experience (years)
CEO	DEO	Chief Executive Officer	15	10
BM	DEO	BIM manager	27	17
CPE	DEO	Chief Project Engineer	14	2
PM	DEO	Project Manager/ Chief Project Engineer	18	6

These experts were selected through purposive sampling, ensuring that each participant had substantial experience with BIM adoption and could offer informed perspectives on the barriers faced by BCO and the role of DEO in overcoming these obstacles. The semi-structured interview format allowed for flexibility, enabling the interviewer to explore both predefined topics and emerging themes based on participant responses.

Interview Protocol

The interview guide focused on the following areas:

1. Introduction and general background with.
2. Personal professional path and BIM implementation experience.
3. Case Studies and Lessons Learned.

All interviews were conducted virtually via Zoom and recorded with the participants' informed consent. The audio recordings were transcribed using MS Word and manually corrected for accuracy. Since the interviews were conducted in Russian, the transcripts were translated into English using Yandex Translator, with further manual revisions to ensure precision.

3.3.3 Document Analysis

To complement the interview data, document analysis was conducted on the BIM Execution Plans (BEPs) and Employer's Information Requirements (EIRs) provided by the DEO. These documents were analyzed to understand the formal processes and expectations surrounding BIM implementation in the projects. This analysis provided further context for the challenges identified in the interviews, especially concerning the alignment of client expectations with project deliverables.

- BEPs were examined to identify how BIM is structured and managed within projects, including the responsibilities of different stakeholders.
- EIRs were analyzed to understand the clients' requirements for BIM use and how these requirements were communicated and fulfilled by the DEO.

By cross-referencing the findings from the interviews with the information provided in these documents, the research was able to validate the key challenges and strategies for improving BIM adoption.

3.3.4 Ethical Considerations

Participants were informed of the purpose of the study, and informed consent was obtained prior to conducting the interviews. Anonymity and confidentiality were guaranteed to protect the identity of participants and the organizations involved. Furthermore, the data were securely stored, and access was limited to the researcher to ensure the privacy of all information collected during the study.

3.4 Data Analysis Technique

3.4.1 Approach to Data Analysis

The data analysis in this research adopted a deductive approach. This approach was chosen as the aim was to test and validate the challenges identified through the literature review, rather than to develop new theoretical insights. By focusing on confirming pre-existing theories, the deductive method enabled a structured examination of how the challenges to BIM implementation, found in academic sources, align with the practical experiences shared by the participants.

Coding Process

The data were analyzed using selective coding, which involved identifying specific challenges related to BIM implementation, as highlighted in the literature review (Table 4), and strategies to address them (Table 5). A predefined coding scheme was used, based on the research questions and literature, which ensured that the analysis focused on the primary objectives of the study.

A software Atlas.ti was used to manage and organize the codes. The software facilitated storing, organizing, and systematically analyzing the data, allowing to track patterns and relationships between different codes and themes.

Table 4 Summary of identified Challenges to BIM implementation from literature review

Code	Challenges	Description	References
	Technical Challenges:		
T1	Interoperability Issues	Difficulty in exchanging information between different BIM software platforms	Waqar et al., 2023; Oesterreich & Teuteberg, 2019; El Asri et al., 2023
T2	Lack of Standardized Data	Absence of common data standards and formats for BIM models	Ahmed, 2018; Wu et al., 2021; Siebelink, 2021
T3	Technology Integration	Challenges in integrating BIM with existing IT infrastructure and software	Saka & Chan, 2023; Radzi et al., 2024
	Organizational Challenges:		
O1	Resistance to Change	Reluctance among professionals to adopt new technologies and workflows	Wu et al., 2021; Ahmed, 2018; Oesterreich & Teuteberg, 2019; Saka & Chan, 2023; Siebelink, 2021
O2	Lack of Management Support	Insufficient commitment and leadership from management to drive BIM adoption	Waqar et al., 2023; Saka & Chan, 2023; Ahmed, 2018
O3	Lack of Collaboration	Poor communication and coordination among project stakeholders	Waqar et al., 2023; Saka & Chan, 2023; Oesterreich & Teuteberg, 2019; Radzi et al., 2024
O4	Legal and Contractual Issues	Uncertainty about legal implications and liability related to BIM use	Saka & Chan, 2023; Ahmed, 2018
	Client Engagement Challenges:		
C1	Lack of client's demand	No client's demand for BIM use	Wu et al., 2021; Oesterreich & Teuteberg, 2019; Saka & Chan, 2023
C2	Lack of Understanding or Awareness of BIM Benefits	Clients' unfamiliarity with BIM technologies	Saka & Chan, 2023; Ahmed, 2018; Radzi et al., 2024
C3	Misalignment of Expectations	Misaligment of client's expectations regarding the costs and benefits of BIM	Liao et al., 2018
	Economic Challenges:		
E1	High Implementation Costs	Significant upfront investment required for software, hardware, and training	Wu et al., 2021; Saka & Chan, 2023; Ahmed, 2018; Radzi et al., 2024
E2	Perceived Lack of Return on Investment (ROI)	Uncertainty about the financial benefits and payback period of BIM implementation	Saka & Chan, 2023; Ahmed, 2018
	Human Challenges:		
H1	Lack of Skilled Professionals	Shortage of qualified personnel with BIM knowledge and expertise	Wu et al., 2021; Saka & Chan, 2023; Ahmed, 2018; Oesterreich & Teuteberg, 2019; Turkova et al., 2020
H2	Inadequate Training and Education	Insufficient opportunities for professionals to acquire BIM skills	Waqar et al., 2023; Saka & Chan, 2023; Ahmed, 2018
	Regional Factor:		
R1	Lack of Regulatory Policies	Absence of policies, incentives, and mandates to encourage BIM adoption	Saka & Chan, 2023; Wu et al., 2021
R2	Cultural Challenges	Differences in working practices, communication styles, and attitudes towards technology	Waqar et al., 2023; El Asri et al., 2023; Siebelink, 2021

Table 5 Codes for identified Strategies

Code	Strategies
S1	Case studies lessons learning
S2	CDE implementation
S3	Internal BIM standart development
S4	Investing in education and support
S5	Software integration program

3.4.2 Document Analysis

BEP and EIR shortcuts can be found in Appendix B. These documents were read to understand their structure and content, confirming that the information shared during interviews aligned with the official documents. The objectives of BIM use, tasks, collaboration techniques, and the client's requirements were examined. No specific frameworks or criteria were applied in the evaluation of these documents; rather, they served as a reference to cross-check and validate the insights gained from the interviews.

3.4.3 Interpretation

The data were interpreted in relation to the research questions by systematically reviewing the themes that emerged from the coding process. The analysis was framed around key questions such as: What are the primary barriers to BIM adoption in the case study? How do these barriers compare with those found in the literature? The process involved comparing the identified challenges to the findings from the literature review, confirming whether the same issues (e.g., technical, organizational, or regulatory challenges) were observed in practice.

The reliability and validity of the interpretations were ensured by triangulating the findings from multiple sources (Lincoln and Guba, 1985), including interviews, document analysis, and existing literature. This multi-source approach helped to mitigate bias and provided a more comprehensive understanding of the challenges.

3.4.4 Challenges in Analysis

No significant challenges were encountered during the data analysis process. However, learning new techniques for qualitative data analysis and effectively using Atlas.ti was essential to ensuring an organized and efficient workflow. The software proved useful in handling the data, making it easier to manage large amounts of qualitative information and derive meaningful insights.

3.4.5 Triangulation

A form of triangulation (Lincoln and Guba, 1985) was employed by comparing the data collected through interviews with the insights derived from document analysis (BEP and EIR) and the literature. This triangulation helped in strengthening the reliability of the findings by ensuring that the research did not rely solely on participants' opinions. Cross-referencing with the BEP, EIR, and literature provided additional context, validating the information gathered from the interviews.

3.4.6 Outcome of Analysis

The analysis confirmed several of the challenges and strategies highlighted in the literature review, providing valuable insights into the barriers and enablers of BIM adoption in the cases studied. By applying a deductive approach and utilizing selective coding, the data gathered from interviews and document analysis (BEP and EIR) revealed both expected and nuanced findings about BIM implementation in practice.

3.5 Validation

The validation was organized through a presentation of BIM technology, regulatory changes, possible challenges and strategic change framework to BCO that is planning to implement BIM in the future project. The presentation was conducted in one session with BCO representatives listed in Table 6. This validation process involved gathering feedback from key stakeholders within the client organization to assess the framework's practicality and effectiveness, ensuring it could be adapted to their specific context.

Table 6 Validation Group

Company	Job title	Years in the company
BCO	Deputy General Director for Strategic Development	10
BCO	Chief Process Engineer	21
BCO	Head of Production Technology Department	8
BCO	Head of Construction Department	6
BCO	Head of Technology Process Automation Department	16
BCO	Head of Information Systems Department	16
BCO	Head of Design Expertize Department	12

Chapter 4. Research Findings

4.1 Introduction

This chapter presents the key findings from the semi-structured interviews conducted with professionals from a design-engineering organization involved in BIM implementation. These findings highlight the challenges faced by client organizations in BIM adoption and how the design-engineering firm supports overcoming these challenges. The analysis focuses on technical, organizational, and Client engagement challenges, as well as strategies that can address these barriers. The analysis revealed several challenges as the most frequent barriers to BIM adoption based on the conducted interviews (Table 7). These challenges were grouped into technical, organizational, and client engagement categories. The most frequently occurring findings are supported by quotes from the interviews and references to relevant literature, ensuring they are grounded in both practical experience and theoretical perspectives.

4.2 Technical Challenges

4.2.1 Interoperability Issues

The challenge of software interoperability emerged prominently across interviews. Design-engineering professionals frequently encounter issues integrating different software tools, such as Revit and Tekla, which complicates project workflows and delays project deliverables.

> *BIM Manager*: "We often face issues when clients use different software platforms. They might not understand the full interoperability problems until they see the discrepancies in the design process".

This finding reflects Oesterreich & Teuteberg's (2019) and El Asri et al.'s (2023) insights that software interoperability remains a significant barrier to BIM collaboration(List of challenges).

4.2.2 Lack of Standardized Data

Another key technical barrier identified is the lack of standardized data across client organizations. Inconsistent data formats complicate project integration and data exchange, resulting in frequent delays and errors.

> *Project Manager*: "Many clients lack clear data standards, which leads to confusion when models from different teams don’t integrate smoothly".

This issue is echoed in the literature, where Wu et al. (2021) and Siebelink (2021) stress the need for common data standards in BIM to ensure seamless collaboration between stakeholders.

Table 7 BIM adoption challenges in terms of their frequency during the interviews

Code	Challenges	CEO	BIM manager	Chief Progect Engineer	Project Manager	Total
	Technical Challenges:					
T1	Interoperability Issues	1	3	2	2	8
T2	Lack of Standardized Data	2	2	2	2	8
T3	Technology Integration	2	1	1	2	6
	Organizational Challenges:					
O1	Resistance to Change	2	2	1	1	6
O2	Lack of Management Support	1	1	1	1	4
O3	Lack of Collaboration	2	3	2	2	9
O4	Legal and Contractual Issues	1	1	1	1	4
	Client Engagement Challenges:					
C1	Lack of client's demand	2	2	2	2	8
C2	Lack of Understanding or Awareness of BIM Benefits	3	2	2	3	**10**
C3	Misalignment of Expectations	2	2	1	2	7
	Economic Challenges:					
E1	High Implementation Costs	2	1	1	1	5
E2	Perceived Lack of Return on Investment (ROI)	1	1	1	1	4
	Human Challenges:					
H1	Lack of Skilled Professionals	2	2	1	1	6
H2	Inadequate Training and Education	1	1	1	2	5
	Regional Factor:					
R1	Lack of Regulatory policies	1	1	1	1	4
R2	Cultural Challenges	1	1	1	2	5
		26	**26**	**21**	**26**	

4.3 Organizational Challenges

4.3.1 Resistance to Change

Resistance to adopting BIM technologies was cited as one of the major organizational challenges. Both client organizations and external contractors often hesitate to transition from traditional processes to BIM-based workflows.

> *CEO*: "Many clients resist BIM because they are comfortable with the methods they've used for years. They don't see the immediate value in making a switch".

This reluctance aligns with the findings of Ahmed (2018) and Oesterreich & Teuteberg (2019), who identify resistance to change as a common barrier in BIM implementation.

4.3.2 Lack of Collaboration

Poor collaboration and miscommunication among project teams and stakeholders were also noted as significant organizational challenges. The BIM Manager emphasized the necessity for clear communication channels and collaborative practices to mitigate misunderstandings that can delay project timelines.

> *BIM Manager*: "Effective collaboration is key, but we frequently encounter miscommunications that delay projects when clients and teams aren't aligned on BIM requirements".

This challenge is consistent with the work of Saka & Chan (2023) and Radzi et al. (2024), who highlight that improving communication and collaboration is crucial for successful BIM implementation.

4.4 Client Engagement Challenges

4.4.1 Lack of Client's Demand for BIM

A lack of client demand for BIM emerged as a prevalent challenge, especially when clients are unfamiliar with the advantages that BIM can offer. This lack of demand often stems from a limited understanding of BIM's long-term benefits.

> *CEO*: "Clients don't ask for BIM because they don't fully understand what it offers. They think it's an additional expense".

This mirrors the literature, where Wu et al. (2021) and Saka & Chan (2023) argue that increasing client demand for BIM requires more extensive education on its benefits.

4.4.2 Lack of Understanding of BIM Benefits

Participants noted that the lack of client understanding of the benefits of BIM compounded the issue of low demand. Without understanding how BIM could improve project outcomes, clients were often reluctant to invest the necessary resources for its adoption.

> *BIM Manager*: "Clients don't see the long-term benefits of BIM. They view it as an additional cost instead of a tool that can reduce errors and streamline project delivery".

> *CPE*: "We had to spend a lot of time explaining to clients why BIM was important, but even then, many didn't understand why it was necessary".

The literature similarly emphasizes the need for client engagement and education in promoting the adoption of BIM (Arayici et al., 2011).

4.4.3 Misalignment of Expectations

Even when clients are interested in adopting BIM, their expectations are often unrealistic or misaligned with the capabilities of the technology. Clients may expect BIM to resolve all project issues or to lower costs without understanding the necessary investment in time and resources.

> *CPE*: "Clients expect BIM to be a magic solution for all project issues, but they don’t realize the effort required to make it work effectively".

This finding is supported by Liao et al. (2018), who highlight the importance of managing client expectations regarding the costs and benefits of BIM adoption.

4.5 Regional Regulatory and Cultural Factors

4.5.1 Evolving Regulatory Landscape

Regulatory changes are increasingly creating external pressure on client organizations to adopt BIM. The Chief Project Engineer highlighted that government mandates for using BIM on public projects are expected to increase, making it essential for clients to adapt.

> *CPE*: "The regulatory landscape is shifting, and soon, government projects will mandate BIM. Clients need to be prepared for this change".

4.5.2 Design-Engineering Firm Support

Design-engineering firms play a critical role in helping clients navigate these evolving regulations. They provide the necessary expertise to ensure compliance with new standards and to prepare clients for the future of BIM in their projects.

> *CEO*: "We work closely with clients to help them meet regulatory requirements and ensure they are ready for upcoming changes".

4.5.3 Cultural challenges

Differences in communication approaches present a barrier, especially when discussing the technical aspects of BIM. This can lead to misunderstandings or slow decision-making, particularly when clients are unfamiliar with the technology. As mentioned by the CEO, many clients rely on traditional methods and are not accustomed to the collaborative nature required for BIM, which causes friction in project communication:

> CEO: "We had a goal for ourselves—to demonstrate the advantages of the technology to the customer. But the customer had no specific BIM requirements either".

In addition, an overall reluctance or misunderstanding of the technology itself, which reflects a challenge in changing attitudes towards adopting innovative technologies like BIM. Many clients and stakeholders are resistant to change, as explained by the BIM Manager and others, which hinders the full implementation of BIM:

> "We try to offset this by introducing regulations, instructions, training, and involvement in various meetings where we show what problems it leads to if this specialist does not work in BIM with us".

4.6 Interrelations of the Main Challenges

The main challenges identified during this research – technical barriers, organizational resistance, and client engagement issues – do not exist in isolation. Instead, these challenges are interconnected, with one often amplifying or mitigating the effects of another. Understanding these interrelations is key to developing comprehensive solutions for BIM adoption.

4.6.1 Lack of Client Demand and Resistance to Change

The lack of client demand for BIM is closely linked to resistance to change within client organizations. Clients are often reluctant to adopt BIM due to a lack of understanding of its long-term benefits, which, in turn, reinforces their preference for traditional project management methods.

When clients do not actively request BIM, internal stakeholders in design-engineering firms may also resist pushing for its adoption, leading to further stagnation. The CEO of DEO noted that "clients don't ask for BIM because they don't fully understand what it offers", and this low demand contributes to internal resistance among teams that could otherwise benefit from its efficiencies.

Client education and engagement strategies are vital, as they can simultaneously reduce resistance to change by demonstrating the practical benefits of BIM. Involving clients early and explaining how BIM can improve project outcomes may generate demand, which in turn motivates internal teams to adopt and integrate BIM processes more enthusiastically.

4.6.2 Interoperability Issues and Lack of Collaboration

Interoperability challenges – particularly the difficulty in aligning various software platforms – are compounded by a lack of collaboration among project teams. When communication between different teams or stakeholders is weak, issues with incompatible software become more pronounced, leading to delays and data loss.

The BIM Manager mentioned that "effective collaboration is key, but we frequently encounter miscommunications that delay projects when clients and teams aren't aligned on BIM requirements". Without clear collaboration protocols, the technical difficulties related to software interoperability are amplified.

Improving collaboration – through the implementation of tools such as Common Data Environments (CDE) – can reduce the severity of interoperability issues by ensuring that all teams work with consistent, up-to-date information. When teams are better aligned, many of the technical challenges related to software integration and data exchange can be mitigated.

4.6.3 Misaligned Expectations and Technical Challenges

The misalignment of expectations from clients often stems from a limited understanding of BIM's technical capabilities. Clients may expect BIM to solve all project-related issues, without realizing the technical complexities involved in achieving full interoperability and real-time collaboration.

The CPE noted that "clients expect BIM to be a magic solution for all project issues, but they don't realize the effort required to make it work effectively". This mismatch in expectations exacerbates technical challenges when clients push for outcomes that the current systems cannot easily deliver, such as flawless model integration across multiple platforms.

Addressing technical challenges requires more than just improving software tools; it also necessitates aligning client expectations through proper education about BIM's limitations and strengths. A two-pronged approach that tackles both the technical and educational aspects will help reduce project delays and misunderstandings.

4.6.4 Regulatory Pressures and Client Demand

The evolving regulatory landscape is starting to place more pressure on client organizations to adopt BIM, especially for public-sector projects where governments are beginning to mandate its use. However, clients may still lack the internal demand for BIM due to limited awareness of these regulatory changes.

Regulatory pressures are likely to increase client demand for BIM over time, as organizations realize that failing to adopt BIM could result in non-compliance with new government standards. The CPE highlighted that "soon, government projects will mandate BIM. Clients need to be prepared for this shift".

By helping clients understand how regulatory changes will drive future demand for BIM, design-engineering organizations can proactively work with clients to ensure they are ready for these changes. This interrelation also suggests that regulatory awareness campaigns can serve as a catalyst for increasing client demand.

4.6.5 Summary of Interrelations

The interrelations between the identified challenges (Fig.8) reveal several key insights:

1. Client demand and resistance to change are mutually reinforcing, making client education a critical strategy for overcoming both.

2. Interoperability issues become more severe when collaboration between teams is weak, suggesting that fostering better communication and collaboration can alleviate technical difficulties.
3. Misaligned client expectations exacerbate technical challenges, reinforcing the need for both client education and technical upgrades to work in tandem.
4. Regulatory pressures are likely to drive future client demand, providing an opportunity for design-engineering firms to prepare clients for compliance with new standards.

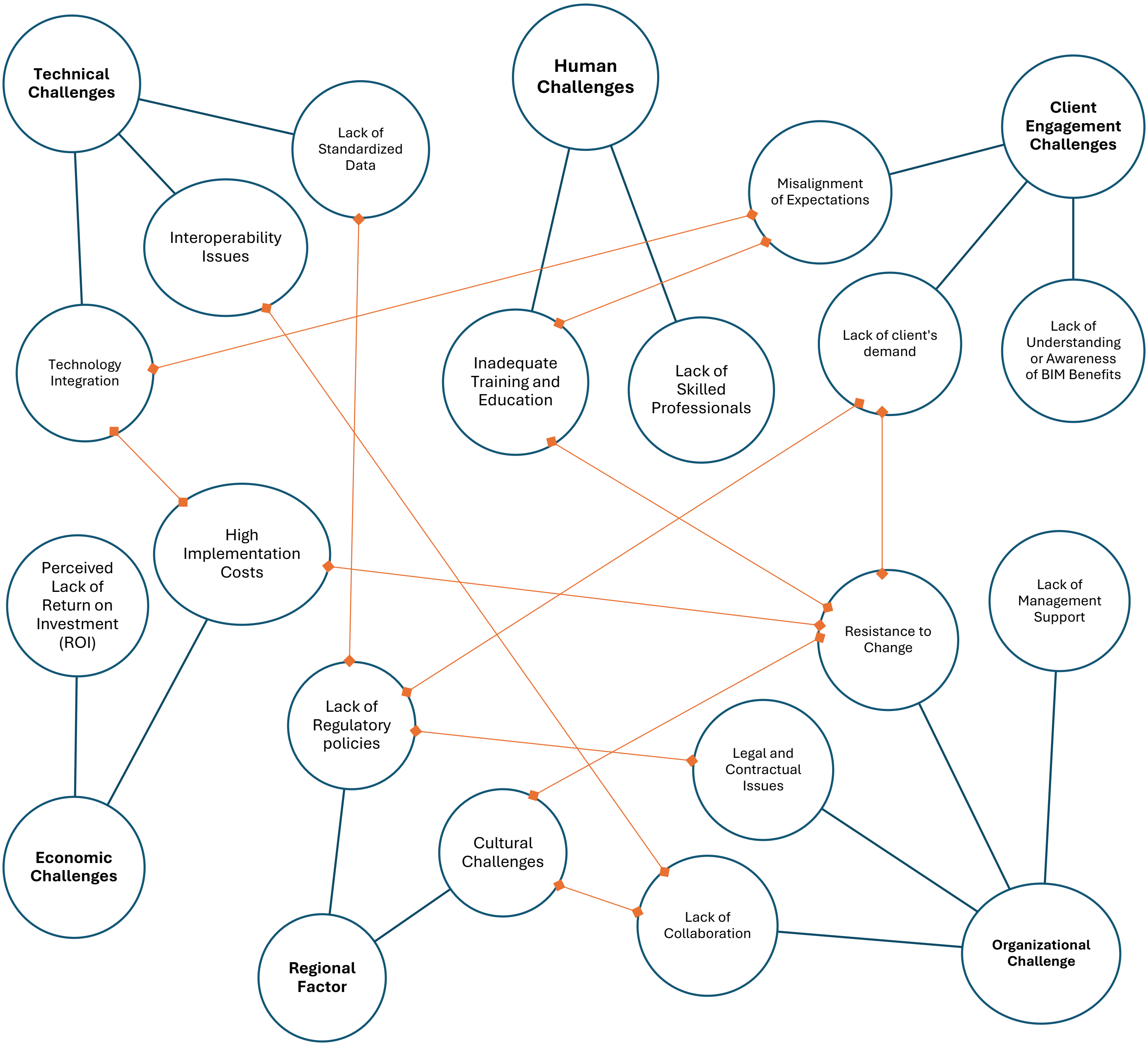

Figure 8 Interrelation of Challenges

4.7 Strategies for Overcoming Challenges

4.7.1 Client Education and Engagement

To address the lack of client demand and misaligned expectations, interviewees emphasized the importance of client education. Providing workshops and actively engaging clients in the early stages of the project can help them better understand the value of BIM.

> *Project Manager*: "We conduct workshops with clients to show them how BIM can reduce errors and improve efficiency. This helps them see the value of investing in BIM".

Table 8 Frequency of the strategy theme discussed in the interview

Code	Strategies	CEO	BIM manager	Chief Progect Engineer	Project Manager	Total
S1	Case studies lessons learning	1	1		1	3
S2	CDE implementation	1	1	1	1	4
S3	Internal BIM standart development		1	1	1	3
S4	Investing in education and support	1	1	1	1	4
S5	Software integration program	1	1	1	1	4

Radzi et al. (2024) also stress the importance of increasing client education to drive BIM adoption, aligning with the approach taken by this design-engineering firm.

4.7.2 CDE Implementation

The use of a CDE was identified as an effective strategy to overcome collaboration issues and facilitate data sharing between project teams. By implementing BIM360, the design-engineering firm ensures all stakeholders can access real-time data and stay aligned.

> *BIM Manager*: "BIM360 allows us to track changes in real time, ensuring that everyone – clients and contractors alike – can see the most current version of the model".

The use of CDEs to improve collaboration is also advocated by Saka & Chan (2023) and Oesterreich & Teuteberg (2019) as a key element of successful BIM workflows.

4.7.3 Change Management Strategies

The interviewees also discussed the importance of implementing change management strategies to reduce resistance to BIM adoption. This involves both internal training for their team and external education for their clients to foster a smoother transition to BIM processes.

> *CEO*: "We've developed a change management model to retrain our staff and educate our clients about BIM. It has helped reduce resistance significantly".

This strategy is supported by Ahmed (2018), who argues that structured change management models can mitigate resistance to new technologies.

By addressing these interrelated challenges in a holistic way, BCO and DEO can more effectively implement BIM, ensuring smoother transitions and more successful project outcomes.

4.8 Summary of Findings

The research findings reveal that technical, organizational, and client engagement challenges are the primary barriers to successful BIM adoption. However, these challenges can be addressed through client education, the implementation of CDEs, and structured change management strategies. The evolving regulatory landscape will continue to push clients toward BIM adoption, and the DEO will remain a key partner in facilitating this transition.

These findings contribute to the growing body of literature on BIM adoption challenges and strategies and provide actionable insights for both client organizations and design-engineering firms working to improve BIM implementation in the AEC industry.

Chapter 5. Framework and Validation

5.1 Introduction

This chapter presents the structured framework for transitioning to BIM implementation, which was developed based on several key sources: the findings from the literature review, the analysis of semi-structured interviews conducted with professionals from a DEO, and recognized change management models such as ADKAR and Kotter's 8-Step Change Model, see Table 9 Framework and Change Management Models (ADKAR and Kotter's 8 step). The framework addresses the main challenges identified in the literature and interviews – such as interoperability issues, resistance to change, and the need for client education – and provides strategies for overcoming these barriers.

Table 9 Framework and Change Management Models (ADKAR and Kotter's 8 step)

	ADKAR Model	Framework Phases	Kotter's 8-Step Model	
A	**Awareness**: Build awareness of the need for change through readiness assessments and gap analysis.	**Phase 1: Preparation and Planning**	**Create Urgency**: Assess current capabilities and highlight gaps to create urgency.	1
			Form a Powerful Coalition: Engage stakeholders and define roles for BIM implementation.	2
D	**Desire**: Define objectives and scope to foster desire for BIM adoption.		**Create a Vision for Change**: Develop a roadmap with clear objectives and communicate the vision for how BIM will improve outcomes.	3
K	**Knowledge**: Provide training and develop competencies, ensuring the team has the necessary skills to use BIM effectively.	**Phase 2: Training and Skill Development**	**Communicate the Vision**: Use training programs to reinforce the vision.	4
			Remove Obstacles: Identify and remove skill gaps through training.	5
	Knowledge/Ability: Upgrade technology and infrastructure, ensuring employees can apply BIM effectively in their work.	**Phase 3: Technology and Infrastructure**	**Remove Obstacles**: Implement technology upgrades to eliminate technical barriers.	
A			**Create Short-Term Wins**: Achieve early successes through improved technology.	6
	Ability: Apply knowledge in pilot projects, testing BIM implementation in real scenarios and refining processes.	**Phase 4: Pilot Projects**	**Create Short-Term Wins**: Select pilot projects to demonstrate the benefits of BIM and show early successes.	
			Build on the Change: Use pilot projects to refine processes.	7
R	**Reinforcement**: Roll out BIM across the organization, continuously monitoring progress to ensure sustained use and success.	**Phase 5: Full-Scale Implementation**	**Anchor the Changes in Corporate Culture**: Fully integrate BIM into organizational practices, ensuring its ongoing use and value.	8

The framework was validated by presenting it to a client organization planning to implement BIM in future projects. Feedback from key stakeholders within the client organization allowed for testing its applicability and effectiveness in real-world settings. The following sections outline the framework, its foundational components, and the results of the validation process.

5.2 Framework for Transition to BIM Implementation

The framework is structured around five key phases, which guide BCO through each stage of BIM adoption. It addresses the challenges found in the literature review and interviews – such as technical interoperability, organizational resistance, and client engagement gaps – and provides solutions based on strategic approaches drawn from both the literature and the experiences of industry professionals.

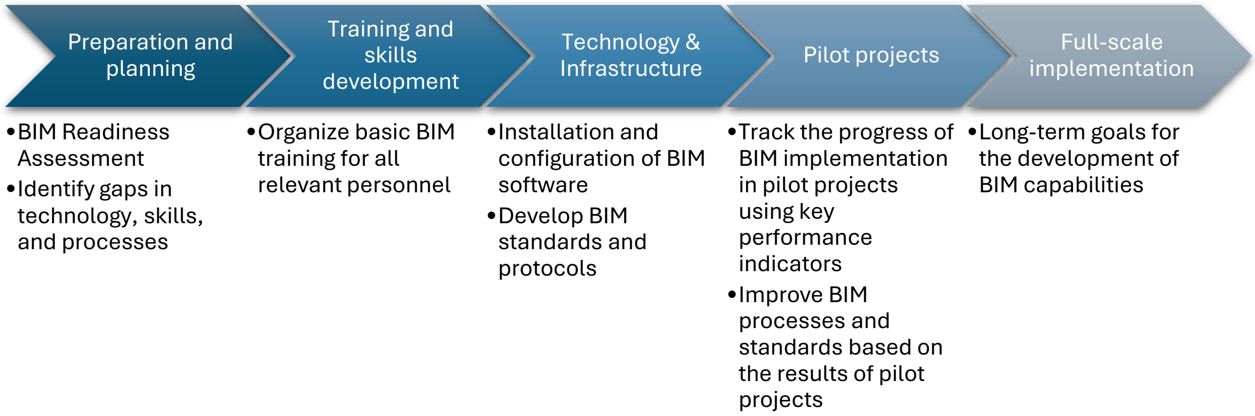

Figure 9 Concept of a Framework to BIM implementation

5.2.1 Phase 1: Preparation and Planning

1.1 Assess Current Capabilities

Informed by the literature review and interviews, this step involves a BIM Readiness Assessment that evaluates the client's current capabilities in relation to BIM. The literature emphasizes the importance of a thorough gap analysis, which identifies differences between current processes and those required for BIM implementation.

1.2 Define Objectives and Scope

Based on the strategies discussed in the interviews, clear objectives are set to address specific client needs, whether focusing on improving collaboration, design accuracy, or lifecycle management. The scope is determined by considering whether BIM will be applied to specific projects or across the organization.

1.3 Develop a BIM Implementation Plan

Drawing on the interviews and literature, a detailed roadmap is created, outlining steps for BIM adoption, including resource allocation, milestones, and responsible parties. This plan integrates the strategies necessary for a structured BIM transition, including addressing technological and human resource needs identified in the literature.

5.2.2 Phase 2: Training and Skill Development

2.1 Conduct BIM Training Programs

Training is essential, as highlighted in both the literature and interviews, to overcome skill gaps within client organizations. Tailored programs are developed to address both basic and advanced BIM competencies, particularly focusing on technical proficiency in software like Revit and Navisworks.

2.2 Develop BIM Competencies

The interviews revealed the importance of regular skill assessments and the need for certification programs to ensure a high level of BIM expertise within the organization. This aligns with the literature, which stresses the importance of continuous training to build a knowledgeable workforce capable of handling BIM processes.

5.2.3 Phase 3: Technology and Infrastructure

3.1 Select and Implement BIM Software

Drawing on both interviews and literature, this phase focuses on selecting software that aligns with the organization's needs, considering factors such as interoperability and scalability. The literature emphasizes the critical nature of choosing the right technology to ensure seamless integration with existing systems.

3.2 Upgrade IT Infrastructure

IT infrastructure upgrades, especially hardware and data management systems, are necessary to support BIM processes. This is echoed in the interviews, where participants highlighted the importance of scalable infrastructure to handle large BIM datasets.

3.3 Establish BIM Standards and Protocols

Based on both interviews and literature, it is recommended that industry standards, such as ISO 19650, be adopted to ensure consistent and structured BIM modeling. The interviews highlighted the importance of setting collaboration protocols to manage data sharing among project teams.

5.2.4 Phase 4: Pilot Projects

4.1 Select Pilot Projects

The literature and interviews both stress the value of pilot projects to test BIM workflows and identify operational challenges before full-scale implementation. Projects are selected that are representative of the client’s typical work and will allow for the evaluation of BIM's real-world effectiveness.

4.2 Monitor and Evaluate Pilot Projects

Key performance indicators (KPIs), including efficiency and accuracy, are tracked throughout the pilot phase, based on best practices identified in the literature and feedback from the interviews.

4.3 Document Lessons Learned

The interviews emphasized the need to compile comprehensive reports on the lessons learned from each pilot project. This feedback-driven approach is supported by the literature, where continuous improvement is key to refining BIM processes before scaling them across the organization.

5.2.5 Phase 5: Full-Scale Implementation

5.1 Roll Out BIM Organization-Wide

Drawing on findings from the pilot projects, BIM is implemented across all applicable projects. Both the interviews and literature highlight the importance of establishing strong monitoring systems to ensure adherence to BIM standards and protocols.

5.2 Continuous Improvement

The need for ongoing feedback mechanisms and benchmarking against industry best practices was underscored in both the interviews and literature. This ensures that BIM processes are continuously refined to adapt to new challenges and evolving industry standards.

5.3 Update BIM Strategy

The interviews and literature stress the importance of regularly reviewing and updating the BIM strategy to reflect advancements in technology and shifts in organizational goals.

5.3 Validation Process

After the presentation of the Framework the client organization provided the following key feedback:

Comprehensive Preparation Phase: Stakeholders appreciated the thoroughness of the readiness assessment and gap analysis, noting that it provided them with a clear understanding of their current capabilities relative to BIM adoption.

Training and Skill Development: The emphasis on skill development was seen as particularly useful. The client recognized that the proposed training programs/courses and certification pathways would help address their internal skill gaps in BIM.

Technology and Infrastructure: The organization highlighted the importance of the proposed IT infrastructure upgrades, particularly in ensuring that their hardware could handle large BIM datasets, complex modeling, and integration with internal business systems.

Pilot Projects: The iterative approach to pilot projects, allowing for refinement before full-scale implementation, was seen as a key strategy for reducing risk and ensuring that BIM processes are optimized before widespread adoption.

Implementation costs: One of the primary concerns raised during the feedback session was related to the implementation costs of BIM. The client sought clarity on the long-term financial implications, including software and hardware investments, training, and potential productivity gains. They emphasized the importance of assessing the return on investment (ROI) to justify these initial expenses. The feedback highlighted that cost considerations would be a key factor in determining the pace and scale of BIM adoption within the organization.

5.4 Conclusion

The BIM Transition Framework provides a comprehensive roadmap for BCO to transition smoothly to BIM adoption, addressing the key challenges identified in the literature review and interviews. The validation process demonstrated the framework's adaptability and practical application, with adjustments made to reflect the specific needs of the client organization. By following this framework, organizations can ensure successful BIM implementation, enhance collaboration, and align with evolving industry standards and regulations.

Chapter 6. Discussion

6.1 Introduction

This chapter interprets the research findings in relation to the five main challenges identified. Also. These challenges are discussed in the context of the research questions and the supporting literature, with particular attention to how DEO can address these barriers. Additionally, this chapter explores the broader implications for the AEC industry and considers the role of policy and regulatory frameworks in fostering BIM adoption.

6.2 Results interpretation

The findings of this research reveal several frequently encountered challenges that are crucial to the discussion of BIM adoption in the CIS region. Following the coding of interview data, the most frequently cited challenges were found in technical, organizational, and client-related categories. These findings contribute significant insights into the distinct hurdles that hinder BIM adoption in the CIS region, further differentiating it from other regions.

One of the most prominent challenges identified was interoperability issues (T1), a recurrent theme in the interviews. Many professionals reported difficulties with integrating different BIM software platforms, particularly when dealing with clients or partners using varied systems. This challenge mirrors existing literature, which highlights the persistent problem of software incompatibility in the BIM environment, causing delays and communication breakdowns in collaborative projects (Oesterreich & Teuteberg, 2019). The lack of standardized data (T2) was another technical barrier frequently mentioned by participants. Inconsistent data formats and the absence of unified data management practices led to confusion and errors during project execution, further complicating BIM adoption. These findings align with Wu et al.'s (2021) work, which emphasizes the necessity of common data standards to facilitate smoother project integration and collaboration.

From an organizational perspective, the lack of collaboration (O3) between various stakeholders, especially between building client organizations (BCO) and design-engineering organizations (DEO), was another frequent challenge. The interviews revealed that inconsistent BIM practices and insufficient communication often hindered effective collaboration. This challenge is particularly relevant in the CIS context, where the hierarchical organizational structures inherent in post-Soviet environments often obstruct the adoption of more collaborative, digital workflows. Ginzburg et al. (2016) note that in such environments, top-down management and resistance to change can slow the integration of innovative practices like BIM.

Client-related challenges also emerged as key barriers. The lack of client demand (C1) was frequently mentioned, with many interviewees pointing out that clients in the CIS region rarely request the use of BIM, nor do they fully understand its benefits. This issue significantly slows the adoption process, as contractors and project managers are less inclined to invest in BIM without client-driven demand. Furthermore, client awareness (C2) of BIM benefits was frequently highlighted as a major barrier. Many clients were unfamiliar with the long-term advantages of BIM, such as improved project efficiency and cost savings, which resulted in reluctance to invest in BIM processes. This finding echoes the work of Oesterreich & Teuteberg (2019), who identified client engagement as a critical factor in BIM project success.

These frequent challenges point to the need for a more structured approach to tackling BIM adoption in the CIS region. Technical barriers such as interoperability and data standardization require the implementation of unified software and data protocols. Organizational challenges demand a cultural shift towards more collaborative working practices, while the client-related challenges highlight the importance of educating clients on the value of BIM. Addressing these issues could accelerate the adoption of BIM and enhance the digital transformation of the construction industry in the CIS region.

6.3 Addressing the Research Questions

Main Research Question:

What are the main challenges that building client organizations face in adopting and implementing BIM during the digital transformation of the AEC industry, and how can these challenges be effectively addressed with the support of design-engineering organizations?

The five main challenges were consistently identified in the research as significant barriers to BIM adoption.

- Interoperability Issues (T1),
- Lack of Standardized Data (T2),
- Lack of Collaboration (O3),
- Lack of Client Demand (C1),
- Lack of Awareness of BIM Benefits (C2).

These challenges can be effectively addressed with the support of DEOs, which play a crucial role in facilitating BIM adoption. DEOs can provide technical support by helping BCOs navigate interoperability issues and develop common data standards that streamline project workflows. Moreover, DEOs can assist in educating clients about the long-term benefits of BIM, helping to align expectations and increase demand for BIM-driven projects. By implementing structured change management frameworks, DEOs can guide BCOs through the organizational shifts required for successful BIM integration, reducing resistance to change and fostering a culture of collaboration. Additionally, DEOs can support BCOs in meeting regulatory requirements by ensuring that BIM processes align with evolving standards, especially as the region gradually transitions towards parametric, data-driven regulations.

In conclusion, while the challenges faced by BCOs in the CIS region are significant, particularly in the technical, organizational, and regulatory domains, the involvement of DEOs offers viable solutions. Through technical expertise, client education, and structured change management, DEOs can help BCOs overcome barriers to BIM adoption, accelerating the digital transformation of the construction industry in this region. These efforts are especially important in a context where government policies are gradually shifting towards supporting digitalization, but where clients and organizations still require significant support to realize the full potential of BIM.

Sub-Question 1:

What challenges do companies encounter in BIM adoption and implementation?

The research revealed that the challenges faced by BCO are both technical and organizational in nature.

- **Interoperability Issues:** The integration of different software tools (e.g., Revit, Tekla) remains a significant challenge, making it difficult for various teams to collaborate effectively. The BIM Manager highlighted, "we often face issues when clients use different software platforms". This finding is supported by Eastman et al. (2011), who also noted that software incompatibility hinders project efficiency and collaboration.
- **Lack of Standardized Data:** The absence of standardized BIM data across projects makes it challenging for BCO to maintain consistency in their project workflows. The Project Manager emphasized, "many clients lack clear data standards, leading to confusion when models don't integrate smoothly". The literature echoes this concern, with Wu et al. (2021) stressing the need for unified data standards to facilitate smooth BIM adoption.
- **Lack of Collaboration:** A lack of clear collaboration protocols was identified as a major organizational challenge. The BIM Manager noted that "effective collaboration is key, but miscommunication between teams often delays projects". This aligns with Saka & Chan (2023), who argue that establishing effective collaboration frameworks is critical to achieving BIM success.

Sub-Question 2:

How does the level of client engagement and education affect the successful implementation of BIM in projects, and what approaches can enhance client understanding and alignment of expectations?

Client engagement and education emerged as critical factors in the successful adoption of BIM:

- **Lack of Client Demand:** One of the primary reasons for low BIM adoption is the lack of demand from clients, driven by a limited understanding of BIM's value. As the

CEO pointed out, "clients don't ask for BIM because they don't fully understand what it offers". The literature suggests that better client education could help bridge this gap, creating greater demand for BIM.

- **Lack of Understanding or Awareness of BIM Benefits:** Clients often view BIM as an unnecessary expense rather than an investment in improving project outcomes. The CPE noted that "clients expect BIM to solve all problems without fully understanding the effort required to implement it effectively". This finding is consistent with Liao et al. (2018), who stressed the need for managing client expectations to align with the reality of BIM's capabilities.

Approaches to Enhance Client Engagement and Understanding:

- Workshops and Training: Both the literature and interviews emphasize the importance of engaging clients early in the project through workshops and educational programs. These initiatives help clients understand the long-term benefits of BIM and align their expectations with project goals. The Project Manager noted, "we conduct workshops with clients to show them how BIM can reduce errors and improve efficiency".

Sub-Question 3:

What strategies and best practices can clients adopt to overcome the identified challenges and effectively implement BIM? How can design-engineering organizations contribute to the successful implementation of these strategies?

The strategies and best practices identified through the research include:

- **Client Education and Involvement:** Educating clients about BIM's potential benefits and providing clear examples through workshops can help generate demand and align expectations. Design-engineering organizations play a vital role in delivering this education. As the CEO mentioned, "our workshops help clients see the long-term value of BIM and how it can enhance project outcomes". This aligns with Radzi et al. (2024), who argue that client education is critical for effective BIM adoption.
- **Adopting Standardized Protocols:** Implementing BIM standards and collaboration protocols, such as ISO 19650, helps to mitigate both interoperability and collaboration challenges. The BIM Manager emphasized the use of BIM360 as a platform to facilitate real-time collaboration and ensure data consistency. This is supported by the literature, where Saka & Chan (2023) stress the importance of standardized BIM protocols for successful implementation.
- **Change Management:** A structured change management approach is necessary to address organizational resistance and ensure that both clients and internal teams are aligned with BIM processes. The CEO highlighted that "retraining staff and educating clients is essential for overcoming resistance to BIM". Kotter's 8-Step

Model and ADKAR provide a framework for managing this change effectively, as discussed in the research findings.

Sub-Question 4:

How do regulatory and policy factors influence the adoption and implementation of BIM by clients, and what initiatives can support standardization and effective implementation? How can design-engineering organizations assist clients in adapting to evolving regulations?

Regulatory factors are becoming a key driver of BIM adoption, especially as governments begin to mandate its use in public infrastructure projects. The CPE noted that "the regulatory landscape is shifting, and soon BIM will be required for most large projects". This aligns with Saka & Chan (2023), who suggest that regulatory mandates will accelerate BIM adoption in many regions.

Support from Design-Engineering Organizations: DEOs are crucial in helping BCO navigate these new regulatory requirements. By providing expertise and ensuring that clients are regulation-ready, these firms can facilitate smoother transitions to BIM. The CEO emphasized, "we work closely with clients to ensure they are prepared for upcoming regulatory changes".

6.4 Theoretical Implications

The findings from this research largely align with existing literature but provide new insights, particularly for CIS countries. The lack of client demand and awareness of BIM's benefits emerged as more significant challenges than initially expected. These findings emphasize the importance of client education and regulatory support in driving BIM adoption. Furthermore, the interoperability and data standardization issues identified echo the global challenges of BIM implementation, highlighting the need for global standards like ISO 19650 to ensure consistency across projects.

6.5 Unexpected Findings

One of the most unexpected findings was the extent to which client education and awareness influence BIM adoption. While technical challenges were expected to play a significant role, the lack of client demand due to insufficient understanding of BIM benefits proved to be a critical barrier. This underscores the need for proactive educational strategies to generate interest and foster demand for BIM among clients.

Additionally, the research revealed that the lack of standardized data was a more pressing issue than anticipated. Standardization remains a key technical hurdle, exacerbating interoperability challenges and hindering collaboration across teams and organizations.

6.6 Implications for the AEC Industry

Industry Impact

The specific socio-technical context of the CIS region – particularly interoperability issues, lack of standardized data, and client engagement gaps – significantly affects the pace and success of BIM adoption. Unlike in regions where the regulatory environment and economic incentives strongly support digital transformation, BIM implementation in the CIS is hindered by a confluence of organizational inertia, outdated regulations, and limited financial resources.

Policy Implications

Governments in post-Soviet countries should consider mandating BIM for public projects, as this could create the necessary demand and motivate organizations to invest in the technology. Design-engineering organizations must also play a key role in ensuring that clients are prepared for regulatory compliance.

Future of BIM in the Region

The future of BIM adoption in CIS countries will depend on:

- Increased client education, emphasizing the long-term value of BIM.
- Regulatory support, which will push organizations to adopt BIM in line with global standards.
- Investments in technology and data standardization, which will help overcome technical barriers and improve collaboration.

6.7 Conclusion

The findings of this research provide a clearer understanding of how the specific context of the CIS region shapes the challenges and opportunities for BIM adoption. Addressing the five main challenges – Interoperability Issues, Lack of Standardized Data, Lack of Collaboration, Lack of Client Demand, and Lack of Understanding or Awareness of BIM Benefits – is essential for the successful adoption of BIM. With targeted strategies, such as improving client education, addressing regulatory barriers, and fostering collaboration between Building Client Organizations (BCO) and Design Engineering Organizations (DEO), BIM adoption can be accelerated. This research contributes to the growing body of knowledge needed to develop these tailored strategies, supporting the region's transition from Soviet-era construction methods to modern, digitally-driven workflows.

Chapter 7. Conclusion and Recommendations

7.1 Conclusion

The objective of this research was to identify and analyze the main challenges faced by building client organizations in adopting and implementing BIM during the digital transformation of the AEC industry, particularly in CIS countries. Through a combination of literature review, interviews with professionals from a design-engineering organization, and the development of a structured BIM transition framework, this study provided in-depth insights into the technical, organizational, and client-related barriers to BIM adoption.

Key Findings

The research identified five main challenges faced by client organizations:

1. Interoperability Issues: The inability to integrate different BIM software tools, which leads to project delays and misaligned workflows.
2. Lack of Standardized Data: The absence of unified data standards complicates collaboration and leads to inconsistencies in project models.
3. Lack of Collaboration: Weak collaboration frameworks and poor communication between teams exacerbate technical challenges and reduce project efficiency.
4. Lack of Client Demand for BIM: Clients often do not request BIM due to a lack of understanding or awareness of its potential benefits.
5. Lack of Understanding or Awareness of BIM Benefits: Many clients perceive BIM as an unnecessary expense rather than an investment in improved project outcomes.

Role of Design-Engineering Organizations

The findings also highlighted the critical role that design-engineering organizations play in supporting client organizations to overcome these challenges. By offering technical expertise, facilitating client education, and implementing collaborative project management strategies, design-engineering firms act as crucial partners in the successful transition to BIM. These firms can also help clients navigate evolving regulatory requirements and ensure compliance with new BIM standards, such as ISO 19650.

Interrelation of Challenges

The research further revealed that the identified challenges are interconnected. For example, the lack of client demand and resistance to change are closely related to the lack of understanding of BIM benefits. Similarly, interoperability issues are worsened by a lack of collaboration and standardized data. Addressing these challenges holistically will lead to smoother BIM implementation and greater project efficiency.

7.2 Recommendations

Based on the research findings, the following recommendations are provided for building client organizations, design-engineering firms, and policymakers to enhance BIM adoption and overcome the identified challenges.

7.2.1 Recommendations for Building Client Organizations

1. **Invest in BIM Education and Training:**
   Client organizations should invest in educating their employees at all levels about BIM's capabilities and long-term benefits. This can be achieved through:

    - Workshops and seminars organized in collaboration with design-engineering firms.
    - BIM certification programs for key staff members to ensure they have the necessary skills to implement and manage BIM effectively.

2. **Adopt Standardized Data Protocols:**
   To overcome interoperability and collaboration challenges, client organizations should adopt international BIM standards such as ISO 19650. This will help ensure that data is consistent across projects and can be easily shared between different teams and software platforms.

3. **Enhance Collaboration Frameworks:**
   Clear communication and collaboration protocols must be established within project teams to ensure smooth integration of BIM into existing workflows. Implementing tools such as Common Data Environments (CDEs), like BIM360, can improve real-time collaboration and reduce data inconsistencies.

4. **Align Expectations and Realities:**
   It is crucial for client organizations to have realistic expectations of what BIM can achieve. By working closely with design-engineering firms, clients can better understand BIM's capabilities and limitations, avoiding misaligned expectations that could lead to project inefficiencies.

7.2.2 Recommendations for Design-Engineering Organizations

1. **Provide Tailored BIM Education for Clients:**
   Design-engineering firms should play an active role in educating their clients about BIM's value. This can be done through:

    - Customized training programs designed to address specific client needs.
    - Regular client workshops that demonstrate BIM's potential to improve project accuracy, collaboration, and cost-efficiency.

2. **Early Client Persuasion in BIM implementation on the Project:**
   Persuading clients to adopt BIM early in the project is crucial for ensuring they understand its full potential and are committed to its implementation. By actively

educating and persuading clients during the early stages of project discussions—before formal project planning and modeling—design-engineering firms can align client expectations with BIM's capabilities, fostering stronger collaboration and facilitating smoother project execution. This approach helps overcome initial hesitations and ensures that clients are fully engaged in leveraging BIM throughout the project lifecycle.

3. **Promote the Use of Collaborative BIM Tools:**
   Design-engineering firms should continue to promote the use of BIM collaboration tools such as CDEs to facilitate real-time data exchange between all project stakeholders. These tools help reduce interoperability issues and ensure that all teams are working from the most up-to-date information.

4. **Prepare Clients for Regulatory Compliance:**
   As regulations increasingly mandate the use of BIM in public projects, design-engineering organizations should ensure their clients are ready for compliance. This includes helping clients understand and adopt industry standards and preparing them for future regulatory changes.

7.2.3 Recommendations for Policymakers

1. **Mandate BIM for Public Projects:**
   Governments in CIS countries should mandate the use of BIM in large public infrastructure projects. This would create the necessary demand for BIM and drive the market toward greater digitalization in the AEC industry.

2. **Provide Incentives for BIM Adoption:**
   To encourage faster adoption, governments could provide financial incentives or tax breaks to companies that invest in BIM technologies and training. These incentives would motivate organizations to overcome initial cost barriers and invest in BIM.

3. **Support the Development of BIM Standards:**
   Policymakers should work to develop and promote national BIM standards that align with international protocols, such as ISO 19650. These standards will provide a unified framework for BIM adoption across the industry and reduce technical challenges related to interoperability.

7.3 Limitations of the Research

This research, while providing valuable insights into the challenges and strategies for BIM adoption in the CIS region, faces several limitations that should be acknowledged. One notable limitation is the relatively small sample size. The data was gathered through only four interviews, all of which were conducted with professionals from a single design-engineering organization. While these interviewees were experts in their field with substantial experience in BIM implementation, a broader range of perspectives across multiple organizations could have provided a more comprehensive understanding of the challenges and variability in BIM adoption processes.

Another limitation is related to the validation process. The research framework was validated through interaction with representatives from just one organization. This restricts the generalizability of the findings, as the challenges and strategies identified in this validation process may not fully reflect the experiences of other organizations, particularly those in different sectors or operating under different regulatory frameworks.

Despite these limitations, the research still holds significant value. The insights were drawn from experts in the field who are deeply involved in BIM implementation, and the findings contribute to a relatively underexplored area in academic research. The CIS region has limited studies on BIM adoption, making this research an important contribution to understanding the unique socio-technical and regulatory challenges faced in post-Soviet countries. Given the scarcity of literature on BIM implementation in this region, even a small sample of expert insights is valuable for advancing the discourse and guiding future research and practice.

7.4 Future Research Directions

While this research has provided valuable insights into the challenges of BIM adoption, there are several areas for future investigation:

1. **Comparative Studies Across Regions:**
   Future research could compare BIM adoption challenges in post-Soviet countries with those in other regions to identify global best practices and region-specific solutions.
2. **Longitudinal Studies on BIM Adoption:**
   A longitudinal study tracking organizations' progress in BIM adoption over time would provide valuable data on how challenges evolve and what strategies prove most effective in the long term.
3. **Exploring the Role of Emerging Technologies:**
   Research on how emerging technologies such as Artificial Intelligence (AI), Digital Twins, and Internet of Things (IoT) can enhance BIM's effectiveness in lifecycle management could provide valuable insights for future developments in the field.

7.5 Final Thoughts

This research has contributed to a better understanding of the challenges and strategies involved in BIM adoption by building client organizations. By identifying the key barriers – such as interoperability issues, lack of standardized data, and client engagement gaps – and suggesting actionable solutions, this study provides a roadmap for overcoming these challenges and ensuring smoother BIM implementation. With the combined efforts of client organizations, design-engineering firms, and policymakers, the AEC industry can fully embrace BIM and drive the digital transformation necessary for improved project outcomes and industry growth.

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Appendix A

Interview summaries

Interview 1. CEO

Question	Answer
Introduce yourself, your experience, and your role in the company.	CEO of the company. The company has been working with BIM for 8 years. I have 10 years of experience with BIM, initially gathered from attending industry events and testing pilot projects.
Describe your professional path and education.	Studied civil engineering with a specialization in tunnel construction, worked as a geotechnical engineer, then a chief project engineer, and eventually became a CEO. Worked with BIM in previous companies on various projects, including industrial, civil, medical, and heritage restoration projects.
What advantages do you see in using BIM for your projects?	Improved coordination between different project disciplines, more accurate specifications, better estimation of material quantities, and the ability to demonstrate higher-quality designs to clients. BIM also helps reduce errors and rework during construction.
How has BIM changed your approach to project management?	BIM has fostered a culture of innovation in the company, attracting specialists interested in new technologies. It has also encouraged exploration of automation and other modern solutions, even if not all innovations have immediate practical benefits.
What standards do you use in your BIM practices?	Internal company standards or those provided by clients. If no client requirements exist, the company sets its own. ISO 19650 is not fully adopted in our country, and national BIM standards, such as SP 333, have issues, especially the overly detailed level of project model requirements, which are impractical.
How important is standardization for BIM?	Very important, especially for repetitive and large-scale projects. Standardization is crucial for ensuring consistency and efficiency. For custom projects, it's harder to standardize everything, but components and processes can still benefit from standardization.
How frequently do clients require the use of BIM, and how do you help form their requirements?	More clients are requesting BIM, though their understanding of it remains limited. Some clients have vague or borrowed requirements from the internet, which often contain unnecessary elements. More knowledgeable clients are better able to link BIM requirements to project goals.
Describe the Ore Processing Plant Reconstruction Project and its use of BIM.	The company was responsible for architectural, structural, and engineering networks, while the client handled the technological solutions. BIM was used for coordination, and a strategy for BIM integration was developed, though the client ultimately opted not to fully adopt BIM due to cost concerns.
What were the main benefits of using BIM in this project?	BIM facilitated coordination between designer and the client. If the client had fully adopted BIM, it could have been used to control subcontractor work, monitor construction progress, and manage financial and technical planning.

What challenges did the client face in implementing BIM?	The client lacked the financial and organizational readiness for full BIM integration, especially after learning about the costs of hiring a BIM manager. They ultimately scaled back their BIM adoption, focusing instead on traditional methods.
Can you provide specific examples where BIM prevented errors in this project?	I wasn't directly involved in checking for collisions, it is generally known that BIM helps catch errors before they reach construction. However, not all potential collisions found in 3D modeling would have reached the construction phase.
How did BIM help in integrating technological and structural solutions in the project?	BIM was very useful in coordinating complex technological equipment with custom-made foundations, staircases, and other architectural elements. Modeling in 3D was far more effective than relying on 2D projections.
What were the challenges in transferring data between structural and analytical models?	There was no direct integration between the 3D and analytical models. Data was transferred manually through specifications, which is still common practice due to technical limitations in automating the process between design and calculation software.
How did the second project, the Paint Shop Project at the Railcar Factory, use BIM?	BIM was used to develop the maximum number of project sections in 3D to demonstrate its advantages to the client. The project included photogrammetry and laser scanning for accurate site measurements. However, the project stopped after the design stage due to budget issues.
What specific BIM technologies and tools were used in this project?	All project sections were modeled in 3D, with drawings and specifications extracted from the model. Photogrammetry and laser scanning were used for site surveying. The company also applied 4D modeling for construction sequencing and Solibri for collision detection analysis.
What lessons were learned from this project?	A key takeaway was the value of presenting early, accurate project cost estimates to help clients avoid overspending. Additionally, having detailed initial technical specifications reduced the need for corrections later in the project.
What general lessons can be drawn from the two projects discussed?	BIM provides significant advantages in improving design quality, coordination, and project visualization. The challenges lie in client education and readiness, as well as balancing immediate project costs with long-term strategic gains.

Interview 2. Chief Project Engineer

Question	Answer
What is your position?	Chief Project Engineer at the company.
What are your main duties in this role?	Organizing project design, including team selection, technical task formation, budget control, and interaction with suppliers and clients.
How did you get to this position?	Started as an automation engineer, worked on various industrial projects, and gained experience in both designing and managing engineering projects.
Have you always worked on industrial projects?	Mostly, about 90% of the projects were industrial.
How long have you worked with BIM technologies?	Since joining the current company 2 years ago, starting with a large mining project in BIM.
How has BIM changed your approach to design?	BIM improves project timelines and reduces coordination issues between disciplines, especially in early-stage problem detection and resolution.
What information do you need at different stages of the project?	Different information is needed for each project phase, depending on the stakeholders—clients, engineers, or suppliers—such as progress reports, specifications, and model information.
How do you interact with suppliers regarding information exchange?	Many suppliers now provide 3D models of their equipment, which are integrated into the BIM model. This helps visualize spaces and equipment functionality.
Does the Client require BIM, or is it your decision?	In the case of the Ore processing Plant project, the Client requested BIM, but it was up to the project team to define the level of detail and finalize the requirements.
How do you assess the Client's readiness for using BIM?	The Client often lacks a clear understanding of BIM beyond receiving a 3D model.
When do information requirements typically arise—during or before the project?	Ideally, these requirements are agreed upon before the project begins, to avoid changes during the design phase.
How do information requirements (like EIR) help at each stage?	These requirements are more like agreements, often simplified in practice and based on mutual understanding rather than strict adherence to documents.
How can the process of defining information requirements be improved?	Increasing general understanding of BIM among all stakeholders, especially c, would simplify the process. Time and experience are key to building this knowledge.
What software do you use for BIM?	Revit is used primarily, with additional software like Tekla for certain structural elements. IFC files are integrated into the overall project. BIM 360 is used for data exchange, though it's expected to be replaced.
How do you manage the Common Data Environment (CDE)?	The project team controls what the client sees in the CDE. Information is uploaded progressively for client review and approval, which helps manage the project flow.

Does the Client require any specific information for post-construction use?	Generally, the Client doesn’t have plans for using the BIM model post-construction, though the model helps with technical oversight during the construction phase.
What would improve the use of BIM in projects?	Raising awareness of BIM's practical uses, including asset management, would lead to better-defined requirements from Clients, making collaboration with designers easier.
How do you assess the quality of your work with BIM?	The use of BIM has led to higher-quality designs by identifying and resolving issues earlier, which might not have been caught until later stages without the model.
What can you add to our discussion today?	The late consumer of the model or the maintenance service needs to realize that they need a BIM model, then the requirements for the model for both builders and designers will immediately be born.

Interview 3. BIM manager

Question	Answer
Tell about your education, role, and work experience.	Civil engineer with a background in both construction and IT. Experience in automating processes with AutoCAD, transitioning to BIM management in multiple companies, including Nemetschek and Autodesk partners. Currently working as a BIM manager in a company known for being a leader in BIM in the country.
When did you begin working in this field?	Began working in 1997, with involvement in transitioning from traditional drafting to AutoCAD and later to BIM technologies, including Revit and other modeling solutions.
What advantages do you see in using BIM in your projects?	Increased project quality, timely collision detection, and the ability to collaborate in a Common data environment. BIM streamlines collaboration, improves design quality, and offers possibilities for integrating 4D and 5D models for construction and operational phases.
Do you believe your company is operating at BIM level 2 or 3?	The company operates primarily at BIM level 2, using federated models and Common data environments. Full BIM level 3, involving comprehensive collaboration, remains a challenge due to varying levels of BIM maturity among clients and project teams.
What standards and guidelines do you use for BIM?	The company uses a mix of local (SP 333) and international standards (UK-based), often creating custom BEP and EIR documents when necessary. Standards are supplemented with details like LOD to ensure clear project requirements, especially in the absence of Client standards.
How do you help clients form their BIM requirements, especially for EIR?	By using an internal EIR template and tailoring it to the client's needs. Clients are often unaware of the full scope of BIM's potential, and the company works to align BIM use with the project's goals, clarifying what is needed and excluding unnecessary tasks like overly complex classifications.
Have you encountered clients with unrealistic BIM expectations?	Some clients believe BIM will automatically eliminate issues such as project delays and design conflicts, expecting BIM to solve everything. While BIM improves quality, it does not guarantee faster timelines or cheaper projects.
How do you assess a client's readiness to use BIM?	The situation is improving, with more clients becoming aware of BIM benefits. Some are interested in integrating BIM for construction and operational phases, though there are still clients who require education and persuasion about BIM's value.
Describe Ore Processing Plant Reconstruction Project and its use of BIM.	The project was for a Kazakhstan-based client, involving the reconstruction of a mining facility. The company had to develop custom BIM requirements (EIR) and manage client expectations about LOD and classifications. The project required collaboration using Revit and Tekla, with challenges in file coordination.

What BIM tools were used in Ore Processing Plant Reconstruction Project?	Revit and Tekla were used for different disciplines. Tekla outputs initially presented issues with non-editable IFC files, leading to adjustments. Despite challenges, BIM allowed for effective clash detection, project visualization, and documentation management.
How do you handle projects with excessive or unclear BIM requirements?	The company helps refine and clarify requirements to align them with the project's objectives, often educating clients on the costs and benefits of their requests. This can involve removing unnecessary elements to reduce complexity and costs.
What were the key elements of the BIM Execution Plan (BEP) for this project?	The BEP outlined project stages, modeling disciplines, file formats, and quality control processes. It also provided instructions for working in a Common data environment, managing the coordination of models, and defining the responsibilities of team members.
Did BIM help prevent conflicts or errors in this project?	BIM allowed for the early detection of design issues, especially related to accessibility and equipment installation, which might have been missed in 2D design. Clash detection and visualization also helped prevent issues before construction began.
How did the project end, and what lessons were learned?	The project is ongoing, with some revisions and issues still being addressed. The use of BIM was successful in facilitating collaboration and visualization, though the coordination of IFC files presented challenges. Lessons include the importance of aligning model coordination early in the project.
Describe the Paint Shop Project at the Railcar Factory.	The project involved the renovation of a Railcar factory's paint shop. The company used 3D laser scanning and photogrammetry for site analysis, modeling the painting process in Navisworks for 4D simulation. BIM was used for demolition planning, even though the client had no initial BIM requirements.
How did BIM add value in this project?	BIM helped demonstrate the benefits of detailed project planning and 4D modeling, which visualized the painting process and demolition sequence. The project also passed government expertise review and provided experience with newer BIM tools, such as Autodesk's cloud-based collaboration features.
What were the outcomes and challenges of the Paint Shop Project at the Railcar Factory?	The project was successful in terms of BIM implementation, but the client delayed the construction phase. The company gained experience in 4D modeling and cloud collaboration tools, though the full potential of BIM was not realized due to project delays.
What lessons were learned from these projects that can be applied in the future?	The projects highlighted the importance of clear communication with clients regarding BIM expectations and the need for better coordination when using multiple software platforms (e.g., Revit and Tekla). The company also learned how to integrate new technologies, such as 4D modeling, into future projects.

Interview 4. Project Manager - Chief Project Engineer

Question	Answer
Can you tell us about your education, role, and work experience?	Graduated in 2006 as an energy engineer. Started working in project management in 2009, became the head of electrical engineering in 2014, and took on the role of Chief Project Engineer (GIP) in 2018, with a focus on BIM projects since then.
What are your responsibilities in your current role?	Managing the department, assigning GIPs, resolving technical issues, prioritizing projects, overseeing cost calculations for commercial proposals, and optimizing internal processes. Focuses on project management rather than design itself.
What was the first project where you used BIM, and how was it applied?	The first project was a multifunctional medical center. The team used Revit for detailed modeling, including internal systems. They also implemented BIM360 for clash detection, marking a significant transition from traditional 2D methods to integrated BIM project management.
How has BIM changed your approach to project design and management?	BIM has improved visual understanding of projects, allowing real-time model access for better decision-making. It eliminates the need to cross-reference multiple 2D drawings, offering a more integrated view of systems and structures.
How important is standardization for successful BIM implementation?	Standardization is key, especially in managing clashes and coordinating systems. Projects typically use a BIM Execution Plan (BEP) and, when available, an Employer's Information Requirements (EIR), even if these documents often need to be created by the project team.
What standards and regulations do you use in your BIM practice?	The company follows internal standards and relies heavily on the BEP, rather than government standards like SP 333 or state contracts, as these are less relevant to their projects.
How often do clients request BIM, and how do you help them define BIM requirements?	Some clients actively request BIM but often lack understanding of its scope. The company helps clients by creating EIRs and explaining the level of detail required. The team also educates clients on the benefits of using a common data environment (CDE) for collaboration.
Have you ever faced unrealistic or unachievable BIM requirements from a client?	Yes, there was a case where a client requested detailed reinforcement modeling in Revit. The frequent changes to planning rendered earlier efforts redundant, leading to a decision to abandon reinforcement modeling in future projects.
How would you assess the readiness of clients to use BIM?	Clients who focus on cost savings and efficiency are more likely to embrace BIM. The transparency of BIM helps ensure accountability, especially with material quantities and costs, making it an attractive option for clients who want more control over their projects.
Does BIM improve communication and understanding with clients?	Absolutely. BIM allows clients to visualize the project more clearly, reducing misunderstandings and helping them provide feedback on aspects like the placement of systems. It also facilitates faster decision-making and error detection.
Do you work with suppliers to integrate their data into BIM models?	While some suppliers are ready to provide BIM data, such as families, the company rarely collaborates directly with suppliers. Most of the necessary data is found in catalogs or created by the project team when needed.

Can you describe the Paint Shop Project at the Railcar Factory?	The project aimed to improve the painting process for railcars. It involved a 25,000 sq.m. production space and included detailed design of internal systems using Revit. The team also used BIM360 for clash detection and project management. The project received a positive permit and passed government review at the State Expertise Agency.
What were the key stages and BIM tools used in this project?	BIM360 was essential for project management, clash detection, and communication within the team. The company automated much of the project setup, including project timelines and task management. BIM360 was also used to manage approvals and keep stakeholders updated in real time.
What challenges did you face in the project?	The main challenge was coordinating an outsourced BIM-modeler who struggled to meet deadlines. The project also involved complex demolition work, where laser scanning and point clouds helped quantify the demolition volume and streamline the process.
What were the outcomes and lessons from the project?	The project was successful in terms of client satisfaction and financial performance. The team improved their internal processes, especially around managing project tasks and using BIM for clash detection. They also refined their project documentation and collaboration methods.
Can you describe the Ore Processing Plant Reconstruction Project?	The project involved a large-scale mining facility with around 15 buildings. Although the client initially wanted to implement BIM, they eventually scaled back their involvement due to challenges like finding a BIM manager. The project remained unfinished, and this was a learning experience for the team.
What were the key issues within this project?	The client lacked internal resources to support BIM and eventually lost interest. The project scope was large, involving multiple buildings and models, but the lack of client engagement made it difficult to complete.
What lessons did you learn from this project?	Clear client communication and understanding of BIM are critical. The team realized the importance of educating all stakeholders on the benefits of BIM to ensure successful project completion.
What improvements would you suggest for better BIM implementation in future projects?	Detailed project planning from the start is essential, along with having a well-structured action plan. This can help reduce project timelines and improve overall project management. The team also needs to continuously refine its internal processes and documentation.

Appendix B

Case study documents shortcut overview

Case study 1. Ore Processing Plant

Employer's Information Requirements (EIR)

Project Scope:

Development of the project and working documentation for an Ore Processing Plant with a capacity of 6.5 million tons of ore per year.

Information Model Requirements:

This document specifies requirements regarding the form, structure, and content of the information model (BIM model) and sets the expectations for participants, processes, and results. The document ensures the unity and integrity of the BIM model, outlines the information contained, and is mandatory. Any deviations must be outlined in the BIM Execution Plan (BEP) and agreed upon with the Client. The primary objectives include improving the quality of design work, performing operational analyses of design solutions, obtaining project data, and visualizing solutions for better spatial planning and optimization.

Objectives of Information Modeling:

- Enhancing design quality and analysis of solutions.
- Prompt project data acquisition.
- Volume and cost calculations.
- Identifying and resolving interdisciplinary conflicts pre-construction.
- Visual control and optimization of design solutions.

BIM Execution Plan (BEP)

Purpose of BIM Use:

- Ensuring spatial coordination of structures, networks, and equipment, both existing and newly designed.
- Providing accurate data on materials and equipment volumes.
- Optimizing design solutions through visual assessments.
- Facilitating the seamless use of data across all project phases, ensuring that data is transferred accurately and without loss.

BIM Modeling Tasks:

1. 3D modeling of buildings and terrain.
2. Coordination and collision detection.
3. Visualization.
4. Change control.
5. Production of automatic specifications and drawings.
6. Using the design BIM model for construction and as-built phases.

Work Stages:

1. Development of the information model (IM) for project documentation.
2. Elimination of collisions in the IM.
3. Preparation of final documentation (PD) for approval.
4. Acceptance of work at different stages, including resolving comments post-review.

Case Study 2. Railcar Factory Paint Shop

Employer's Information Requirements (EIR):

Project Scope:

Development of the project for the Paint Shop Building with BIM technology at the design stage (P).

Main Directions of BIM Modeling:

The document outlines the adoption of BIM for improving decision-making and design processes. BIM ensures uniformity in modeling, improves design efficiency, and facilitates the creation of models for subsequent project stages.

BIM Modeling Tasks:

- 3D coordination and collision detection.
- Optimization of design solutions.
- Change control.
- Automated production of specifications and drawings.
- Using the BIM design model for construction simulation and safety management.

Information Exchange and Document Management:

The BIM model and project documentation are managed in the Autodesk BIM 360 cloud environment, where the Client has access to up-to-date project files updated in accordance with the schedule agreed by the parties for the publication of models and project documentation.

For final inspections, the Contractor, in accordance with the schedule agreed by the parties, provides the Client with the opportunity to view the following materials in the BIM360 environment:

- Summary model in NWD format.
- BIM models of the relevant sections in RVT format with all links and related files.
- Sets of drawings in PDF format. Drawings of one section are combined into a single file.
- Sets of drawings in DWG format are available on request.

Upon completion of the work, the Contractor informs the Client that the consolidated model in NWD format and the models of the corresponding sections in RVT format are final, and can be further used to create Working Documentation, construction and executive models.

After the final payment of the work, the Client 's rights to view all project materials on the BIM360 platform are supplemented by the possibility of downloading them.

BIM Execution Plan (BEP):

Purpose of BIM Use:

The BEP is a document that captures the main points of interaction between project participants for the effective use of information modeling in order to develop project documentation. The document defines the framework for the application of information modeling, distributes the main responsible roles, defines the sequence and procedures for performing each BIM process, with all the necessary introductory and desired results, describes ways to exchange information between project participants and presents technical specifications for the development of a BIM model.

BIM Modeling Tasks:

- Creation of a unified building information model.
- Deriving project documentation from the model.
- Collision detection and spatial coordination.
- Optimization and verification of solutions.
- Production of specifications, drawings, and explanatory notes.
- Using the BIM model for construction management and safety purposes.